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Topics in Microfinance and Behavioural Economics

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Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work.

I declare that my thesis consists of 33,050 words. I can confirm that my thesis was copy edited for conventions of language, spelling and grammar by Eve Richards.

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Abstract

This thesis contributes to economic research in microfinance and behavioural economics and bridges the gap between the two fields. Chapter 2 compares three lending mechanisms used by microfinance organizations: individual lending, simultaneous group lending and sequential group lending. The results are that the optimal choice of lending mechanism depends on the underlying distribution of project returns and on the level of available official contract enforcement. If contract enforcement is weak, sequential group lending unambiguously achieves the highest repayment rate. Hence sequential group lending can operate in settings in which simultaneous group lending and individual lending are not feasible due to weak contract enforcement.

Chapter 3 shows that multiple price lists, currently the standard way of eliciting time preferences, will give biased estimates when income is uncertain. This is first shown theoretically and the resulting hypotheses are then tested empirically. The experiment finds that income risk causes participants to make more patient choices when choosing between two payments in the future. When choosing between an immediate and a future payment, however, income risk has no significant effect. As a result, participants with uncertain income appear more present-biased and less future-biased. Finally, only estimates obtained under safe income show a significant correlation with real-world financial outcomes.

The fourth chapter shows how several features of the microfinance industry can be explained by projection bias over habit formation. Humans have a tendency to

underestimate to what extent their future preferences will differ from their current preferences and this systematic bias is known as projection bias. With the help of a formal model, this paper demonstrates that the prevalence of flat interest rate calculations, the high frequency of repayments, and the problem of over-investment can all be explained by this particular bias. Importantly, the policy implications resulting from this theory differ from those of other prevailing models, such as hyperbolic discounting.

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Chapter 1

Introduction

Over the last two decades, microfinance has captured the interest and imagination of economic researchers and policy makers alike. What started off with one man giving small loans to poor women in Bangladesh, has matured into an industry valued at more than $60 billion in 2010 (de Quidt et al. (2012)). Innovative and unconventional lending mechanisms used by microfinance banks have ensured high repayment rates and have been extensively studied by economists (Varian (1990), Stiglitz (1990), Ghatak (2000), Besley and Coate (1995) to name just a few). The success of microfinance culminated in the Nobel Peace Prize for Mohammed Yunnus and the Grameen Bank of Bangladesh in 2006. In recent years, however, criticisms of the sector have emerged, arguing that interest rates are too high, that borrowers take on more loans than they can repay and that there is no impact on poverty alleviation. Banerjee et al. (2010), the first randomized impact evaluation, indeed finds no impact on poverty reduction, gender gap, health or education.

At the same time, economics has re-discovered the psychological influence in human decision making and the discipline of behavioural economics has begun to establish itself in mainstream economic thought (Camerer (2002), Angner and Loewenstein (2007)). Economists are increasingly incorporating cognitive biases and limitations into their models and particularly in the field of development economics, this is beginning to shape economic policy as well. Insights from behavioural economics in development have been used to explain phenomena as diverse as under-utilization of mosquito nets and fertilizers (Blackburn et al. (2009), Duflo et al. (2008)) and under-saving Ashraf et al. (2006).

This thesis contributes to both these literatures and aims to connect the two fields wherever possible. The focus of Chapter 2 is on microfinance and in particular on a lending mechanism which has received comparatively little attention in the academic literature. It compares a sequential group lending mechanism, in which borrowers receive credit one at a time, to the traditionally considered simultaneous lending mechanism as well as individual lending. It argues that the sequential lending mechanism has the ability to harness social sanctions more effectively than either the traditional, simultaneous group lending mechanism or individual lending. Thus, sequential group lending can be successfully employed in environments in which tradition lending mechanisms break down.

The third chapter of this thesis shows that techniques used by behavioural economists cannot always be directly transfered to a developing country setting. In particular, it demonstrates that the standard way of eliciting discount parameters and time-inconsistencies is not robust to income risk, something which is a very important part of the financial lives of the poor (Collins et al. (2009)). Two theoretical models, based on expected utility theory and loss aversion, are used to show that the estimates of discount factors will be biased under income risk. The resulting hypotheses are then tested empirically on data collected during a laboratory experiment in West Bengal, India. The experiment confirms that the estimation of both discount factors and time inconsistency is affected by income risk and the results correspond broadly to the predictions made by the loss aversion model and reject the expected utility theory model.

The fourth and final chapter focuses on one particular behavioural bias and analyses how this bias can explain several features of the microfinance industry. Evidence from psychology suggests that humans have a general tendency to consistently and predictably underestimate to what extent their future preferences will differ from their current preferences and this bias has become known as projection bias (Loewenstein et al. (2003)). Chapter 4 makes projection bias over habit formation its main focus and analyzes, with the help of a formal model, the implications this bias has for the microfinance industry. The model is able to show why borrowers may over-invest, why repayment meetings in microfinance are very frequent and why borrowers often pay very high repayment rates.

Chapter 2

Sequential Group Lending: A Mechanism to Raise the Repayment Rate in Microfinance

Abstract

This paper compares three lending mechanisms used by microfinance organizations: individual lending, simultaneous group lending and sequential group lending. The main results of the paper are that the optimal choice of lending mechanism depends on the underlying distribution of project returns and on the level of available official contract enforcement. If contract enforcement is weak, sequential group lending unambiguously achieves the highest repayment rate. Hence sequential group lending can operate in settings in which simultaneous group lending and individual lending are not feasible due to weak contract enforcement. Simultaneous group lending in contrast achieves the highest repayment rate if the level of official contract enforcement is high and if the likelihood of default is relatively low.

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JEL Codes: O2, O12, G20, D82

2.1 Introduction

Group lending, a feature found in many microfinance programmes all over the world, was once celebrated as a great innovation in the global fight against poverty. It was argued that group lending would induce borrowers to monitor each other (Stiglitz (1990), Conning (1999) and Varian (1990)), screen each other (Ghatak (2000) and Van Tassel (1999)) and enforce repayment when official enforcement is weak (Besley and Coate (1995)). In recent years, however, group lending has started to disappear as microfinance institutions have moved instead towards individual lending (Gine and Karlan (2006)).

This paper demonstrates how an alternative lending mechanism, sequential group lending, can be used to raise the repayment rate when the lender's ability to enforce contracts is low. The group lending mechanism as traditionally considered is one of simultaneous group lending in which all the borrowers in a group receive their loans at the same time and then are jointly liable for each other's repayment. Sequential group lending, the original group lending mechanism used by the Grameen Bank in Bangladesh, in contrast, entails giving loans to borrowers one at a time on condition that the previous borrower's loan is repaid.

The incentive implications of sequential group lending have previously been studied by Roy Chowdhury (2005) and (2007) and Aniket (2005). Roy Chowdhury (2005) shows that if monitoring and effort decisions are strategic complements then simultaneous group lending can break down. By distributing loans sequentially, borrowers will always have an incentive to monitor each other. Roy Chowdhury (2007) demonstrates how sequential group lending can lead to assortative matching and homogeneous group formation, thus making it cheaper for the lender to screen borrowers. Similarly, Aniket (2005) shows how sequentiality can help to alleviate the problem of moral hazard in effort provision. By temporally separating the monitoring and the effort decision of a group member, the lender has to incentivise only one task per borrower at a time.

This paper shows that there are two further advantages to sequential group lending as compared to simultaneous group lending: the first advantage is that, unlike under simultaneous group lending, it is never the case that one borrower's default can cause another borrower to default. Under simultaneous group lending the joint repayment burden can be so high that a borrower who would have repaid her own loan will choose not to repay for two and hence herself defaults. Under sequential group lending each borrower has to take the repayment decision individually. The logical corollary, however, is that borrowers also will not be able to help each other as much as they can under simultaneous group lending. A borrower who has not yet received a loan will not be in a position to help a group member who is struggling to repay. The choice of optimal lending mechanism is therefore a function of the underlying distribution of output. This tradeoff is analysed in section 3.

The second advantage is that sequential group lending is more efficient at harnessing social sanctions between borrowers. As borrowers wait their turn to be allocated their loan, they threaten their partner with social sanctions should they voluntarily default. Similarly, once borrowers have repaid their share of the loan, they will pressure their peer into repaying, else they would be liable for repayment of a second loan or face the lender's official penalty for not repaying on their partner's behalf. In simultaneous group lending, in contrast, it may occur that both borrowers agree to default on the loan and hence no social sanctions are used. In environments where the lender's available penalty for defaulting is particularly low and hence where official contract enforcement is weak, sequential group lending therefore may be the only mechanism under which lending remains feasible. Section 4 analyses this problem in detail.

2.2 Applications

The idea of harnessing social sanctions using sequential group lending is not new. Rotating savings and credit associations (ROSCAs) are based on a very similar principle. A ROSCA is a group of people who each contribute a specific amount to a savings pot in each period. The money thus accumulated is randomly allocated to a winner. The ROSCA continues with the winner of the pot excluded from receiving the pot in the future and it terminates when every single member has received the pot once.

Without social pressure from other ROSCA members, there would be little incentive to keep on contributing after a member has won the pot[1] . Besley et al. (1993) argue that it is the social connectedness amongst the group members and the threat of social sanctions which insure against such default problems. In this paper we argue that the sequentiality observed in ROSCAs is crucial and that the same mechanism can be exploited by microfinance institutions.

However financial products in developing countries are not the only possible application of this sequential mechanism. Any production process which involves two separate tasks can be carried out in either a sequential or a simultaneous fashion. Bag and Roy (2011) for example, compare contributions in a public good game in sequential and simultaneous frameworks and find that the sequential set-up may lead to higher expected total contributions. The analysis in this paper can be seen as contributing to this emerging literature on sequential mechanisms (see also Winter (2006), Bessen and Maskin (2009)) by showing that social pressure is strongest in a sequential framework.

[1]For a recent and very interesting behavioural explanation see Basu (2011)

2.3 Perfect Enforcement

This section compares the repayment rates of individual lending, simultaneous group lending and sequential group lending under perfect contract enforcement. Perfect contract enforcement is defined as the ability to guarantee repayment if the borrower's output is at least as high as the amount owed to the bank. Alternatively, it is the lender's ability to directly confiscate whatever it is owed.

Borrowers are risk neutral and have access to projects which require one unit of capital and each yield x units of income where x is independently and identically distributed on $[0, \overline{x}]$ with a continuous distribution function $F(x)$. Borrowers are wealth less and therefore must borrow capital from a lender who requires a repayment of $r > 1$ after the project has been realized. This repayment of r is treated as exogenously given for the purpose of this paper. The upper bound on project returns $\overline{x}$ is assumed to be greater than r so that repayment is feasible in at least some states of the world. Later on we will distinguish between the case where $\overline{x} > 2r$ and $r < \overline{x} < 2r$ such that a borrower may or may not be able to repay her partner's loan as well as her own.

To make matters simple, this paper ignores partial repayment. If a borrower's output falls short of the required repayment, the borrower is said to be in default and the bank receives nothing. [2]

The main object of interest throughout the paper is the expected repayment rate, which is defined as the number of loans that are expected to be repaid per group relative to the number of loans that are expected to be made.

[2] This assumption does not affect any of the results of the paper in any meaningful way. For example, one could also assume a degenerate distribution in which output can take only three values: 'zero', 'medium', and 'high', such that partial repayment is not possible. Assuming 'medium' is sufficient just to repay one loan and 'high' is sufficient to repay two loans, the results in this paper are equally valid.

2.3.1 Individual Lending

Individual lending under perfect enforcement simply consists of the borrower repaying whenever output exceeds r. Therefore the expected repayment rate equals:

$$\Pi_{ind}^{*} = 1 - F(r) \tag{2.1}$$

2.3.2 Simultaneous Group Lending

Groups are composed of two borrowers B_1 and B_2. The group is allocated two units of capital and both group members are jointly liable for the repayment of the two loans at the end of the period. The assumption of no partial repayment implies that a group member can repay for her peer only if her output exceeds $2r$. For example if one borrower has a return of $0.5r$ and the other has a return of $1.5r$, the group is still said to be in default. This is purely to simplify the analysis; relaxing this assumption would not affect the results of this paper in a meaningful way.

There are four different states of the world:

	State of the world	**Probability**	**Loans repaid**
Case 1	Both borrowers have a return less than r	$F(r)^2$	0/2
Case 2	One borrower has a return less than r while the other has a return between r and $2r$	$2F(r)\big(F(2r) - F(r)\big)$	0/2
Case 3	Both borrowers have a return greater than r	$\big(1 - F(r)\big)^2$	2/2
Case 4	One borrower has a return less than r while the other borrower has a return greater than $2r$	$2F(r)\big(1 - F(2r)\big)$	2/2

In case 2, simultaneous group lending performs worse than individual lending because one borrower is dragged into default by her struggling partner. In case 4, in contrast, simultaneous group lending is beneficial because a defaulting borrower can be bailed out by her partner. Which of these effects outweighs the other depends on the relative likelihood of each of the cases occurring. If case 4, for example, never occurs because it is not possible for one borrower to have a return greater than $2r$ then individual lending is unambiguously better. In general however, it is not possible to say which of the two mechanisms achieves the highest repayment rate.

The overall repayment rate in simultaneous group lending is given by

$$\Pi^*_{sim} = 1 - F(r)^2 - 2F(r)\big(F(2r) - F(r)\big). \tag{2.2}$$

The first term that is subtracted is simply the probability of state 1 occurring and the second term the probability of state 2 occurring, which are the only cases in which the loan is not repaid.

2.3.3 Sequential Group Lending

Under sequential group lending initially only B_1 is given a loan and upon the successful repayment of it B_2 will receive the second loan. Hence every group receives the first loan, but the second loan is given out only with probability $1 - F(r)$. With probability $F(r)$ the first loan could not be repaid and hence the game terminates. Overall, the expected number of units of capital lent per group therefore is given by $2 - F(r)$. To calculate how many loans are expected to be repaid, consider the four possible states of the world:

	State of the world	Probability	Loans repaid
Case 1	B_1 has a return less than r	$F(r)$	0/1
Case 2	B_1's output is in $[r, 2r)$ and B_2's output is less than r	$F(r)\big(F(2r) - F(r)\big)$	1/2
Case 3	B_1's output is greater than r and B_2's output is greater than r	$\big(1 - F(r)\big)^2$	2/2
Case 4	B_1's return is greater than $2r$ while B_2's return is less than r	$F(r)\big(1 - F(2r)\big)$	2/2

Nothing will be repaid if B_1 has a return less than r and the game terminates. Only one of the two loans will be repaid if B_1 has a return greater than r but less than $2r$ while B_2 has a return less than r. Both loans will be repaid in either of two cases: both have a return greater than r or B_1 has a return greater than $2r$. The overall expected repayment is therefore given by:

$$1 \times \underbrace{F(r)[F(2r) - F(r)]}_{\text{Case 2}} + 2 \times \underbrace{[1 - F(r)]^2}_{\text{Case 3}} + 2 \times \underbrace{F(r)[1 - F(2r)]}_{\text{Case 4}} \tag{2.3}$$

and hence the expected repayment rate under sequential group lending is given by

$$\Pi^*_{seq} = \frac{F(r)[F(2r) - F(r)] + 2F(r)[1 - F(2r)] + 2[1 - F(r)]^2}{2 - F(r)}$$

$$\Pi^*_{seq} = 1 - F(r) + \frac{F(r)\big(1 - F(2r)\big)}{2 - F(r)} \tag{2.4}$$

Another way to think about this repayment rate is that it is a weighted average of the repayment rate of B_1, which is simply $1 - F(r)$, and the repayment rate of B_2, which is higher due to the fact that B_1 may repay for B_2. Proposition 1 therefore follows immediately:

Proposition 1. *With perfect enforcement the repayment rate under sequential group lending is greater or equal to the repayment rate under individual lending*

Proof. follows directly from comparing equations (2.1) and (4). □

The intuition behind this result is that under sequential group lending the first borrower can be asked to help the second borrower repay, yet there is no negative contagion effect that one borrower can drag the other into default, as may occur with simultaneous group lending.

2.3.4 Comparative Statics: The Distribution of Project Returns

Assuming a specific functional form for the distribution of output allows for a more explicit comparison of the three lending mechanisms. With $F(x) = \frac{x}{\overline{x}}$ and $\overline{x} \geq r$ the repayment rates can be expressed as a function of the distribution of output ($\overline{x}$):

$$\pi^*_{sim}(r/\overline{x}) = \begin{cases} 1 - 3r^2/\overline{x^2} & \text{if } \overline{x} \geq 2r \\ 1 - 2r/\overline{x} + r^2/\overline{x^2} & \text{if } \overline{x} < 2r \end{cases}$$

$$\pi^*_{seq}(r/\overline{x}) = \begin{cases} 1 - r/\overline{x} + \frac{r/\overline{x}(1-2r/\overline{x})}{2-r/\overline{x}} & \text{if } \overline{x} \geq 2r \\ 1 - r/\overline{x} & \text{if } \overline{x} < 2r \end{cases}$$

$$\pi^*_{ind}(r/\overline{x}) = 1 - r/\overline{x}$$

These repayment rates can easily be plotted as a function of $r/\overline{x}$, as shown in Figure 1. Part (a) depicts the individual repayment rate versus the simultaneous group lending repayment rate, part (b) depicts individual versus sequential group lending repayment rates and part (c) combines all three lending mechanisms in one figure.

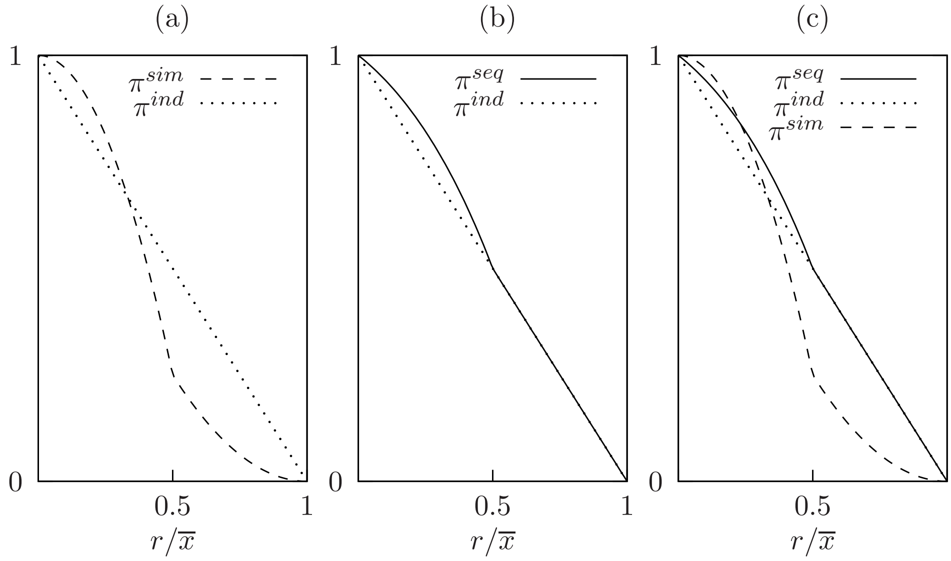
As $\overline{x}$ falls and hence the ratio $r/\overline{x}$ increases, it becomes less and less likely that borrowers will be able to repay. At $r/\overline{x} = 1$ it is impossible to repay even a single loan because the upper bound on project returns is equal to the required repayment.

Given the assumption of a uniform distribution, the midpoint, $r/2\overline{x}$, is the threshold point such that to the right of it, it will be impossible to repay two loans ($\overline{x} < 2r$).

To the left of the midpoint it becomes more and more likely that a borrower will be able to repay for two loans. Towards the origin, as $\overline{x}$ becomes arbitrarily large relative to r and default therefore becomes impossible, the repayment rate rises all the way to 1.

The ratio $r/\overline{x}$ therefore captures both how likely it is that a borrower can repay her own loan and how likely it is that a borrower can repay for two loans. We can hence analyse the repayment rates as a function of $r/\overline{x}$ so as to understand how different distributions affect the repayment rate.

Figure 2.1: The repayment rates as functions of $r/\overline{x}$ given x is uniformly distributed. The closer $r/\overline{x}$ is to 1 the more likely involuntary default becomes.



From Figure 1 we see that for different ranges of $r/\overline{x}$, different lending mechanisms are optimal. For very high values of $\overline{x}$ relative to r, simultaneous group lending achieves the highest repayment rate. For intermediate values, sequential group lending is optimal and for lower values of $\overline{x}$, both sequential group lending and individual lending are identical and achieve the highest repayment rate. Since sequential group lending always performs better or the same as individual lending, we can limit our analysis to comparing the two group lending mechanisms.

Proposition 2. *For x uniformly distributed on some $[\underline{x}, \overline{x}]$, there exist $\tilde{x}$ such that for all $\overline{x} \geq \tilde{x}$ simultaneous group lending achieves the highest repayment rate and for all values of $\overline{x} < \tilde{x}$ sequential group lending achieves the highest repayment rate*

Proof.

- For $\overline{x} < 2r$, $\pi^*_{seq} > \pi^*_{sim}$ since $1 - 2r/\overline{x} + r^2\overline{x^2} < 1 - r/\overline{x}$ for $\overline{x} < 2r$
- For $\overline{x} \geq 2r$, $\pi^*_{seq} < \pi^*_{sim}$ if $1 - 3r^2/\overline{x^2} > 1 - r/\overline{x} + \frac{r/\overline{x}(1-2x)}{2-r/\overline{x}}$ which has solution: $0 < r/\overline{x} < \frac{1}{6}(5 - \sqrt{13})$

Hence for all $\overline{x} \geq \frac{6r}{(5-\sqrt{13})}$, $\pi^*_{sim} \geq \pi^*_{seq}$ and for all $\overline{x} < \frac{6r}{(5-\sqrt{13})}$, $\pi^*_{seq} > \pi^*_{sim}$

□

The intuition behind this result is that as default becomes more likely, the contagion effect inherent in simultaneous group lending outweighs the benefit of being able to mutually assist each other and thus sequential group lending is preferable. However, whenever default is less likely, the mutual insurance aspect of simultaneous group lending outweighs the potential threat of contagion.

This section has demonstrated that allowing for involuntary default re-opens the original problem that making borrowers jointly liable for each other may cause borrowers to be dragged into default by their partners as well as inducing them to help each other. It has also offered a solution in the form of sequential group lending, since this will always improve the repayment rate relative to individual lending, regardless of the distribution of output. The sequential group lending mechanism has completely eliminated the situation in which one borrower's low output realization can cause her partner to be in default as well by temporally separating the repayment decisions.

2.4 Imperfect Enforcement

This section analyses how the three mechanisms compare in their ability to induce repayment when contract enforcement is weak. Under incomplete contract enforcement, the ability of the mechanism to harness social sanctions in order to complement the incomplete official penalty becomes crucial.

The framework used in this section builds on the seminal work by Besley and Coate (1995), who first studied how group lending can help mitigate the problem of weak contract enforcement. The subsections on simultaneous group lending briefly summarise the main result on simultaneous group lending from their paper, in order to compare simultaneous group lending to sequential group lending.

Under imperfect enforcement the borrower has a choice whether or not to repay after the project has been realized. If she chooses to repay she will be able to keep her project's return minus the repayment and if she chooses to default, she faces a penalty from the lender in the form of expropriation of part of her project's return.[3] Imperfect contract enforcement is modelled as the lender's ability to seize only a fraction $(1/\beta) < 1$ of the produced output. Alternatively, one can think of $1/\beta$ as the probability with which the bank manages to seize the output of a defaulting borrower, for example due to weak property rights. [4]

Joint liability is defined as follows: if both borrowers have a return greater than r and either defaults, both will be penalised by the lender and each loses a fraction $(1/\beta)$ of her output. If one borrower has a return greater than $2r$ while her partner has a return less than r then she will be penalised if she does not repay for both

[3] Throughout this paper the term *penalty* is used for the lender's imperfect contract enforcement ability. It is the punishment that the lender can inflict on the borrower for not repaying. The term *sanction* is reserved for social sanctions, which originate from other group members only.

[4] Assuming a linear functional form is a significant simplification of Besley and Coate's original 'penalty function' which is simply increasing in output. In reality this penalty function is likely a combination of many penalties, notably also the exclusion of future access to credit. As long as these additional penalties enter additively and as long as the overall penalty function remains increasing in output, the results of this paper directly go through.

loans. The partner who has a return less than r will not be penalised. Hence we again abstract from partial repayment and focus on the case where a borrower must have an output realization greater than $2r$ to be expected to help her partner.

2.4.1 Social Sanctions

Under joint liability one borrower's decision to voluntarily default may represent a negative externality on a group member who would like to repay the loan. She will either have to bail out her defaulting partner or she will be penalised by the bank for defaulting along with her partner. This negative externality creates the potential for the lender to leverage social sanctions as an additional penalty. In practice these social sanctions can take many forms, ranging from social isolation and reporting the bad behaviour to other members of the community to physical retribution.

We make three important assumptions about social sanctions:

1. Social sanctions are applied only if the decision to default actually represents a negative externality to the other group member. If a borrower's default does not affect her partner's payoff then there will be no social sanctions for it.

2. a group member who voluntarily defaults on a repayment will face social sanctions s from her peers, while a borrower who is known to have defaulted through no fault of her own will be spared from sanctions. That is:

$$s(x_i) = \begin{cases} s & \text{if } x_i \geq r \\ 0 & \text{if } x_i < r \end{cases}$$

(3) Social sanctions are strong enough to induce repayment in a borrower who has enough funds to repay ($s > r$).

It is important to note that the second assumption relies on the fact the group members can perfectly observe each other's project output and therefore know if a default was voluntary or involuntary. This is a common assumption in the literature as microfinance clients, in rural settings in particular, tend know a lot about each other. However, it does mean that the analysis here will be less applicable to urban settings or to settings in which groups are exogenously formed and where group members may have very little knowledge of each other.

Although in practice the degree to which group members sanction each other may depend on several factors, we focus on the case where group members either sanction their partner s or not at all. One could also imagine that social sanctions may be an increasing function in the amount of damage caused by a voluntary default. Alternatively, they could be an increasing function of how close the borrower was to being able to repay her loan. None of the results in this paper are substantially affected if social sanctions are modelled in these ways. All that is needed for the results to hold is that social sanctions inflict an additional cost to defaulting.

Further, one could also imagine that a group member can be sanctioned, although presumably to a lesser extent, for not bailing out a partner who cannot afford to repay her loan. In the current model this is assumed not to be the case because no damage is inflicted on anyone other than the lender. The defaulting partner would gain nothing by being bailed out, because she faces no penalty from defaulting and the game ends at the end of the period. This is of course a simplification; as in reality the game is likely to be repeated and this may be an interesting avenue for further research. [5]

2.4.2 Individual Lending

The borrower will repay her loan if the payoff from doing so is greater than the payoff from defaulting: $x - r > x - (1/\beta)x$ that is if $\beta r < x$. The expected repayment rate

[5] In case of a voluntary default on behalf of the second borrower, she would however benefit from being bailed out by her partner and would therefore also sanction her peer for not doing so. In equilibrium however this will never happen.

for individual lending is therefore

$$\pi_{ind} = 1 - F(\beta r) \tag{2.5}$$

Since $\beta > 1$ the repayment rate under weak enforcement is clearly lower than under perfect enforcement, as one would expect. For all output realizations in $[r, \beta r]$ the borrower defaults although she technically has enough funds to repay the loan. The remainder of the paper therefore distinguishes between *voluntary* default, which occurs when a borrower could repay but chooses not to, and *involuntary* default, which occurs when a borrower cannot repay because her output realization is less than r.

2.4.3 Simultaneous Group Lending

As in the previous section, both borrowers receive a loan and are jointly responsible for repaying it at the end of the period. Borrowers will choose to repay if and only if the payoff from repaying is greater than the payoff from defaulting, i.e. they will repay if $x > \beta r$ if they are not being sanctioned by their peer and they will repay for all $x > r$ if they are being sanctioned.

Decisions are made non-cooperatively and group members have no means of side contracting amongst themselves. There are five possible states of the world:

	State of the world	**Probability**	**Loans repaid**
Case 1	Both borrowers have a return less than βr and hence choose to default	$F(\beta r)^2$	0/2
Case 2	One borrower's output is greater than βr and the other borrower's output is in $[r, \beta r)$	$2\big(1 - F(\beta r)\big) \times \big(F(\beta r) - F(r)\big)$	2/2
Case 3	One borrower's output is in $[\beta r, 2\beta r)$ and the other borrower's output is less than r	$2\ F(r)\big(F(2\beta r) - F(\beta r)\big)$	0/2
Case 4	One borrower's output is greater than $2\beta r$ while the other borrower's output is less than r	$2F(r)\big(1 - F(2\beta r)\big)$	2/2
Case 5	Both borrowers have a output greater than βr	$\big(1 - F(\beta r)\big)^2$	2/2

In case 1 borrowers are in agreement that the loan should not be repaid and hence the group collectively decides to default. Cases 2 and 3 have the borrowers in disagreement on whether or not the loan should be repaid, with the difference that in case 2 social sanctions will induce the borrower with low output to repay, while in case 3 her output is too low and the group is forced to default. Case 4 describes the scenario in which one borrower can pay for her partner who is unable to repay and case 5 represents the case when the borrowers are in agreement to repay the loan. [6] Case 2 is the only case in which the existence of social sanctions improves the repayment rate; in all four other states of the world social sanctions do not encourage repayment.

[6]Note that in case 5, if neither borrower has a return greater than $2\beta r$, there are potentially two equilibria: both borrowers can coordinate on repaying but both borrowers can also coordinate on defaulting. Besley and Coate (1995) assume that borrowers manage to coordinate on the pareto superior equilibrium where both repay. While this is probably a reasonable assumption, it is worth noting that this potential coordination failure disappears under sequential group lending. This was first observed by Ray (1999) and is not unlike the contribution by Roy Chowdhury (2005), who makes a similar point about monitoring.

The repayment rate hence will be:

$$\Pi_{sim} = 1 - [F(\beta r)]^2 - 2F(r)[F(\beta 2r) - F(\beta r)] \tag{2.6}$$

The first term which is subtracted is simply the probability of state 1 occurring and the second term the probability of state 3, which are the only cases when the loan is not repaid. Again it is not clear that simultaneous group lending outperforms individual lending. Cases 2 and 4 increase the repayment rate relative to individual lending by either inducing a defaulting borrower to repay in order to avoid social sanctions or by inducing one borrower to repay her partner's loan as well as her own. Case 3 instead involves one borrower dragging her partner into default because she cannot or does not want to pay for two loans but she would have repaid for one.

The reader who is familiar with the original Besley and Coate (1995) article may be surprised to see this result. Besley and Coate (1995) find that whenever social sanctions are sufficiently strong, simultaneous group lending always achieves a repayment rate at least as high as individual lending (Proposition 3). However, this proposition was based on the assumption that all default is voluntary, that is, that project returns are all greater than r.

2.4.4 Sequential Group Lending

In the first period only B_1 receives a loan and in the second period B_2 will receive a loan conditional on B_1 having repaid. If B_2 does not repay there will be a third period in which B_1 has the option to bail out her partner.

There are three different cases depending on the first borrower's output realization:

$x_1 < r$

If the project return of the first borrower is less than r the game ends in the first period, no further loan is given to the group and there are no social sanctions. This happens with probability $F(r)$.

$x_1 \in [r, 2r)$

In this case the repayment game will be a two-stage game. In the first period B_1 decides whether to repay her loan and in the second period B_2 decides whether to repay her loan.

As a standard sequential move game, this is solved by backwards induction:

t=2 If B_2's output is greater than r the lender will penalise both borrowers should B_2 choose to default. B_2's payoff from defaulting therefore is $x_2 - s - (1/\beta)x_2$ and her payoff from repaying is $x_2 - r$. Hence B_2 will repay for all $x_2 > r$

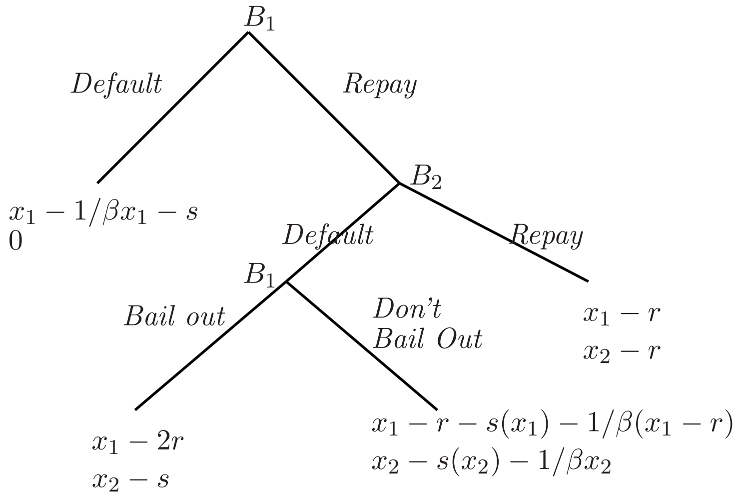
t=1 B_1's payoff from repaying is simply $x_1 - r$ regardless of B_2's output realization. If $x_2 > r$ the second borrower will repay her loan and if $x_2 < r$ B_1 will not be penalised by the lender for being unable to pay for two loans. The payoff from defaulting, however is $x_1 - s - (1/\beta)x_1$ and hence the first borrower will repay for all $x_1 > r$ as well.

$x_1 \geq 2r$

In this case the repayment game will be a three-period game with the added third period in which B_1 chooses whether or not to bail out her partner. The structure of this game is depicted in Figure (2). Again, this game will be solved by backwards induction:

t=3 The payoff for B_1 from bailing out B_2 is always $x_1 - 2r$. The payoff from not bailing out her partner will depend on B_2's output realization. As long as

Figure 2.2: The Sequential Repayment game for the case where $x_1 \geq 2r$ and $x_2 > r$. $s(x_i)$ is the social sanction function defined earlier.



$x_2 < r$ there will be no social sanctions if B_1 does not bail out B_2, since B_2 is not harmed by B_1's decision not to bail her out. However, the bank will confiscate a fraction $1/\beta$ of B_1's remaining output $(x_1 - r)$. Hence B_1 will bail out B_2 if and only if:

$$x_1 - 2r \geq (x_1 - r) - (1/\beta)(x_1 - r)$$
$$x_1 \geq (1 + \beta)r$$

If $x_2 \geq r$ and B_2 did not repay her loan, then B_1 not bailing out B_2 would lower B_2's utility and hence B_2 would sanction B_1. That is, the second borrower would effectively be able to blackmail the first borrower into bailing her out. However, B_2 blackmailing B_1 into bailing her out clearly also lowers B_1's payoff and hence is socially sanctioned as well. Hence, in equilibrium B_1 never has to bail out B_1 if $x_2 > r$.

t=2 B_2's payoff from repaying is $x_2 - r$ and from defaulting it is $x_2 - s - (1/\beta)x_2$.

Hence B_2 will repay for all $x_2 > r$.

t=1 B_1's payoff from defaulting is $x_1 - s - (1/\beta)x_1$. The payoff from repaying is calculated as follows: with probability $F(r)$, B_2 will default and hence B_1 will either have to bail her out or will be penalised by the lender for not doing so since her output is high enough to cover both loans. The expected payoff from repaying therefore is:

- $x_1 - r - F(r)r$ for $x_1 \geq (1+\beta)r$ in which case she will repay on behalf of her partner
- $x_1 - r - F(r)(1/\beta)(x_1 - r)$ for $x_1 \in [2r, (1+\beta)r)$ in which case she will be penalised by the lender for not repaying on behalf of her partner

Comparing the payoff in either of these cases to the payoff from defaulting, we find that B_1 will also repay in the first period for all $x_1 \geq r$. [7]

To calculate the expected repayment, the repayment decisions are summarized below:

	State of the world	**Probability**	**Loans repaid**
Case 1	B_1 has a return less than r	$F(r)$	0/1
Case 2	B_1 has a return in $[r, (1+\beta)r)$ and B_2 has a return less than r	$F(r)[F((1+\beta)r) - F(r)]$	1/2
Case 3	Both borrowers have a return greater than r	$[1 - F(r)]^2$	2/2
Case 4	B_1's return is greater than $(1+\beta)r$ while B_2's output is less than r	$F(r)[1 - F((1+\beta)r)]$	2/2

[7] For $x_1 \geq (1+\beta)r$ we have $x_1 - r - F(r)r \geq x_1 - s - (1/\beta)x_1$, which simplifies to $x_1 \geq \beta(r - s + rF(r))$ and which we know will always hold for $x_1 \geq (1+\beta)r$ and $s > r$. For the case $x_1 \in [2r, (1+\beta)r)$ the condition to ensure repayment is given by $x_1 - r - F(r)(x_1 - r) \geq x_1 - s - (1/\beta)x_1$ which simplifies to $x_1 \geq r - s + F(r)(x_1 - r)$ which also always holds for $s > r$.

The overall expected repayment is therefore given by:

$$1 \times \underbrace{F(r)[F((1+\beta)r) - F(r)]}_{\text{Case 2}} + 2 \times \underbrace{[1 - F(r)]^2}_{\text{Case 3}} + 2 \times \underbrace{F(r)[1 - F((1+\beta)r)]}_{\text{Case 4}}. \quad (2.7)$$

The expected number of units of capital lent out per group is still given by $2 - F(r)$ since the first borrower still repays the first loan whenever her output exceeds r. Hence the expected repayment rate is given by

$$\Pi_{seq} = \frac{F(r)[F((1+\beta))r) - F(r)] + 2F(r)[1 - F((1+\beta)r)] + 2[1 - F(r)]^2}{2 - F(r)}$$

$$\Pi_{seq} = 1 - F(r) + \frac{F(r)[1 - F\big((1+\beta)r\big)]}{2 - F(r)} \quad (2.8)$$

Proposition 3. *The expected repayment rate under sequential group lending, regardless of the level of contract enforcement, is always greater than or equal to the expected repayment rate under individual lending and perfect enforcement.*

Proof. Follows directly from comparing Equations (1) and (8). □

This result stems from the fact that under sequential group lending peer pressure will always induce repayment if possible and for some states of the world it will also induce the first borrower to repay on behalf of her partner. If the first borrower defaults, the second borrower never receives a loan and if the second borrower defaults then either the first borrower must repay on her behalf, or be penalised by the bank for not doing so. This negative externality on the first borrower triggers social sanctions also when the second borrower defaults voluntarily. Voluntary default hence always harms the other group member and hence always triggers social sanctions.

2.4.5 Comparative Statics: Contract Enforcement

This section compares the three lending mechanisms for varying levels of contract enforcement holding constant the distribution of output. As in the previous section on perfect contract enforcement, a uniform distribution of project returns is assumed, but once again the analysis could be repeated for other distribution functions. Using $F(x) = x/\overline{x}$ the repayment rates as a function of the inverse of the lender's penalty β and hence the weakness of contract enforcement can be expressed as:

$$\pi_{sim}(\beta) = \begin{cases} 1 - \beta^2 r^2/\overline{x^2} - 2\beta r^2/\overline{x^2} & \text{if } \beta \leq \overline{x}/2r \\ 1 - \beta^2 r^2/\overline{x^2} - 2r/\overline{x}[1 - \beta r/\overline{x}] & \text{if } \beta > \overline{x}/2r \end{cases}$$

$$\pi_{seq}(\beta) = \begin{cases} 1 - r/\overline{x} + \frac{r/\overline{x}(1-(1+\beta)r/\overline{x})}{2-r/\overline{x}} & \text{if } \beta \leq (\overline{x} - r)/r \\ 1 - r/\overline{x} & \text{if } \beta > (\overline{x} - r)/r \end{cases}$$

$$\pi_{ind}(\beta) = 1 - r/\overline{x}$$

The threshold $\beta = \overline{x}/2r$ for simultaneous group lending is the minimum amount of penalty required such that for all β greater than this no borrower will ever be willing to repay two loans. Similarly the threshold $\beta > (\overline{x}-r)/r$ for sequential group lending is the minimum amount of penalty such that the first borrower may bail out her partner *after having repaid her own loan in the first period.*

As has been demonstrated in the previous section, the relative performance of these repayment rates depends not only on β but also on $r/\overline{x}$. Proposition 2 demonstrated that for all $\overline{x} \geq \tilde{x}$ and $\beta = 1$ simultaneous group lending has a higher repayment rate and for all $\overline{x} < \tilde{x}$ the converse holds. We therefore distinguish between these two different cases here as well.

Figures 3 and 4 plot the repayment rate as a function of β for both cases:

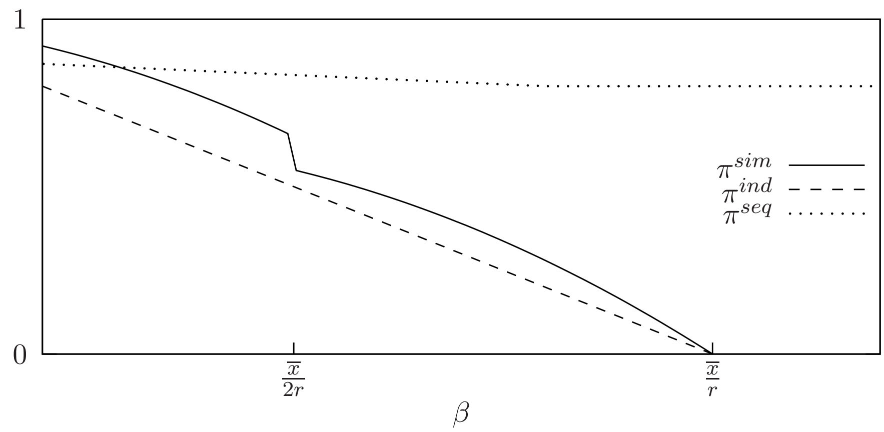


Figure 2.3: The repayment rates as a function of β plotted for $\overline{x} \geq \tilde{x}$. For very high values of β simultaneous group lending has the highest repayment rate, but for all $\beta \geq \tilde{\beta}$ sequential group lending has the highest repayment rate.

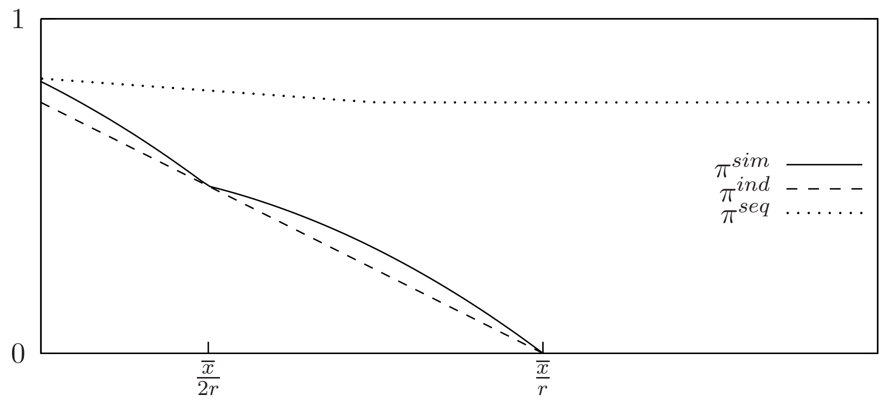


Figure 2.4: The repayment rates as a function of β plotted for $\overline{x} < \tilde{x}$. For all levels of β sequential group lending has the highest repayment rate.

In the first case, simultaneous group lending has a higher repayment rate for high levels of contract enforcement (low β) but quickly drops below sequential group lending as the level of contract enforcement declines. In the second case, sequential group lending always has the highest repayment rate, for all levels of contract enforcement.

Proposition 4. *If project returns are uniformly distributed on some* $[\underline{x}, \overline{x}]$*, there exists a* $\tilde{\beta} > 1$ *such that for all* $\beta \geq \tilde{\beta}$ *we have* $\pi_{seq} \geq \pi_{sim}$ *and* $\pi_{seq} \geq \pi_{ind}$*.*

Proof: A formal proof is left for the appendix, but the intuition follows directly from Figures 3 and 4.

The intuition is once again that sequential group lending is more efficient at leveraging social sanctions. Unlike simultaneous borrowers, sequential borrowers always threaten to sanction each other because there is always a negative consequence from a partner's voluntary default. With simultaneous group lending however, it can be the case that both borrowers are in agreement that the loan should not be repaid and hence they can jointly decide to default. Thus, a voluntary default always triggers social sanctions under sequential group lending but not under simultaneous group lending.

2.4.6 Minimum Amount of Enforcement Required

Sequential group lending is the most efficient at harnessing social sanctions and therefore will be most useful in circumstances where the enforcement ability of the lender is particularly weak. This subsection demonstrates that the minimum amount of contract enforcement required for the credit market to function is lower under sequential group lending than under any other lending mechanism.

For the lender to be able to operate, the following zero profit condition must be satisfied

$$\pi * r \geq \rho$$

where ρ is the opportunity cost of capital and r is the exogenously given interest rate. The lender is therefore able to operate only if he achieves a minimum repayment rate of $\pi_{min} = \rho/r$. The opportunity cost of credit, ρ, is assumed to be low enough that individual lending under perfect enforcement is feasible, that is $r(1 - r/\overline{x}) > \rho$.

Under individual lending the minimum amount of penalty needed is therefore given by:

$$\begin{aligned} r(1 - \beta r/\overline{x}) &= \rho \\ \Rightarrow \quad \beta_{ind}^{min} &= \frac{(r-\rho)\overline{x}}{r^2} \end{aligned} \tag{2.9}$$

Under simultaneous group lending the minimum amount of penalty required is given by:

$$\begin{aligned} \left(1 - \beta^2 r^2/\overline{x}^2 - 2\beta r^2/\overline{x}^2\right) r &= \rho \\ \Rightarrow \beta^2 + 2\beta - \frac{(r-\rho)\overline{x}^2}{r^3} &= 0 \end{aligned}$$

which is a quadratic in β and has solution given by:

$$\beta_{sim}^{min} = -1 \pm \sqrt{1 + \frac{(r-\rho)\overline{x}^2}{r^3}} \tag{2.10}$$

Proposition 5. *There exists an x' such that for all $\overline{x} \geq x'$ the minimum penalty required for simultaneous group lending is lower than for individual lending ($\beta_{sim}^{min} \geq \beta_{ind}^{min}$). The converse holds for all $\overline{x} < x'$.*

Proof. The proof follows directly from comparing the expressions for β_{sim}^{min} and β_{ind}^{min} and is worked out in the appendix. □

The intuition for this result is that for high values of $\overline{x}$ it is more likely that borrowers will be able to assist each other in the repayment of their loans; hence the repayment rate increases. This in turn implies that the required penalty to obtain a certain repayment rate is lower for high values of $\overline{x}$.

Similarly, for low values of $\overline{x}$ individual lending has a higher repayment rate than simultaneous group lending because one borrower dragging the other borrower into default is more likely. This in turn means the required penalty for simultaneous group lending has to be greater to compensate for the higher incidence of default.

For sequential group lending to be feasible the following requirement on β has to be met:

$$\big(1 - r/\overline{x} + \frac{F(r)[1 - F\big((1+\beta)r\big)]}{2 - F(r)}\big)r \geq \rho \tag{2.11}$$

which holds for all values of $\beta \geq 1$.

Proposition 6. *The minimum amount of official penalty required for sequential group lending to be feasible is less than the minimum amount of penalty required for either simultaneous or individual lending.*

Proof. Follows directly from the fact that both (2.9) and (2.10) are greater than 1 while (2.11) holds for all $\beta \geq 1$ □

Given the assumption that the opportunity cost of capital is low enough for individual lending under perfect enforcement to be feasible, sequential group lending can operate for extremely small levels of official penalty. The official penalty is in this case used only to trigger the much larger social sanctions which are available in every period. Of course, if the lender wants to achieve a repayment rate greater than the individual lending perfect enforcement repayment rate $(1 - F(r))$, then further penalty is required to induce borrowers to repay their partner's loan as well.

This section has demonstrated that sequential group lending is the only lending mechanism that remains feasible for very low levels of official contract enforcement.

Sequential group lending triggers social sanctions more frequently than simultaneous group lending and hence makes more efficient use of the available social capital.

2.5 Conclusion

This paper set out to compare and contrast three lending mechanisms commonly observed in microfinance: individual lending, simultaneous group lending and sequential group lending. The main findings are that the optimal choice of lending mechanism depends on the distribution of project returns and the amount of contract enforcement available to the lender. Ceterus paribus, simultaneous group lending performs best when the likelihood of default is low and the likelihood of being able to pay for two loans is high. However, it performs worse than the other two mechanisms when the probability of default is high.

The empirical prediction of this paper is that sequential group lending is most likely to raise the repayment rate in settings where the lender's enforcement ability is low. In fact, sequential group lending is feasible in environments in which the lender has so little enforcement ability that individual and simultaneous group lending would be unfeasible.

It is important to note that in the real world the lender's enforcement ability consists of several components, ranging from the confiscation of output to threats of legal action or withholding all future access to credit. For example, a monopolistic moneylender who can credibly threaten to cut off borrowers from future access to credit may still have a very strong contract enforcement ability even if he has no way of confiscating output. That is, in such a setting the penalty function of the lender may have the form $(1/\beta)x + V$ where V represents the present discounted value of future access to credit. Whenever this combined punishment ability of the lender is weak, sequential group lending is likely to raise the repayment rate.

The corporate finance literature recently has also turned to analysing the question of joint versus individual financing of projects. Banal-Estanol et al. (2011) and Leland (2007), for example, find, similarly to the results in this paper, that joint financing involves a trade-off between coinsurance and risk of contamination and they derive conditions under which individual financing is preferable to joint financing. To the best of the author's knowledge a sequential mechanism, as studied here, has not yet been considered by the corporate finance literature and may be of interest there as well.

One disadvantage of sequential group lending which is not directly analysed in this paper is the fact that one profitable project is not financed immediately, but instead is delayed to the next period. In microfinance this is a minor concern since NGOs and other microfinance institutions usually have insufficient outreach and the demand for credit tends to far outstrip the supply. However, in a setting where enough credit is available to fund all projects immediately, sequential group lending would introduce another inefficiency by forcing efficient projects to lie idle.

Another reason why the mechanism considered here is likely to be most appropriate for microfinance is that projects tend to have a very short time to maturity and the first instalment is almost always due just one week after the loan has been given out. Hence the time delay before starting the second project is only a matter of a few weeks instead of several months, as may be the case in other financial settings.

Chapter 3

Risk and Time Inconsistency: Evidence from a Field Experiment in West Bengal

Abstract

This study shows that multiple price lists, currently the standard way of eliciting time preferences, will give biased estimates when income is uncertain. This is first shown theoretically and the resulting hypotheses are then tested empirically. The experiment finds that income risk causes participants to make more patient choices when asked to choose between two payments in the future. When asked to choose between an immediate and a future payment, however, income risk has shown no significant effect. As a result, participants with uncertain income appear more present-biased and less future-biased. Finally, only estimates obtained under safe income show a significant correlation with real-world financial market outcomes.

Keywords: Hyberbolic Discounting, Field Experiment, Uncertainty
JEL Codes: C93, O12, C81, D81

3.1 Introduction

This chapter shows that the standard method of eliciting time preferences will yield biased estimates in the presence of income risk. This is first shown with a theoretical model based on which hypotheses are formed, which are then tested empirically. Since income risk is not allocated exogenously in the field, the hypotheses were tested experimentally with the help of a laboratory experiment in West Bengal, India.

Time inconsistencies, and present-bias in particular, have started to receive a lot of attention in development economics and have been linked to phenomena as diverse as under-saving and over-borrowing (Ashraf et al. (2006), Bauer et al. (2011)) and under-utilization of mosquito nets and fertilizers (Blackburn et al. (2009), Duflo et al. (2008)). The presence of these behavioural biases gives rise to a potential need for direct policy intervention such as the introduction of commitment savings accounts or time-limited subsidies for fertilizer. Eliciting time preferences correctly therefore has direct policy relevance.

However, the challenges of eliciting time preferences of poor subjects in developing countries are very different from those of eliciting the same preferences of undergraduates in a controlled laboratory environment. One of the main differences between eliciting time preferences in developed and developing countries is that the lives of the poor are full of risk and uncertainty. Choosing between an immediate payment and a later payment will depend on more than the discount factor; in particular it will also depend on the need for insurance, which is implicitly provided by offering a future payment.

This study formalizes this result with the help of two different theories of choice under uncertainty. The main theoretical result is that the estimates of time preferences, as found using a standard multiple price list, will be biased if the participant is exposed to income risk. Specifically, two different models of choice under uncertainty are compared: one of Expected Utility Theory (EUT) and one of reference point dependence. Both models predict that income risk can bias the elicitation of time preferences, but potentially in different directions which allows to directly test the models against each other.

The laboratory experiment indeed confirms that income risk affects the estimation of the discount factors and the results are broadly in line with the reference point model. When choosing between immediate payments and future payments, participants' choices do not significantly differ whether they are exposed to income risk or not. When choosing between future payments, however, participants make more patient choices if they are subject to income risk. This leads to different distribution of overall biases across treatments with more present-bias (impatient now, patient later) and less future-bias (patient now, impatient later) amongst participants exposed to income risk.

In the final section of this chapter, I correlate estimates of time inconsistency with real world financial market outcomes. While estimates of time inconsistency obtained in the risk free treatment group correlate significantly with outcome variables of interest, the estimates obtained under income risk do not. The fact that income risk has affected the estimates of time preferences would largely remain a theoretical exercise, of limited interest to practitioners and policy makers, if it did not also affect the correlations with outcomes researchers care about. The fact that only estimates obtained under safe income correlate significantly with financial outcome variables is indicative evidence of the fact that risk has introduced a significant amount of measurement error in the estimates of time inconsistency, thereby weakening the accuracy of the elicited measures. Researchers and practitioners wishing to elicit discount parameters and measures of time inconsistency in a risky environment may therefore benefit from offering insurance payments similar to the safe income treatment in this experiment.

The paper is organized as follows: Section 3.2 discusses the related literature, Section 3.3 describes the experiment, Section 3.4 provides an overview of the data obtained in the experiment, Section 3.5 provides a theoretical discussion of the effects of the treatments on the elicited discount factor and Section 3.6 gives the results of the experiment. Section 3.7 studies how correlations between elicited time preferences and financial outcome variables of interest are affected by income risk and Section 3.8 concludes.

3.2 Related Literature

This paper contributes to two separate literatures. The first is the literature on time inconsistencies in developing countries and its implications for policy. One of the first papers in this literature was Ashraf et al. (2006) who show that take up of commitment savings products is higher amongst present-biased individuals. In a recent contribution, Bauer et al. (2011) show that strongly hyperbolic women are likely to save less and borrow more than their time consistent counterparts. Duflo et al. (2008) and Duflo et al. (2009) link the underutilization of fertilizer by farmers in Kenya to hyperbolic discounting and Blackburn et al. (2009) find use of mosquito bed nets in Orissa (India) consistent with hyperbolic discounting. This paper contributes to this literature by providing evidence on the linkages between repayment data and discounting behaviour and by explicitly considering future-biased preferences as well as present-biased preferences.

The second literature this paper contributes to is the more technical, rapidly growing literature on the estimation of time preferences and time-inconsistencies in particular. In a seminal contribution Andersen et al. (2008) demonstrate that jointly eliciting and estimating risk and time preferences significantly reduces the estimated discount factor. Similarly Andreoni and Sprenger (2010) show that offering convex budget sets considerably changes the estimated time preferences due to the concave nature of the utility function. This paper builds on these observations by considering the effects of financial uncertainty and a concave utility function.

There have been several theories that have listed uncertainty as an explanation for observed time inconsistencies. Dasgupta and Maskin (2005) for example, show that hyperbolic discounting and time inconsistency can be explained by uncertainty about when payoffs are realized.

A more basic example of uncertainty resulting in time inconsistencies is that of 'researcher risk': money that is offered today is guaranteed, any money that is just promised in the future is less certain and may therefore be discounted more heavily. This bias, however, only goes in one direction, making people appear present-biased. It cannot explain the phenomenon of future-bias.

Very closely related to this study is also the experiment by Fernández-Villaverde and Mukherji (2002) who test for hyperbolic discounting allowing for the presence of random utility shocks. They design an experiment which asks undergraduate students to choose when to play a computer game for a certain amount of time and they allow for the fact that there is some uncertainty about how much utility the participants may derive at a given point in time from playing this computer game. Again the form of uncertainty studied here is of a very different nature and of a form that applies to monetary as well as non-monetary stakes.

Also related is Takeuch (2011) who finds evidence that people tend to be future-biased over short horizons and present-biased over longer horizons. This study is consistent with this hypothesis as the time horizon is extremely short and there is also a higher incidence of future-bias than present-bias. Varying degrees of uncertainty in the long and short run could potentially explain why subjects reverse their preferences for different horizons.

3.3 The Experimental Setting and Description of the Experiment

The experiment took place in a rural part of Hooghly, West Bengal, which is roughly 80 kilometres from Kolkata. The exact location is shown in Figure 3.1. The participants were female microfinance clients and SHG members from a local NGO called Mandra Unnayan Samsad. The majority of the participants were agricultural day labourers with no safe income. The average weekly income was Rs. 280 or roughly £3.50 and many participants were considered to be 'ultra poor' with hardly any financial income at all.

The average weekly standard deviation in income of the participants was equal to roughly Rs. 160. This number was derived by individually eliciting the belief of the future income distribution of every participant (see Delavande et al. (2011) for methodological details). The standard deviation of experimental income is higher with Rs. 400; however, it is of the same order of magnitude.

Participants who took part in the experiment had to attended three experimental sessions over the course of three weeks. In the first session, a group was welcomed and it was explained that each participant was to be allocated into one of three different treatment groups. This allocation was done publicly and at the individual level. Out of a large bag participants were asked to draw a folded piece of paper each, which allocated them into one of the three treatment groups. The participant kept this piece of paper throughout the three weeks to remind them which treatment they had been allocated to. These pieces of paper, shown in the appendix, both visually and numerically explained the various treatments.

Treatment 1 (Risk free treatment)**.** *Participants receive a risk free payment of Rs. 200 in each of the three session.*

Treatment 2 (With income risk in the future)**.** *Participants receive a risk free pay-*

Figure 3.1: The geographic location of the NGO

ment of Rs. 200 in the first session. In the remaining two sessions, the participant is exposed to experimentally generated income risk by playing a lottery that pays Rs. 800 with probability 0.25 and nothing with probability 0.75.

Treatment 3 (With income risk in all periods)**.** *Participants face experimentally generated income risk in all three sessions by playing a lottery that pays Rs. 800 with probability 0.25 and nothing with probability 0.75.*

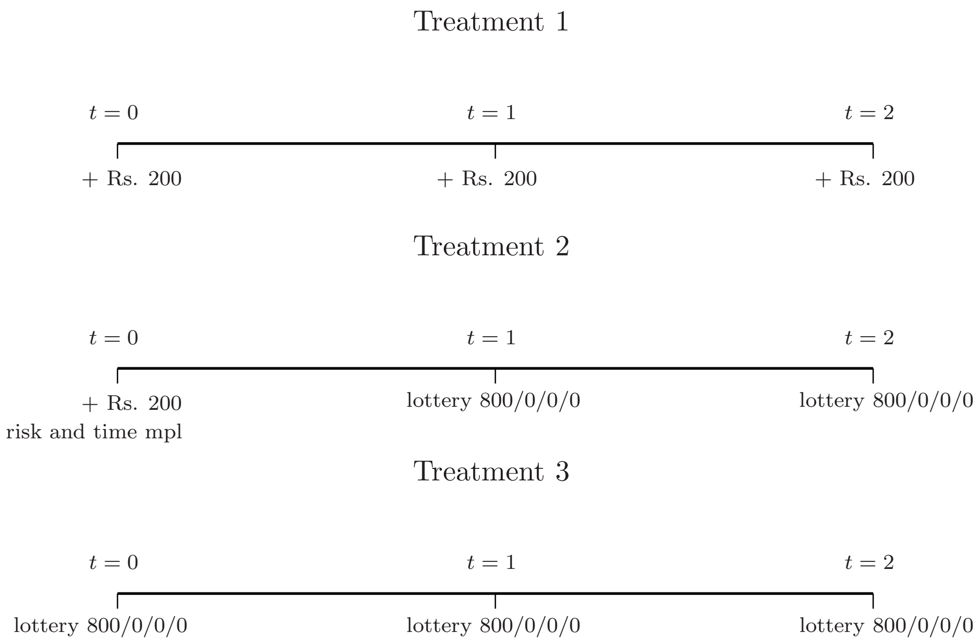
Treatment 1 was designed to most closely resemble a risk-free environment. Unfortunately, the experiment is unable to generate a completely risk free environment, since the experiment itself is embedded in the real world and participants' real-world income is subject to significant risk. Treatment 1 should therefore be seen only as a relative benchmark to which the risk treatments (Treatments 2 and 3) can be compared.

Treatment 2 was designed in order to understand whether experimentally induced future income risk can affect the estimates of discounting parameters. The lottery was implemented by putting three red balls and one green ball into a bag and asking the participant to draw one ball without looking. A green ball meant the participant won Rs. 800 and a red ball meant the participant won nothing.

Treatment 3 consisted of the same lottery in every single meeting, including the first meeting. The aim of this treatment was to test the hypothesis that the current income realization will affect the choices in the multiple price list.

All treatments are summarized in Figure 3.2.

Figure 3.2: The Three Treatments



Once the participants had been allocated to their treatment groups, they were asked to leave the room and come back in one by one. They were then individually helped by a field assistant to fill out survey forms and the multiple price lists, designed to elicit time preferences. [1]

Multiple price lists are among the most common methods of eliciting time preferences. A multiple price list offers the choice between a fixed amount of money in one period and varying amounts of money in a later period. Here the choice was between Rs. 200 at the earlier date and varying amounts of money at the later date. The value of the deferred payment monotonically decreases from Rs 250 all the way to Rs. 150, thus offering decreasing returns to delaying the payment. For each row the participant had to choose either the sooner or the later payment and was told that one of their choices would randomly be selected and paid out. This randomization was done using a bag of ping pong balls numbered for each row.

The point at which the subject switches from preferring the, usually larger, later payment to the smaller, sooner payment can then be used to derive bounds on the discount factor. In the limit as the intervals between choices become arbitrarily small, the switching point denotes complete indifference between the two options. In practice, the interval midpoint is often used to find a point estimate for the discount factor.

Each participant was asked to fill out two such multiple price lists as shown in Figure 3.3. The first one offered the choice between Rs. 200 immediately and varying amounts of money next week, and the second one offered the choice between Rs. 200 next week and varying amounts the week after next week.

A time consistent participant is one who switches at the same point in both multiple price lists. That is, one is time consistent when one is neither more patient in the future or in the presence, but has the same level of patience (and hence discount factor) in all periods. Participants who switched sooner in the first multiple price

[1] This had to be done individually as participants were mostly illiterate and when, during pilot sessions, they were asked to respond to questions in the presence of other group members, it was impossible to completely stop others from interfering, giving advice or simply distracting the participant.

list than in the second multiple price list are classified as present-biased and those who switched later in the first price list than in the second are classified as future-biased. Participants who switched multiple times (about 10%) were excluded from the analysis as they most likely had difficulty in understanding the instructions. The number of participants with multiple switches does not vary systematically across treatments.

Before answering any questions about time preferences though, all participants received the first payment which varied according to which treatment they had been allocated to earlier. Participants in either treatment 1 or 2 received Rs. 200 immediately and participants in treatment 3 first played the lottery and either received nothing or Rs. 800 before being asked any questions. Once this money was handed out, the participant was asked to fill in a multiple price list in order to elicit their discount factors.

Figure 3.3: Participants were asked to fill out two multiple price lists. One for the immediate and one for the future discount factor. The final column in each table denotes the interval of the discount parameter if the participant switches from preferring the delayed payment to the sooner payment in that row.

Multiple Price List 1				
	Today		In 1 Week	Naive $\beta * \delta$ interval
1.	Rs 200	vs.	Rs 250	$(0, 0.8)$
2.	Rs 200	vs.	Rs 220	$(0.8, 0.91)$
3.	Rs 200	vs.	Rs 210	$(0.91, 0.95)$
4.	Rs 200	vs.	Rs 200	$(0.95, 1)$
5.	Rs 200	vs.	Rs 190	$(1, 1.05)$
6.	Rs 200	vs.	Rs 180	$(1.05, 1.11)$
7.	Rs 200	vs.	Rs 150	$(1.11, 1.33)$

Multiple Price List 2				
	In 1 Week		In 2 Weeks	Naive δ interval
1.	Rs 200	vs.	Rs 250	$(0, 0.8)$
2.	Rs 200	vs.	Rs 220	$(0.8, 0.91)$
3.	Rs 200	vs.	Rs 210	$(0.91, 0.95)$
4.	Rs 200	vs.	Rs 200	$(0.95, 1)$
5 .	Rs 200	vs.	Rs 190	$(1, 1.05)$
6.	Rs 200	vs.	Rs 180	$(1.05, 1.11)$
7.	Rs 200	vs.	Rs 150	$(1.11, 1.33)$

After the discounting exercise, the individuals were asked to choose one of 6 lotteries in order to elicit their degree of risk-aversion. The elicited CRRA coefficients can then be used to control for the curvature of the utility function. The approach used for eliciting risk aversion followed closely the original Binswanger (1980) methodology of eliciting risk preferences in developing countries. The participant is offered a choice between lotteries which increase monotonically both in expected return but also in variance. Once a participant has chosen her preferred lottery, bounds on her CRRA coefficient can be determined the same way the time multiple price list is used to determine bounds on the discount factor.

Finally, participants were asked to answer a few simple IQ questions. The test used was a culture fair IQ test originally developed by Cattell (1949) and Cattell (1960). This particular test was written by Weiss (2006). A sample question is given in the appendix. This test was administered in light of prior evidence that cognitive ability correlates with economic preference parameters Dohmen et al. (2010).

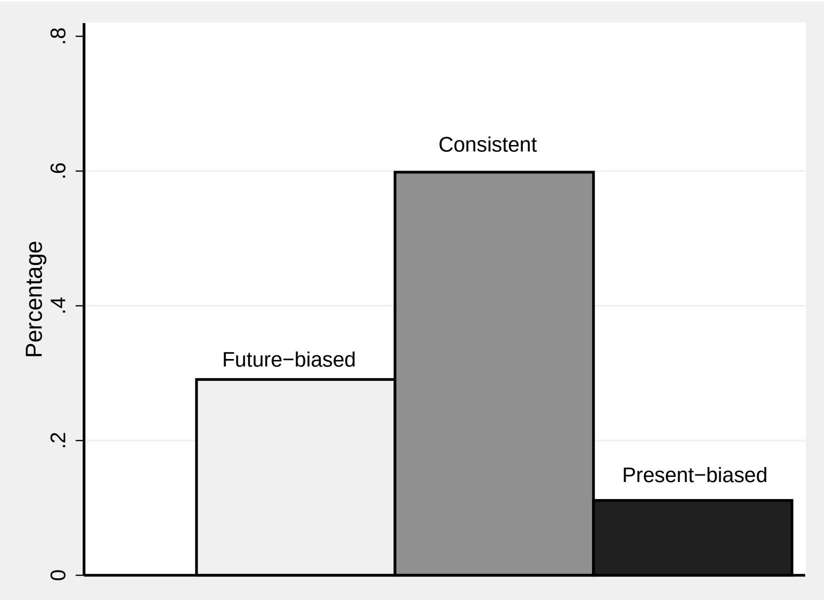
3.4 The Data

A total of 134 women took part in the experiment. 45 were allocated to treatment 1, 46 to treatment 2 and 43 to treatment 3. Since treatment 3 involves a lottery before the decisions in the discounting game are taken, there are effectively two sub treatments in treatment 3: treatment 3(a) for participants who won nothing before answering the discounting questions and treatment 3(b) for participants who won Rs. 800 before answering the discounting games.

Overall about 60% of the sample exhibited time consistent preferences, 30% were future-biased and the remaining 10% were present-biased. How this differs across treatments will be analysed in more detail in Section (3.6).

Surprisingly, about a third of respondents weakly preferred a smaller amount

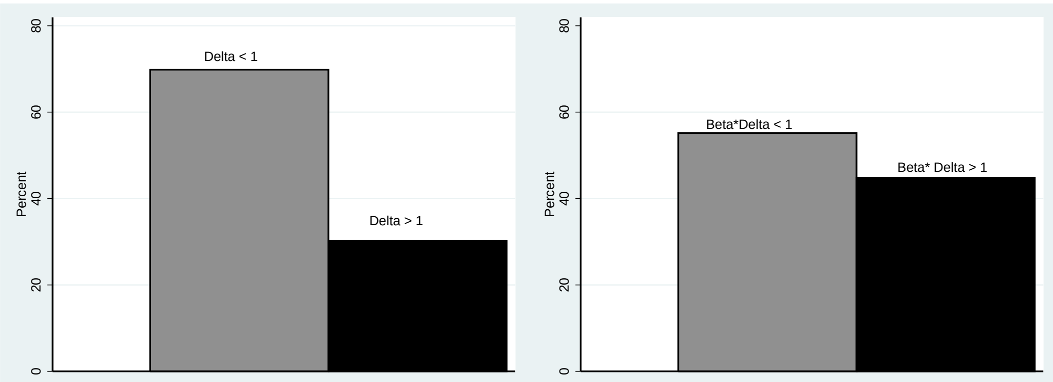
Figure 3.4: Distribution of the biases



further in the future to a sooner, larger amount. That is, they appear to have a discount factor greater than 1. This phenomenon is even stronger when comparing payments in the current period to payments in the future, where 45% of participants at least weakly prefer a smaller payment in the future to a larger immediate payment.

Figure 3.5: For a large fraction of the participants the discount factor exceeds 1

(a) Future Discount Factor (b) Immediate Discount Factor



To check that observable characteristics are balanced across treatments, I regress each treatment condition on a range of individual level characteristics and use an F-test to test the balance across treatments. The results are presented in Table 3.1 and for all treatment conditions the F-test fails to reject that all covariates enter with a zero coefficient at conventional levels.

In addition, most coefficients are individually not significantly different from zero with the exception of 'age'. However, the difference, although significantly different from zero, is extremely small. In addition, all results in this study are fully robust to the inclusion of all these individual level characteristics as is demonstrated in the appendix.

Table 3.1: Testing the balance across treatments

	(1) Treatment 1	(2) Treatment 2	(3) Treatment 3
Age	0.00	0.01*	-0.01**
	(0.00)	(0.00)	(0.00)
IQ	-0.04	0.03	0.00
	(0.03)	(0.03)	(0.03)
Education	0.01	-0.02	0.01
	(0.03)	(0.03)	(0.03)
literate	-0.02	0.17	-0.16
	(0.21)	(0.21)	(0.21)
CRRA	-0.00	0.02	-0.02
	(0.03)	(0.03)	(0.03)
Income	-0.00	0.00	-0.00
	(0.00)	(0.00)	(0.00)
Hindu	-0.28	0.22	0.06
	(0.18)	(0.18)	(0.18)
Observations	128	128	128
F-test	0.874	1.342	0.890
Prob > F	0.529	0.236	0.516

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.5 Theoretical Discussion

Before turning to the results of the experiment, this section analyses the theoretical predictions of income risk on the estimated discount factor.

Two separate models of choice under uncertainty are examined. First, the predictions under classical expected utility theory (EUT) are derived. Then, predictions under reference dependent utility are contrasted to these predictions. In recent years a whole host of reference dependent utility models has been developed, but the most natural choice given the set up of the experiment is the one of Kőszegi and Rabin (2007) who model the reference point as a stochastic belief of future expectations.

Once participants have been allocated into their respective treatment groups, they hold a piece of paper to remind them how much money to expect in the future and with what probability. For most participants a significant amount of time elapses between allocation to a treatment group and making the choices in the experiment, thereby allowing expectations enough time to form.

3.5.1 Classical Expected Utility Theory

Assume that expected utility theory holds and agents have instantaneous utility over consumption c given by $u(c;\theta)$ with $u_\theta > 0$, $u_{\theta\theta} < 0$ and $u_{\theta\theta\theta} > 0$, where θ measures concavity of the utility function. The condition on the third derivative corresponds to assuming the utility function satisfies *prudence* which implies precautionary savings. This assumption is implied by standard utility functions which satisfy DARA and/or CRRA such as the isoelastic utility function.[2]

Assume further that agents are (potentially) quasi-hyperbolic discounters who in addition to the classical exponential discount factor δ discount all future periods relative to the current period with an additional β. Hence the immediate discount

[2] It will be made explicit later on where this condition matters and what happens if it is not satisfied

factor between the current period and the future is given by $\beta\delta$ and the future discount factor between two periods in the future is given by δ.

Due to the randomization in the experiment, there is no reason to expect the discount factors of participants to differ systematically across treatments, since allocation to treatment groups is random.

On the contrary, the *estimated* discount factor may differ. As was outlined in section 3.3, researchers often deduce the discount factor based on the number of patient choices made in the multiple price list. This section is going to show that participants who make identical choices in the multiple price list, but are in different treatments, do not necessarily have the same discount factor. Estimated parameters will be denoted with a hat, such as $\widehat{\beta\delta}$ in order to differentiate them from the true $\beta\delta$ according to which participants make their choices in the multiple price lists. For the sake of simplicity, we assume here that discount parameters are estimated as outlined previously: a linear utility function is assumed and the estimates of the discount factors can then be directly calculated without a need of complex estimation techniques.

Finally, assume that agents cannot save between periods. While this assumption may seem extreme, it is not completely inaccurate for the typical rural Indian woman who took part in this experiment. In fact, 99% of participants (all but one) said they are not happy with the way in which they can save money and would like access to a better savings technology. 62% do not have a savings account and most of those who do have one, have to share it with their husband.[3]

[3] In addition, a model that allows for perfect saving, the payments in the experiment would be negligible compared to the life time income of the participants. As such, we should expect to see near perfect risk-neutrality and discount factors of 1 only (Heinemann (2008)). Since this is clearly not the case, some assumptions need to be relaxed.

The Immediate Discount Factor

The immediate discount factor is defined as the discount factor between the current period and the future. In classical economic theory this should be identical to the long run discount factor, but if agents are time-inconsistent the two may be different.

A participant in treatment 1, who accepts the immediate payment of Rs 200, will have utility of $u(\overline{y}+200)+\beta\delta_1 u(\overline{y})$, where $\overline{y}=200$ is her safe, per period income.[4] The utility from accepting the delayed payment of Rs. m, on the contrary, will be $u(\overline{y})+\beta\delta_1 u(\overline{y}+m)$.

Assuming that at the switching point the participant is roughly indifferent between these two options, we can implicitly derive the value of $\beta\delta_1$ for participants in treatment 1:[5]

$$u(\overline{y}+200)+\beta\delta_1 u(\overline{y}) = u(\overline{y})+\beta\delta_1 u(\overline{y}+m) \tag{3.1}$$

This expression can straightforwardly be rearranged to give an explicit value of $\beta\delta$:

$$\beta\delta_1 = \frac{u(\overline{y}+200)-u(\overline{y})}{u(\overline{y}+m)-u(\overline{y})} \tag{3.2}$$

Now consider a participant in treatment 2 who switches at the same point in the multiple price list and hence is also indifferent between Rs. 200 now and Rs. m in the future. Her immediate discount factor is implicitly defined by:

$$u(400)+\beta\delta_2 E(u(y)) = u(200)+\beta\delta_2 E(u(y+m)). \tag{3.3}$$

[4]Note, that the analysis here abstracts from background income and the associate risk in income. The reason for doing so is that it will be the same across treatments.

[5]To derive the theoretical predictions, I am going to treat the switching point in the multiple price list as denoting indifference between the two options. Of course in reality the intervals are relatively large so that these are only the lower bounds on the discount factor rather than point estimates. However, instead of referring everywhere to the 'lower bound on the discount factor', I am simply going to refer to 'the discount factor' for ease of comprehension.

Where $E(y) = \overline{y} = 200$ since y is equal to 800 with probability 0.25 and zero with probability 0.75. This can again be simply rearranged for $\beta\delta$:

$$\beta\delta_2 = \frac{u(400) - u(200)}{E_y\big(u(y+m) - u(y)\big)} \tag{3.4}$$

Comparing (3.2) and (3.4) directly shows that two participants making identical choices in the multiple price list do not have the same discount factor if they are in different treatments. In particular, it is the case that the participant in treatment 2 is not as patient as her counterpart in treatment 1 (has a lower $\beta\delta$), although they made the same choices in the price lists.

Proposition 7. *Given the same discount factor $\beta\delta$ a participant in Treatment 1 (without income risk) will switch for a lower m than a participant in Treatment 2 (with income risk).*

Proof. $u'(y+m) - u'(y) < 0$ by $u'' > 0$. $u''(y+m) - u''(y) > 0$ by $u''' > 0$. Hence $u(y+m) - u(y)$ is convex. Applying Jensen's inequality then directly gives $\beta\delta_1 > \beta\delta_2$. Hence for a given switching point m, participants in Treatment 1 are more patient than participants in Treatment 2, $\beta\delta_1 > \beta\delta_2$. □

A researcher who is not aware of the differential background risk, however, would naively conclude that anyone switching at the same point in the multiple price list has the same discount factor.

Assuming that $\beta\delta$ is identically distributed across treatment groups, we hence expect the distribution of switching points to differ across treatments and in particular, we expect the participants in treatment 2 to make more patient choices. Hence the following hypothesis follows.[6]

Hypothesis 1. *Participants in treatment 2, who are exposed to income risk, will make more patient decisions in the multiple price list than participants in treatment*

[6]Clearly, the opposite would hold for $u''' < 0$.

1, who are not exposed to income risk. The naively estimated immediate discount factor $\widehat{\beta\delta}$ *therefore overestimates the true immediate discount factor.*

Next, we turn to participants in Treatment 3 who either won Rs. 800 or nothing before answering the multiple price list. A participant from Treatment 3 who switches between receiving Rs. 200 immediately or Rs. m next week has a discount factor $\beta\delta$ implicitly defined by

$$u(y_1 + 200) + \beta\delta_3 E(u(y)) = u(y_1) + \beta\delta_2 E(u(y + m)). \tag{3.5}$$

where y_1 is either equal to 800 or 0 depending on the outcome of the lottery.

$$\beta\delta_3 = \frac{u(y_1 + 200) - u(y_1)}{E\big(u(y + m) - u(y)\big)} \tag{3.6}$$

Clearly the difference to Treatments 1 and 2 now depends on the realization of the lottery.

Hypothesis 2. *Participants who received a large payment ($y_1 = 800$) in treatment 3 make more patient choices in the multiple price list than participants in treatments 1 and 2 who receive a smaller payment ($y_1 = 200$). The naively estimated immediate discount factor* $\widehat{\beta\delta_3}$ *therefore overestimates the true discount factor* $\beta\delta_3$

Proof. As for Hypothesis 1, we first establish that for a given $\beta\delta$ the optimal switching point in treatment 2 is higher than in treatment 3 by directly comparing 3.6 to 3.4. The above hypothesis follows again by assuming that the underlying distribution of true $\beta\delta$ is the same across treatment groups. □

This is a very intuitive result, stating that those participants who had a very high current income realisation will appear more patient in the short run than their counterparts who have received nothing at all or much less. Again, a researcher who does not know about the current income realization would deduce a wrong discount factor based on the choices in the multiple price list.

Hypothesis 3. *Participants who receive no payment ($y_1 = 0$) in treatment 3 will make fewer patient choices in the multiple price list than participants in treatments 2 and 3(b) who receive a payment ($y_1 = 200$ and $y_1 = 800$ respectively). The naively estimated immediate discount factor $\widehat{\beta\delta_3}$ therefore underestimates the true immediate discount factor $\beta\delta_3$*

Proof. As above and comparing equations 3.2 to 3.6 and 3.4 to 3.6. □

Again this is a very intuitive result stating that those participants who received nothing in the current period will appear more impatient than those who received something (either Rs. 200 or Rs. 800) in an otherwise identical environment.

The Future Discount Factor

The future discount factor, in contrast, is determined by the trade-off the participant makes between receiving payments in one week or in two weeks. The future discount factor is determined in exactly the same way as the immediate discount factor, by equating utility from the sooner and later options and solving for δ:

$$u(\overline{y}+200) + \delta_1 u(\overline{y}) = u(\overline{y}) + \delta_1 u(\overline{y}+m) \tag{3.7}$$

$$\Rightarrow \quad \delta_1 = \frac{u(\overline{y}+200) - u(\overline{y})}{u(\overline{y}+m) - u(\overline{y})}. \tag{3.8}$$

For participants in treatment 2, on the contrary, we have the following condition:

$$E_y u(y+200) + \delta_2 E_y u(y) = E_y u(y) + \delta_2 E_y u(y+m) \tag{3.9}$$

$$\Rightarrow \quad \delta_2 = \frac{E_y u(y+200) - E_y u(y)}{E_y u(y+m) - E_y u(y)}. \tag{3.10}$$

Applying Jensen's inequality twice, it is clear that the numerator as well as the denominator of δ_2 are greater than the numerator and denominator of δ_1. Due to $u''' > 0$ and hence $u(y+m) - u(y)$ being convex, the increase in the denominator is larger (smaller) than the increase in the numerator when $m > 200 \quad (m < 200)$. While it is analytically non-trivial to show this, the increase in the increase in the larger of the two, numerator and denominator, is always larger than the increase in the smaller of the two as is shown in Figure 3.7 and 3.6.[7]

Figure 3.6: Future discount factors in treatments 1 and 2 as a function of the switching point, assuming CRRA utility function with $\gamma = 0.5$ and risk as in experiment.

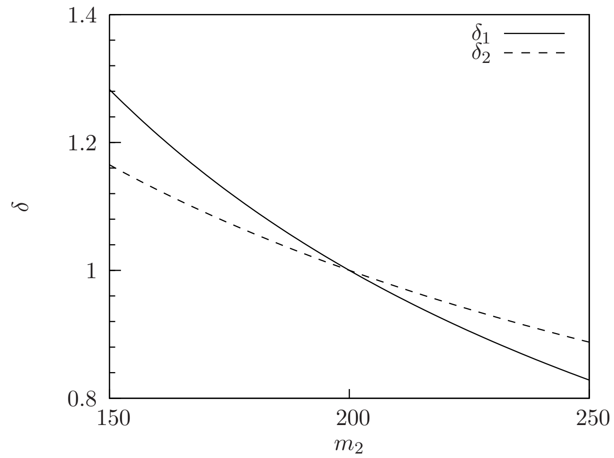


Figure 3.7: The discount factors for varying values of γ holding fixed $m_2 = 210$

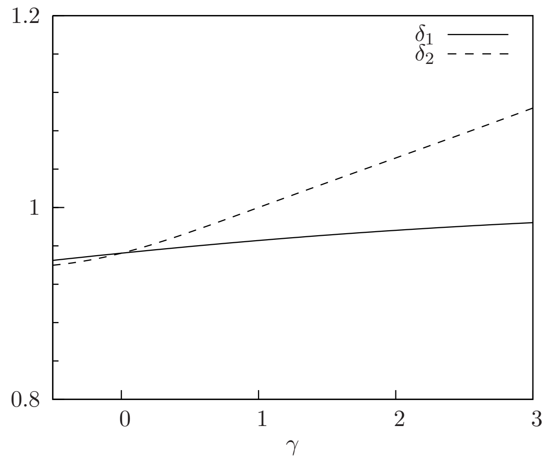


Figure 3.6 plots, for a given CRRA coefficient of $\gamma = 0.5$, the relationship between discount factor and switching point. For example, participants with $\delta = 1.2$ would prefer Rs. 200 next week to Rs. 150 in two weeks if they were allocated to treatment 1. On the contrary, if they were allocated to treatment 2 they would prefer Rs. 150 in two weeks time to Rs. 200 in one week. Hence a participant in treatment 1 is more patient than a participant in treatment 2 with the same switching point.

[7]This holds for all DARA utility functions (which is implied by our assumption of $u''' > 0$). The result is reversed for IARA utility functions. For CARA utility functions the two functions coincide.

For $m > 200$ the opposite holds however: a participant who switches at $m > 200$ is more patient if he is in treatment 2 than if he were in treatment 1. Participants who have a discount factor such that it falls between the two thresholds for δ_1 and δ_2 would therefore choose different switching points in different treatments. If they were allocated to treatment 1, they would prefer the later option and if they were allocated to treatment 2 they would prefer the sooner option.

Figure 3.7 shows that this is not only the case for the special case of $\gamma = 0.5$, but that this holds for the entire parameter space of a CRRA utility function. Figure 3.7 plots the discount factors given a fixed switching point $m > 200$ but for varying degrees of γ. The difference in discount factor, given the same switching point, is therefore clearly increasing in the degree of risk aversion of the participant. [8]

Treatment 2 and treatment 3 only differ in the first period, so under the assumption of no savings between periods the predictions for treatments 3 and 2 should be identical. It is discussed below how these predictions would differ if we were to relax the assumption of no savings.

Hypothesis 4. *The naively estimated future discount factor $\hat{\delta}$ is higher (lower) in Treatment 2 and 3 than that in Treatment 1 for $m > 200$ $(m < 200)$. In other words, income risk introduces a bias away from 1.*

Proof. see Figure 3.6 □

Participants in treatment 3 either received a very large payment or nothing at all in the first period while participants in treatment 2 all received a payment of medium size. If either money can be saved directly or if there is some means of transferring utility over time, we would expect this to have an effect in the decision in the multiple price lists.

[8] The mean CRRA coefficient in my sample 1.7 and the median is 0.9.

Participants who have received the large positive income shock for example, would be more likely to appear patient as their immediate budget constraint has been relaxed. Similarly participants who receive nothing at all could appear less patient than their counterparts in treatment 2 who received some income at least.

This section derived the predictions of EUT for what effects we should expect the experimental treatments to have. It has demonstrated that without resorting to behavioural assumptions it is possible to generate different discount factors for the present and the future. Lack of access to a savings technology combined with income risk are sufficient to create this effect. This is not to say that there is no underlying behavioural bias present, but in addition to any existing temptation the participant may have, lack of savings in an uncertain environment can theoretically give rise to time inconsistent choices in the lab.

3.5.2 Reference Point Dependent Utility

The previous section outlined a model of EUT and derived the effects of uncertainty on the estimated discount factor. In contrast, this section analyses what predictions can be made if agents are not EU maximizers, but instead are loss averse relative to their expectations. The model of expectations as reference points used here directly follows Kőszegi and Rabin (2007)

Instead of evaluating the outcome relative to a fixed reference point, Kőszegi and Rabin (2007) allow the reference point itself to be stochastic. For example, consider someone who does not expect to take part in a gamble in which he gains \$1 if a coin comes up heads and in which he loses \$1 if it comes up tails. He will, with equal probability, have \$1 more than expected and 1 less than expected. That is, he experiences a gain with probability 0.5 and a loss with probability 0.5. In this case the model coincides with the standard model in which the reference point represents the status quo.

However now suppose the agent already expected to take part in this gamble. His reference point in that case is that he wins one dollar with probability 0.5 and that he loses one dollar with probability 0.5. His expected utility of taking part in the gamble is hence evaluated as follows: With probability 0.5 he will neither gain or lose anything because he had the right expectation. With probability 0.25 on the other hand he will have expected to win \$ 1 and he loses \$ 1, which is an overall loss of 2 dollars. Similarly with probability 0.25 he expected to lose, yet he won and thus he has a relative gain of 2 dollars. An expected gamble therefore evokes two separate feelings: one of loss when a win was expected and one of a gain when a loss was expected.

Formally, let utility from wealth w be $u(w|r) = m(w) + \mu(m(w) - m(r))$ where r is the reference point and μ is the gain loss utility relative to the reference point. $m(w)$ is the classical outcome utility and for the purposes of this paper we also follow Kőszegi and Rabin (2007) in assuming that $m()$ is linear. The model requires several standard assumptions on the gain-loss utility $\mu()$:

Assumption 1.

1. *μ is continuous for all x and twice differentiable.*
2. *μ is strictly increasing.*
3. *If $y > x \geq 0$ then $\mu(y) + \mu(-y) < \mu(x) + \mu(-x)$.*
4. *$\mu'' < 0$ for $x > 0$ and $\mu'' \geq 0$ for $x < 0$.*
5. *If $x > 0$ $\lim_{x\to 0}(\mu'_{+x}/\mu'_{-x}) \equiv \lambda > 1$*

These assumptions are mainly due to the original Kahneman and Tversky (1979) article and were first formalized by Bowman et al. (1999). For the limited purposes of this paper we are going to use a specific functional form for μ given by

$$\mu(x|r) = \begin{cases} (x-r)^{\alpha} & \text{if } (x-r) \geq 0 \\ -\lambda(r-x)^{\alpha} & \text{if } (x-r) < 0 \end{cases}$$

with $\lambda > 1$.

The expected utility from a gamble is then derived as follows: if a random variable x is drawn from a distribution F and the reference lottery is a probability measure G, the expected utility of x, given the reference lottery, is given by:

$$u(F|G) = \int \int u(w|r)dG(r)dF(w). \tag{3.11}$$

This captures the notion that every outcome is evaluated relative to all possible outcomes in the reference lottery. The expected utility is simply the weighted utility of all possible states.

For the three treatments we have three different reference lotteries:

1. Treatment 1: the expectation is to receive Rs. 200 in each meeting.

2. Treatment 2: the expectation is to receive Rs. 200 in the first meeting and to play the lottery $(800, 0.25; 0, 0.75)$ in the following two meetings.

3. Treatment 3: the expectation is to play the lottery $(800, 0.25; 0, 0.75)$ in all three meetings.

The multiple price list, which offers payments either right away, in one weeks time or in two weeks time, is then presented to the participant. Any money she earns through the price list is unexpected and therefore not part of her reference lottery. The participant's choice is then to decide when she would like to receive this 'extra' income.

The Immediate Discount Factor

In the first multiple price list the participant chooses between either surprising herself with Rs. 200 today or with a future Rs. m next week. For those in treatment 1, utility from accepting the Rs. 200 right away is given by $u(400|r = 200) + \beta\delta_1 u(200|r = 200)$ and utility from accepting Rs. m next period is given by $u(200|r = 200) + \beta\delta_1 u(200 + m|r = 200)$. Again assuming that at the switching point the participant is roughly indifferent between the two options we can find a value for $\beta\delta_1$:

$$\beta\delta_1 = \frac{u(400|r = 200) - u(200|r = 200)}{u(200 + m|r = 200) - u(200|r = 200)} \tag{3.12}$$

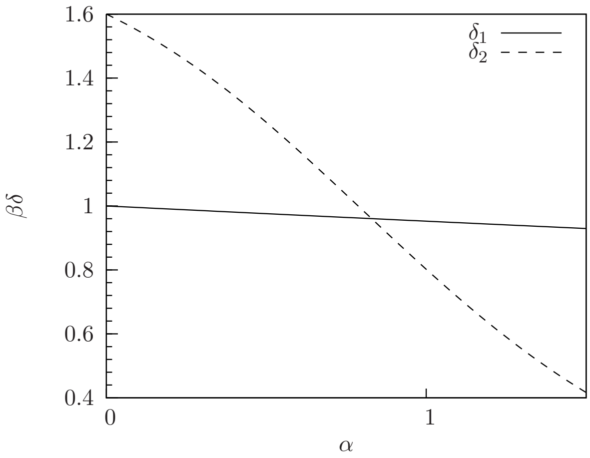
In treatment 2, if the participant chooses the current payment of Rs. 200, she will face next week's lottery without any additional income. In this case she will receive overall Rs. 400 this week, Rs. 200 more than expected given the treatment allocation, and the expected utility of the lottery on its own next week:

$$u(400|r = 200) + \beta\delta_2 Eu(lottery|r = lottery) \tag{3.13}$$

Her expected utility from the lottery on it's own, $Eu(lottery|r = lottery)$, is given by $200 + 3/16\mu(800) + 3/16\mu(-800)$. That is, the expected utility consists of the expected value of the lottery plus utility and disutility due to being positively or negatively surprised by the lottery outcome. Since $\lambda > 1$ the loss of not receiving Rs. 800 weighs more than the gain of receiving Rs. 800 and hence the agent would prefer the Rs. 200 certainty equivalent of the lottery.

If instead the participant chooses to receive Rs. m next period she will receive Rs. 200 this week as expected, but next week she will receive an unexpected Rs. m as well as face the lottery.

Figure 3.8: The immediate discount factors as a function of the concavity/convexity of the loss and gains function for $m = 210$ and $\lambda = 2$



$$u(200|r = 200) + \beta\delta_2 Eu(m + lottery|r = lottery) \tag{3.14}$$

Assuming once again that the participant is indifferent at the switching point, we can solve for $\beta\delta_2$:

$$\beta\delta_2 = \frac{u(400|r = 200) - u(200|r = 200)}{Eu(m + lottery|r = lottery) - Eu(lottery|r = lottery)} \tag{3.15}$$

These two values of $\beta\delta_1$ and $\beta\delta_2$ are plotted in Figures 3.8, 3.9 and 3.10. In Figure 3.8 it can be clearly seen that for sufficiently high levels of concavity of the gains function and respective convexity of the loss function, that is for α sufficiently smaller than 1, we have $\beta\delta_2 > \beta\delta_1$ with the opposite being the case if agents are risk loving in gains and risk averse in losses ($\alpha > 1$).

The intuition behind this result is relatively straight forward: because the utility function is concave in gains, the relative increase in utility from receiving Rs. 800 to receiving Rs $800 + m$ is less than the increase from 0 to m. Similarly, convexity

Figure 3.9: The immediate discount factors as a function of the degree of loss aversion λ for $\alpha = 0.75$ and $m = 210$

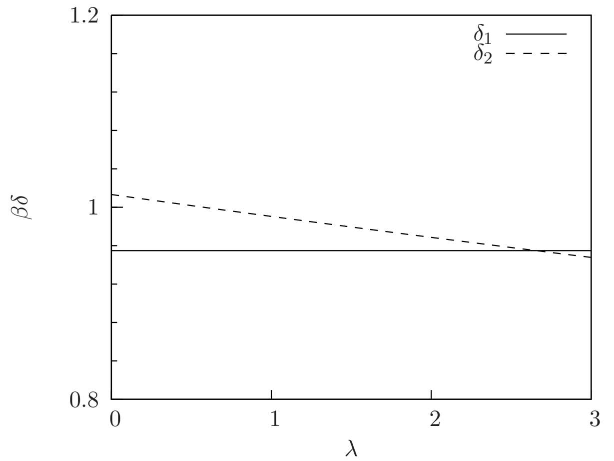
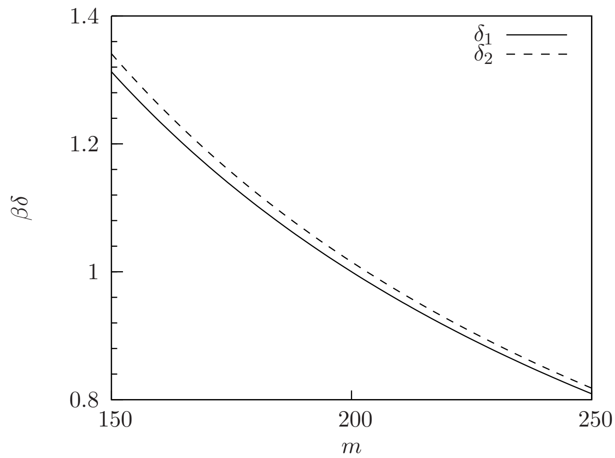


Figure 3.10: The immediate discount factors as a function of the switching point m for $\alpha = 0.75$ and $\lambda = 2$



in losses implies that the gain from reducing a loss of 800 to a loss of Rs. $800 - m$ is not as great as the benefit of receiving Rs. m instead of zero. This implies that a participant in treatment 2 has to be more patient than a participant in treatment 1 in order to have the same switching point.

However, there is also a counterbalancing effect at play as can be seen in Figure 3.9. Since $\lambda > 1$, losses weigh more heavily than gains. Hence for sufficiently large values of λ, the gain from reducing losses outweighs the loss of utility due to concavity/convexity of the utility function. For the special case of a piece-wise linear utility function with a kink at the reference point for example, this second effect outweighs the prior and $\beta\delta_2 < \beta\delta_1$.

Hence to conclude, this model of loss aversion cannot predict in which direction uncertainty will affect the estimation of the immediate discount factor. Calibration with 'standard' parameter values suggests that we should observe lower naive discount factors in the risk treatment as seen in Figure 3.10. However, the amount of estimates available for these parameters in similar settings is very limited and it is therefore difficult to judge what reasonable estimates for these parameters should be.

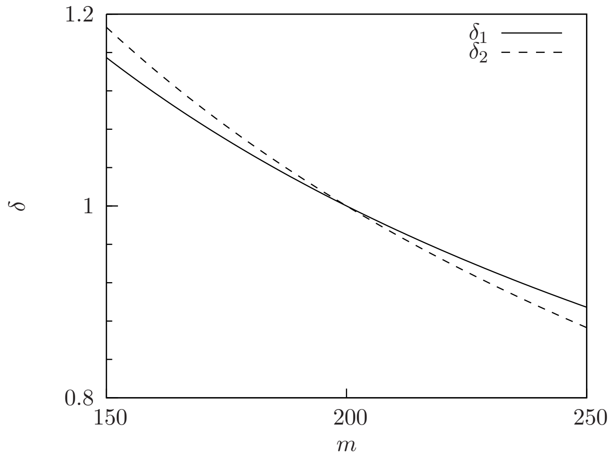
The Future Discount Factor

To derive estimates of the future discount factor, the participant has to choose between two periods in both of which he either faces no income risk (treatment 1) or in both of which he faces the same amount of income risk (treatment 2 and 3).

In treatment 1, the estimates are therefore straightforwardly the same as for the immediate discount factors.

$$\delta_1 = \frac{u(400|r = 200) - u(200|r = 200)}{u(200 + m|r = 200) - u(200|r = 200)} \tag{3.16}$$

Figure 3.11: The future discount factor with $\alpha = 0.5, \lambda = 2$ as a function of the switching point



For participants in treatments 2 and 3 however, the estimates are now given by:

$$\beta\delta_2 = \frac{Eu(200 + lottery|r = lottery) - Eu(lottery|r = lottery)}{Eu(m + lottery|r = lottery) - Eu(lottery|r = lottery)}. \qquad (3.17)$$

In both periods the agent faces a lottery and therefore can only choose in which period she would like to have a safe payment in addition to the lottery. The two discount factors are plotted in Figures 3.11, 3.12 and 3.13. Since the participant now faces the same potential loss in each period, there is no longer a benefit to delaying consumption in order to offset potential losses. Hence, the two discount factors can now be unambiguously signed. For $m > 200$ we have $\delta_2 < \delta_1$ and vice versa for $m < 200$ as is depicted in 3.11.

Hypothesis 5. *The naively estimated future discount factor $\hat{\delta}$ in treatment 2 and 3 is higher (lower) than that in treatment 1 for $m > 200$ $(m < 200)$.*

As can be seen by comparing Figure 3.11 and Figure 3.6, uncertainty has exactly the opposite effect in the reference point model and in the EUT model. The fact that both theories give directly opposite predictions allows us to test easily which

Figure 3.12: The future discount factor with $\gamma = 0.75, m = 210$ as a function of the degree of loss aversion

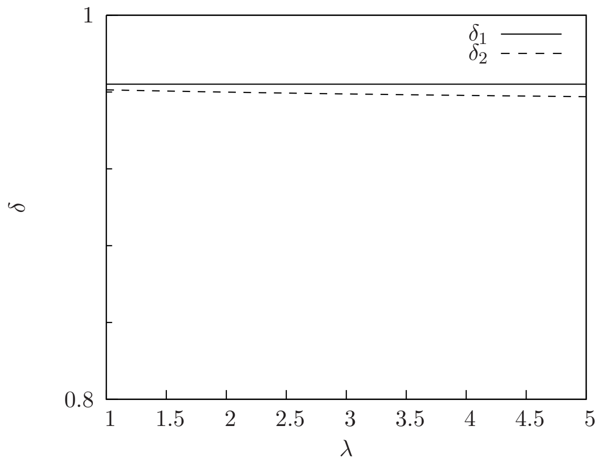
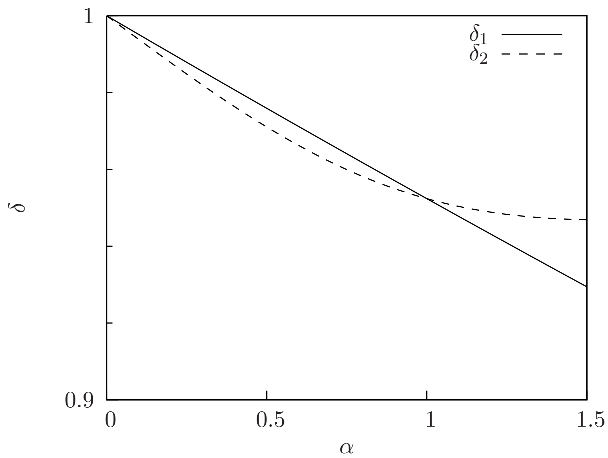


Figure 3.13: The future discount factor with $m = 210, \lambda = 2$ as a function of the convexity/concavity



theory finds more support in the data.

Figure 3.12 shows that this results holds for all values of λ, holding fixed m. Not receiving anything is costly because it represents a loss relative to the expectation of winning the lottery. Agents prefer to minimize this loss by receiving additional, safe income. The participant in the risky treatment therefore has an additional reason to prefer the higher payment relative to the participant in the safe treatment. Hence, a participant in the risky treatment who switches at the same point as someone in the safe treatment is, in fact, less patient.

3.6 Results

This section will present results on how the decisions in the multiple price lists were affected by the various treatments and hence by income risk. For each multiple price list the relevant information is how many patient choices a participant makes before switching to the earlier payment. Under the null hypothesis that income risk has no effect on decision making in the price lists, the choices should not differ systematically across treatments.

To understand if these switching points systematically vary across treatments, I test the hypothesis that the switching points in all three treatments, and therefore the parameters a researcher would estimate using these switching points, come from the same distribution. This is first done using the Kruskal Wallis equality of rank test and then the treatments are compared pairwise using the Whitney-Mann-Wilcoxon rank sum test.

These non-parametric hypothesis tests are preferred to a standard t-test in this setting for two reasons: Firstly the intervals in the multiple price list are somewhat arbitrary. Point estimates of discount factors are therefore necessarily very sensitive to the exact interval chosen and hence any comparison of these point estimates is equally dependent on the chosen intervals. Instead, the nature of the data should be interpreted as ordinal and the question of interest is whether or not uncertainty can cause participants to make more or fewer patient choices. For this a rank sum test is the most natural choice.

The second reason for choosing the rank sum test is that it does not rely on the assumption of a normal distribution. In light of both the nature of the data and the small sample size, this is another reason to prefer the non-parametric tests.

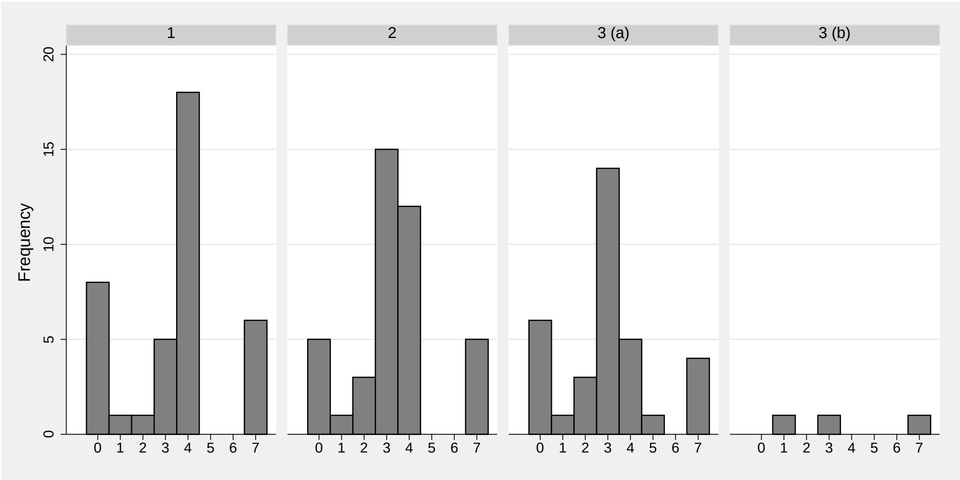
3.6.1 The Effects of Uncertainty on the Immediate Discount Factor $\beta\delta$

In order to understand how the treatments have affected participants' choices in the first multiple price list, I compare the distribution of choices across all treatments.

These distributions are graphically represented in Figure 3.14 for each treatment group. To put this in perspective, a participant with 3 patient choices has an estimated discount factor just under 1 ($\widehat{\beta\delta} \in [0.95, 1]$) and a participant making 4 patient choices has a estimated discount factor just above 1 ($\widehat{\beta\delta} \in [1, 1.05]$). Hence, it is not surprising to see that over an interval of one week most participants make 3 or 4 patient choices in all three treatments. There are also clearly a few differences in the distributions such as fewer participants switching after 3 patient choices in treatments 2 and 3 relative to 1. However, to test if these are significant differences the Kruskal-Wallis rank sum test is used.

After correcting for ties (since more than one participant has a switching point of 3, for example) the Kruskal-Wallis test fails to reject the null hypothesis of equal distribution with $\chi^2 = 2.42$ and $p = 0.49$. Similarly Whitney-Mann-Wilcoxon pairwise tests cannot reject that when any two treatments are compared pairwise that they come from the same distribution. Mean switching points (reported in the appendix) do not differ significantly across treatments either.

Figure 3.14: The distribution of switching points in the first multiple price list, eliciting immediate discount factors, reported individually by treatment.



Taken together, this suggests that uncertainty had no noticeable effect on the choices made in the price list. While this contradicts the simple EUT model derived in the theory section, it does not reject nor confirm the reference point theory.

It is also worth noting that this finding is also in line with a model in which the experimental payments (and therefore also experiment risks) are absorbed by the background income of the participant. However, such a model would also predict that participants should behave as being approximately risk neutral and extremely patient as any gain from the experiment is negligible relative to life-time income (Heinemann (2008)), neither of which is observed here.

3.6.2 The Effects of Uncertainty on the Future Discount Factor δ

To understand how choices between payments in the future are affected by risk, this subsection compares the choices in the second multiple price list by treatment.

The distribution of choices are once again represented graphically in Figure 3.15. It is interesting to note that the distributions in this figure look remarkably different from the those of the immediate discount factor. For treatment 1 in particular, the

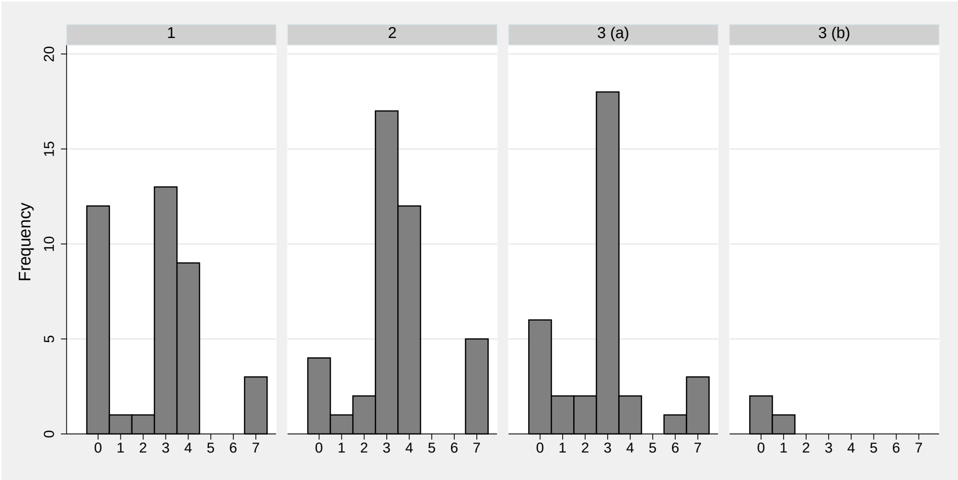


Figure 3.15: The distribution of switching points in the second multiple price list, eliciting future discount factors, reported individually by treatment

distributions should look identical if participants were all completely time consistent ($\beta = 1$). In the remaining treatments uncertainty in itself could potentially have induced otherwise time consistent participants to appear time-inconsistent, but for treatment 1 the fact that the distributions look very different can be considered evidence of pure time-inconsistent preferences.

The Kruskal-Wallis test formally confirms that the observed samples in the 4 treatments do not come from the same population. With a $\chi^2 = 9.768$ and $p = 0.020$ we can reject the hypothesis that the distributions in all treatment groups come from the same population.

Comparing them pairwise using the Withney-Mann-Wilcoxon rank sum test we can reject that treatment 1 and treatment 2 come from the same population ($p = 0.074$) and that treatment 2 and 3 come from the same population ($p = 0.05$). That treatment 1 and 3 come from the same distribution, however, cannot be rejected ($p = 0.76$).

While the median for both treatment 1 and treatment 2 is 3 patient choices, the mean is higher in treatment 2 than in treatment 1 (2.5 patient choices in treatment 1 versus 3.4 in treatment 2, details are reported in the appendix). Participants in the risky treatment therefore, on average, appear more patient than those in the safe treatment.

Going back to the theory, the hypothesis gave different predictions depending on whether $\delta > 1$ or $\delta < 1$. For $\delta < 1$ the EUT model predicted that participants would make fewer patient choices and for $\delta > 1$ participants were expected to make more patient choices. The reverse was the case for the reference point theory. Unfortunately the nature of the non-parametric test used here does not allow to test for this differential impact directly.

The majority of the participants in treatments 2 and 3 has made choices such that $\delta < 1$ (52 to 23 respectively) which suggests that overall we can focus on the predictions made for the case of $\delta < 1$.

To further investigate this, the Kruskal-Wallis test on the subsample of those participants with $\delta < 1$ also rejects the hypothesis that the four treatments come from the same distribution with $p = 0.039$. Again the Withney-Mann-Wilcoxon rank sum rejects pairwise that treatments 1 and 2 and treatments 1 and 3 originate from the same distribution. The median number of patient choices in the second MPL is 2 in treatment 1 and 3 in treatments 2 and 3. Hence participants, on average, make more patient choices under risk than under certainty, thereby directly contradicting the predictions made by EUT (or implying $u''' < 0$) and supporting those of the reference point model.[9]

[9]Alternatively, using an OLS regression we can more directly control for the differential impact, although at the expense of potentially erroneous standard errors. This alternative analysis comes to the same conclusion and is reported in the appendix for completeness.

3.6.3 The Effects of Uncertainty on the Bias

Since uncertainty has had differential effects on the immediate and on the future discount factors, it can be expected that time inconsistency has been affected as well.

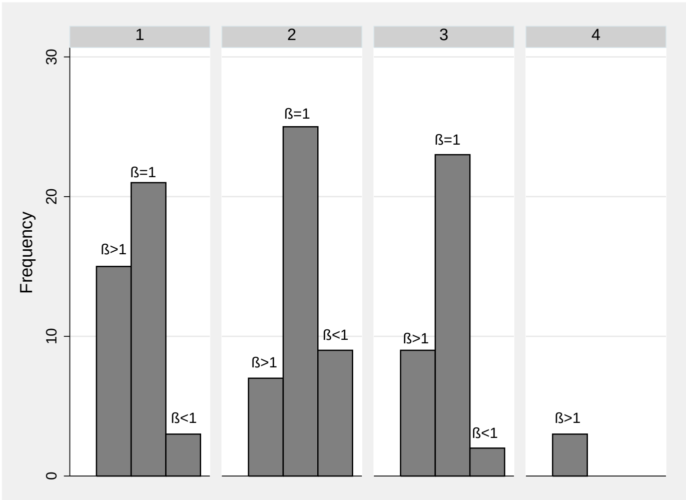


Figure 3.16: The biases by treatment

Figure 3.16 shows how the biases are distributed across treatments. $\beta > 1$ refers to future-biased participants who make more patient choices now compared to in the future, $\beta = 1$ refers to time consistent participants who are equally patient now and in the future and $\beta < 1$ refers to present-biased participants who are more patient in the future than now.

The Kruskal-Wallis test clearly rejects the hypothesis that all treatment groups follow the same distribution with $\chi^2 = 12.75$ and $p = 0.005$.

In treatment 1, more participants are future-biased than present-biased and in treatment 2 this inequality is reversed with more participants being present-biased than future-biased. Formally, the Mann-Whitney-Wlicoxon test also rejects that choices in treatment 1 and 2 originate from the same distribution ($p = 0.013$).

Interestingly the distribution of biases between treatment groups 1 and 3 is once again not significantly different ($p = 0.72$) while the difference between 2 and 3 once again is significant according the Whitney-Mann-Wilcoxon test ($p = 0.07$). Since the immediate discount factor is very similarly distributed across treatment groups, the fact that the future discount factor seems to respond to uncertainty has led to an increase in what appears to be present-biased preferences and reduced the incidence of future-bias.

This finding is indicative of the fact that our estimates of time inconsistency are very sensitive to the relative riskiness of the background environment in which they are elicited. Considering that the amount of income risk induced by this experiment is not out of line with what one may expect to find in developing countries, especially across seasons, this result has direct relevance to researchers wishing to elicit time preferences in the field.

3.7 Financial Market Outcomes

This section studies whether being present or future-biased has any effect on actual financial decision making and if income risk can present an obstacle to identifying these correlations. This section will also address in detail the question if income risk affects the correlations between real world decision making and parameters elicited in the experiment. If the correlations are robust to the income risk generated by the experiment, then even if there is a significant effect on the estimated parameters, income risk should not pose a major concern for most researchers who are only interested in the implications of time inconsistency.

One outcome variable of interest here is the repayment rate for the participants loans. The ideal repayment metric to look at would of course be the incidence of default, but for many microfinance organizations default is not a very well defined concept. Often loan durations are simply extended until the final payment has been made. Usually these delayed repayments are then associated with a fee or simply higher interest payments. Mandra Unnayan Samsad, the NGO I was working with, also has an extremely low fraction of defaults: in the entire sample of participants only one had ever defaulted on a loan.

Another way of studying the repayment behaviour however, is to look at how many of the scheduled payments have been missed. There is a considerable amount of variation among the participants in my sample in how many late or missed repayments they have. Missing a repayment is not costless because the interest on the full outstanding amount has to be paid at every monthly due date and the amount of interest decreases with every repayment that has been made.

Before turning to the results it is worth noting that temptation to spend the money elsewhere is by no means the only motivation for skipping a payment. The money could, for example, have been invested in a project that pays only after several months and the higher return more than makes up for paying higher interest. In addition, it is not obvious whether a present-biased borrower should repay *sooner* or *later* than a time consistent borrower. The present-biased borrower may, for example, be aware of her bias and know that if she does not stick to a rigid repayment schedule, she will not be able to meet her financial obligations at the end of the year when the loan is due. This is no doubt an interesting theoretical question to study, but beyond the scope of this paper. The analysis here remains agnostic to what one should expect on a theoretical basis and only studies the correlations in the data.

Table 3.2 lists various financial outcome variables and correlates them with individual level characteristics, including a dummy for whether or not the individual appeared present or future-biased. The regressions in this table are run on the entire sample of participants, that is participants from all treatments combined. Since the indicator variables for being future and present-biased are themselves estimated,

Table 3.2: Determinants of financial decision making

	(1) Has A Bank Loan	(2) Late Bank Payments	(3) Has A Group Loan	(4) Late Group Payments	(5) Size of Bank Loan	(6) Size of Group Loan
Presentbias	0.20	0.68	-0.22	-3.38**	3,249	-743
	(0.15)	(1.44)	(0.15)	(1.48)	(2,588)	(2,209)
Futurebias	0.11	0.82	-0.04	-1.96	3,268*	-96
	(0.11)	(1.06)	(0.10)	(1.48)	(1,908)	(394)
Meanincome	-0.00	0.01	0.00	0.00	-13	3
	(0.00)	(0.01)	(0.00)	(0.01)	(14)	(4)
Literate	0.63***	0.62	-0.38*	-7.63**	7,683**	-1,932
	(0.22)	(2.18)	(0.22)	(3.27)	(3,423)	(1,268)
IQ	0.02	-0.03	0.02	-0.96***	399	102
	(0.04)	(0.34)	(0.04)	(0.30)	(609)	(149)
Education	-0.22	-0.38	0.13	4.86**	-919	843
	(0.16)	(1.32)	(0.16)	(1.89)	(2,572)	(805)
crra	0.02	0.22	0.08**	-0.29	-323	371***
	(0.04)	(0.37)	(0.03)	(0.42)	(654)	(130)
Age	0.00	-0.04	-0.00	0.03	114	1
	(0.00)	(0.04)	(0.00)	(0.08)	(81)	(16)
Constant	0.12	2.64	0.19	7.29**	-8,631**	-1,454*
	(0.22)	(2.76)	(0.22)	(3.50)	(4,048)	(861)
Sigma					6,793***	1,403***
					(874)	(150)
Observations	99	47	99	35	99	99

Bootstrapped standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 3.3: OLS estimates on whether or not the participant has a bank loan broken down by treatments. The estimates of present- and future-bias obtained in treatment 1 correlated significantly with the decision to obtain a bank loan, while in income risk treatments the correlations remain insignificant.

	Participant has a bank loan: yes/no		
	(1)	(2)	(3)
	Treatment 1	Treament 2	Treatment 3
Presentbias	0.38**	0.13	0.22
	(0.18)	(0.28)	(0.28)
Futurebias	0.10	0.27	-0.01
	(0.21)	(0.25)	(0.21)
Income	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)
Literate	0.40	0.41	0.74
	(0.36)	(0.50)	(0.68)
IQ	0.02	-0.04	0.12**
	(0.09)	(0.07)	(0.05)
Education	-0.04	-0.01	-0.27
	(0.26)	(0.35)	(0.38)
CRRA	0.08	-0.06	-0.04
	(0.06)	(0.07)	(0.06)
Age	0.01	0.00	-0.00
	(0.01)	(0.01)	(0.01)
Constant	0.11	0.53	-0.20
	(0.49)	(0.46)	(0.34)
Observations	32	34	36
R-squared	0.26	0.19	0.43

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3.4: Tobit estimates on the size of the bank loan broken down by treatments. Again, the estimates of present- and future-bias obtained in treatment 1 are the only ones which significantly correlate with the outcome variable.

	(1)	(2)	(3)
Presentbias	6,500**	1,996	-5,546
	(3,176)	(7,245)	(16,950)
Futurebias	4,341*	5,697	-3,486
	(2,433)	(5,233)	(6,913)
Income	0	-27	-12
	(30)	(28)	(65)
Literate	10,421*	1,978	14,471
	(5,632)	(10,222)	(24,819)
IQ	37	-340	5,150
	(1,101)	(1,780)	(4,355)
Education	-2,972	3,016	-2,570
	(3,836)	(9,217)	(13,052)
CRRA	-262	-1,335	-1,929
	(679)	(2,070)	(4,384)
Age	194*	-39	-111
	(117)	(227)	(495)
Constant	-8,886	2,275	-21,940
	(5,700)	(10,529)	(19,677)
Sigma	4,496***	6,676***	5,422**
	(732)	(2,301)	(2,229)
Observations	32	34	36

Standard errors in parentheses
$***p < 0.01, **p < 0.05, *p < 0.1$

standard errors are bootstrapped. Results under robust standard errors are similar, although slightly more significant in places.

Columns (1) looks at the characteristics of who has a loan from a bank and the only significant correlation is that literate women are more likely to have a loan from a bank. Column (2) focuses on those participants who do have a bank account and studies the number of missed/late payments. Column (3) looks at the characteristics of women with an intragroup loan and colummn (4) looks at the number of missed payments for the intragroup loan. Interestingly, present-biased woman repay their loans significantly faster than time consistent women. Columns (5) and (6) are tobit regressions on the loan size for both bank and intragroup loans. OLS regressions, as well as the Heckman two-step model, give similar results.

Overall, it appears that our estimates of present- and future-bias do not correlate very strongly with most financial outcome variables. With the exception of number of late payments for the intragroup loan and size of bank loan, they remain insignificant throughout. However, as was demonstrated in the previous section, estimates from treatment 2 and 3 have been affected by the experiment and are therefore less likely to correspond to the true parameters than those in treatment 1. To see if the measurement error thus introduced has affected the correlations, I next repeat some of these regressions for each treatment separately. For the repayment behaviour the sample size unfortunately becomes too small at the treatment group level, hence these cannot be broken down any further.

Table 3.3 shows the results for whether or not the participant has a bank loan. As we can see the coefficient on being present-biased has become significant, despite the fact that the sample size is reduced to a third. In the remaining treatments the correlations remain insignificant. The point estimates are not all significantly different from each other; however, a researcher who ran these regressions in an environment in which participants have no income uncertainty (treatment 1) and a researcher who ran the same regressions in an environment where participants do face income uncertainty (treatments 2 and 3) would have drawn very different conclusions. The most accurate estimates clearly seem to be the ones elicited for participants in treatment 1 and the measurement error introduced by uncertainty in the other treatments has influenced the estimates of time inconsistency so far that correlations with outcome variables of interest have become insignificant.

The same exercise is repeated in table 3.4 for the size of the bank loan [10] . Again, despite the reduced sample size, estimates of the coefficients on being present- and future-biased have become more significant for the subsample of participants in treatment 1 and have become insignificant for treatments 2 and 3.

It is also interesting that the point estimates on future-and present-biased appear to be both positive. In fact, throughout most regressions we see that point estimates on present and future-biased are in the same direction. This suggests that future- and present-biasedness are in some way related and maybe displaying future-biased preferences is even a way of trying to commit to not spending money immediately and hence guaranteeing future income. Trying to differentiate between participants who are 'truly' future-biased and present-biased participants who want to commit to having savings in the future is therefore an interesting avenue for further research.

This section has demonstrated that future- and present-bias do correlate with important financial decisions and that the extent to which this correlation is observable can depend on the risk environment in which these parameters are elicited. Researchers wishing to elicit estimates of time inconsistencies therefore may wish to offer insurance payments such as were offered in treatment 1 in this experiment in order to obtain the most accurate preferences possible.

[10] Once again similar results hold for OLS and Heckman two-step procedures

3.8 Conclusion

This experiment exposed subjects to exogenously induced variation in the riskiness of their income stream over the next three weeks and tested to what extent this affected elicited discount factors. It clearly affected current and future discount factors differently with the current discount factor being entirely unresponsive to changes in riskiness and with the future discount factor increasing in riskiness. This implies that in treatment groups with risky income, more participants appeared present-biased and fewer participants appeared future-biased, thereby significantly affecting the distribution of biases.

Finally, this study also shows that the discount parameters elicited under safe income streams correlate more significantly with actual financial decision making than discount factors elicited under risky income streams. This is suggestive of the fact that income risk can introduce substantial measurement error in the estimation of discount factors.

To mitigate this effect, it may be advisable to offer a form of safe income as insurance when eliciting discounting parameters, the way it was done in this experiment for the safe income treatment. However, further research into the best mechanism to elicit time preferences in developing countries is clearly needed.

Chapter 4

Microfinance and Projection Bias Over Habit Formation

Abstract

This paper shows how several characteristics of the microfinance industry can be explained by the behavioural phenomenon of projection bias over habit formation. Evidence from psychology suggests that humans have a tendency to underestimate to what extent their future preferences will differ from their current preferences. This systematic and predictable bias has become known as projection bias. With the help of a formal theoretical model, this paper demonstrates that the prevalence of flat interest rate calculations, the high frequency of repayments, and the problem of over-investment can all be explained by this particular bias. Importantly, the policy implications resulting from this theory can differ from those of other prevailing models, such as hyperbolic discounting.

Keywords: Projection Bias, Flat Interest Rates, Repayment Frequency, Over-Investment
JEL Codes: O12, D03, G10

4.1 Introduction

Microfinance was once heralded as the panacea for global poverty. The economic rationale was straightforward: the poor had previously been excluded from the world's capital markets and microfinance would connect them. This would allow them to undertake small-stake, high-return projects and eventually lead them out of poverty. The reality has been somewhat sobering in comparison: there has been anecdotal evidence[1] of over-indebted borrowers facing intimidation and threats when missing repayments and according to Roodman (2011) "the best estimate on the average impact of microcredit on poverty has been zero". This has given rise to debates in policy and academia about whether or not microfinance, or which aspects of microfinance, improve welfare.

At the same time, the discipline of economics has re-discovered psychology as an important component of human decision making. The subfield of behavioural economics has hence begun to influence mainstream economic thought as well as economic policy (Angner and Loewenstein (2007), Camerer (2002)). Particularly in development economics, insights from psychology have proven to be useful, not only in understanding decision making, but also in actively shaping policy interventions (for example see Mullainathan (2007) or Bertrand et al. (2004)).

The aim of this paper is to connect these two worlds by focusing on one particular behavioural bias and by demonstrating how it can explain some of the characteristics of the microfinance industry.

The bias under consideration here is *projection bias* over habit formation. Insights from psychology lead us to believe that accurately predicting one's future preferences, habit levels and tastes is something humans find extremely difficult to do (Loewenstein and Adler (1995) and Loewenstein and Van Boven (2003), etc.).

[1] For example, see http://www.bbc.co.uk/news/world-south-asia-11997571 .

In fact, as section 4.2 will outline in greater detail, there is abundant evidence that humans underestimate to what extent the future will differ from the present and this predictable bias is known as projection bias.

The characteristics of the microfinance industry that can be explained with the help of this bias include over-investment, frequent repayment and the presence of flat interest rate calculations and high interest rates in general. [2]

The prevalence of flat interest calculations is usually explained by the fact that the lender can advertise a low interest rate while charging a very high effective interest rate. "Why did such a system appear in lending? The answer is obvious and cannot be debated: it allows the institution to charge nearly twice as much interest for the quoted interest rate as with the declining balance method" (Waterfield (2008)).

This paper, however, shows that with concave utility, borrowers may consciously choose the contract with the more expensive flat interest rate because it does not force them to have an increasing consumption profile. In itself, this would not be a problem, but for agents who are subject to projection bias over habit formation this will lead to a substantial loss in welfare. When offered the choice between the optimal, decreasing repayment profile and one of flat interest payments, the borrower will prefer the flat interest payment, thereby reducing overall welfare.

A second characteristic of the microfinance industry is the high frequency of repayments. Estimates suggest that the cost associated with the weekly repayment meetings are a substantial component of the overall cost of operation (Karduck and Seibel (2004), Shankar (2007)). Empirical studies, randomizing between weekly and monthly repayment schedules (Field and Pande (2008), Mcintosh (2008)) have found

[2] With a flat interest rate calculation the interest payment for each instalment is calculated on the original principal and not on the remainder which is still outstanding, thereby implying a significantly higher APR or effective interest rate. This is in contrast to the 'declining balance method' in which the interest is calculated only on what is still owed to the lender. (See CGAP (2002) for a detailed comparison of all kinds of interest rate calculations used by MFIs).

no negative impact on repayment rates thus suggesting that MFIs could substantially lower costs by reducing the number of meetings.

However, this paper shows that for borrowers who suffer from projection bias over habit formation, the high transaction cost associated with frequent meetings is more than compensated for by the gain in welfare from repaying large instalments quickly. Secondly, it will be shown that when borrowers exhibit habit formation and when contract enforcement is incomplete, frequent repayments make it easier to satisfy the repayment incentive constraint. This is similar to the result of Fischer and Ghatak (2009) who show that the repayment incentive constraint for hyperbolic discounters is easier to satisfy when repayments are frequent.[3]

Finally, the paper will demonstrate that when borrowers are not aware of their habit changing over time, they will overestimate the marginal utility of future income and will therefore over-invest. Over-indebtedness of microfinance borrowers has recently emerged as a concern in many south Indian states. Srinivasan (2009) estimated that "the average debt outstanding is estimated in INR $49,000$ (about $1000) per household, which is eight times the national average MFI loan outstanding and about 11 times the average member-level loan outstanding in case of SHGs". This trend in recent years has sparked demand for regulatory intervention such as the establishment of credit bureaus in order to limit the number of sources one individual borrower can borrow from simultaneously.

The paper proceeds as follows: the next section gives further background on projection bias and provides evidence for its existence. The next section gives background and evidence on the existence of projection bias. Section 4.3 introduces the basic model, Section 4.4 explains why borrowers prefer a flat repayment schedule

[3]Jain and Mansuri (2003) give another interesting interpretation for why frequent repayments may be necessary. In their model the high frequency forces the borrower to use a moneylender who can screen the individual borrowers directly, thereby solving the adverse selection problem for the MFI.

and may therefore be willing to accept flat interest calculations. Section 4.5 shows that altruistic lenders have an incentive to hold frequent repayments when borrowers suffer from projection bias over habit, despite potentially incurring very large transaction costs. Section 4.6 outlines how frequent repayments can help overcome enforcement problems and section 4.7 shows that agents suffering from projection bias will over-invest in a given project and will therefore over-borrow. Section 4.8 discusses and compares the model relative to one of hyperbolic discounting and Section 4.9 concludes.

4.2 Background

The defining feature of projection bias is that agents do not (fully) understand that their preferences evolve over time. All inter-temporal transactions, such as saving and borrowing, require actors to accurately predict their future preferences. For example, when deciding whether or not to save up money in order to invest in a project, agents must predict how much utility they will derive once the project starts to pay off and how much disutility they will have to endure while saving up the money.

The inability to do so accurately is what Loewenstein et al. (2003) have coined *projection bias*. Gilbert (2006) refers to it as 'presentism' and defines it as 'the tendency for current experience to influence one's view of the past and the future.'

Examples of projection bias can be found in virtually all domains of life: It is the tendency to overestimate future hunger when doing grocery shopping on an empty stomach and to underestimate it when shopping on a sated stomach (Nisbett and Kanouse (1969)). Sackett and Torrance (1978) find that non-patients' prediction of quality of life under chronic dialysis is consistently lower than that reported by actual dialysis patients. Conlin et al. (2007) find that people are more likely to regret the purchase of a 'cold-weather' item if they have bought it on a particularly cold day.

Most related to the current paper is the evidence of projection bias over habit formation. Acland and Levy (2010) find evidence of projection bias over habit in gym attendances. In their sample, two thirds of participants develop a habit of attending the gym after having been given short run incentives to do so. However, ex ante they failed to predict 90% of that habit. While habit formation over gym attendance may not be exactly the same as habit formation over past consumption, Muellbauer (1988) also finds evidence of the fact that people generally understand that their habit levels over consumption change over time but that again, they underestimate the extent to which this happens. Finally, Badger et al. (2007) find that heroin addicts value an extra dose of the heroin substitute Buprenorphine more highly when they are currently craving than when they are currently satiated. Taken together, there is compelling evidence that people tend to underestimate to what extent current consumption will affect the marginal utility of future consumption, which is the bias being modelled in this paper.

4.3 The Environment

The utility function of the agent is subject to habit formation and is given by $U(c_t, s_t)$ where c_t is consumption and s_t is the habit stock of the agent in period t. The initial habit stock s_1 is for simplicity set to equal zero. This is not without loss of generality. A large initial habit stock,in particular, is likely going to result in a different optimal consumption plan involving the agent ' breaking the habit' and going through an initial period of very little consumption. However, setting the initial habit stock equal to zero is a realistic assumption in the setting of microfinance entrepreneurs.

The future habit stock evolves according to $s_{t+1} = (1 - \gamma)s_t + \gamma c_t$ for some

$\gamma \in (0, 1]$. Hence, the more the agent consumes in one period, the higher his future habit stock will be. The parameter γ captures how quickly the habit stock adjusts over time.

The instantaneous utility function is simply given by $v(c_t - s_t)$ with $v' > 0$ and $v'' < 0$. Hence a fully rational agent will choose a consumption path to maximize his true lifetime utility given by $U(c_t, s_t) = v(c_1 - s_1) + v(c_2 - s_2)$.

Agents who suffer from projection bias however cannot fully predict how their future utility is affected by habit accumulation. There are various ways of modelling this misprediction and this paper follows the approach taken by Loewenstein et al. (2003). Let *perceived* lifetime utility at $t = 1$ be

$$\begin{aligned}\tilde{U}(c_t, s_t|s_1) &= (1-\alpha)U(c_t, s_t) + \alpha U(c_t, s_1) \\ &= v(c_1 - s_1) + (1-\alpha)\big(v(c_2 - s_2)\big) + \alpha\big(v(c_2 - s_1)\big).\end{aligned}$$

That is perceived utility is equal to a weighted average between actual future utility and future utility if the habit state remained unchanged. Full projection bias, given by $\alpha = 1$, would imply that the agent is completely unaware of his habit changing over time. If $\alpha = 0$ the agent predicts his future utility correctly and exhibits no projection bias at all.[4]

4.4 Borrowing on Flat Interest Rates

Borrowers live for 2 periods and have access to a project which requires a lump sum investment of 1 unit of capital. If undertaken, this project produces x output in each of the two periods. This could, for example, be the acquisition of a buffalo or goat, a rickshaw, or a sewing machine. Borrowers are assumed to have no capital and

[4] An alternative formulation would be to allow the agent to realize that his habit stock will adjust, but to underestimate the extent to which this happens. For example see Muellbauer (1988)

cannot save towards this project. Hence, in order to undertake the project, they must borrow the funds from a lender. The lender is free to require a repayment $t_i, i \in 1, 2$ in either or in both periods. In order to highlight the effects of projection bias on welfare, this section is going to assume that repayments are always enforceable and that default hence never occurs.

This section introduces a simplified version of the model which nonetheless gives insight into the mechanisms at play. In particular, the simplification is that:

Assumption 2. *The agent cannot save or borrow between periods.*

This means that by controlling the repayment requirements in each period, the lender can effectively control the borrower's consumption in each period. After subtracting the repayment, the borrower's consumption will be $x - t_1$ in period 1 and $x - t_2$ in period 2. This assumption will be relaxed in the later parts of the paper and it will be shown that this does not matter. Savings are assumed away initially only to make the analysis clearer.

Assumption 3. *Projection bias is complete. That is, the agent is completely unaware of habit formation and in the formulation above* $\alpha = 1$.

While all main results are entirely robust to relaxing these assumptions, the model is substantially more tractable and the main points are very easy to understand in this simplified setting.

4.4.1 Borrowing from a For-profit

A for-profit lending institution's aim is simply to maximize profit subject to the agent's participation constraint and subject to a break even constraint . If the lender charges t_1 in the first period and t_2 in the second period, he formally solves:

$$\max_{t_1,t_2} t_1 + t_2$$

subject to

$$v(x - t_1) + v(x - t_2) > u_0 \qquad \text{(PC)}$$

$$t_1 + t_2 \geq \rho \qquad \text{(ZPC)}$$

where ρ is the opportunity cost of capital. This maximization is straightforwardly solved by noting that the agent prefers to have equal consumption in either period and hence is willing to pay the most for credit when the payments are exactly equal $t_1 = t_2$. The equilibrium contract will be $t_1^{FP} = t_2^{FP}$ such that the participation constraint exactly binds.

4.4.2 Borrowing from an Altruistic Lender

Deriving the optimal contract from the point of view of an altruistic lender gives us a benchmark relative to which we can compare the contract offered by the for-profit firm. This could, for example, be an altruistic NGO, a benevolent government or a social entrepreneur who wishes to maximize the welfare of the poor. The altruistic lender will then try to structure the loan contract in such a way that it maximizes actual utility $U(c_t, s_t)$ and hence borrower welfare. The constraints faced by the lender are (1) the borrower has to be willing to accept the contract offered (the Participation Constraint or PC) (2) the lender has to break even (the Zero Profit Condition or ZPC).

Formally, the lender solves the following problem:

$$\max_{t_1,t_2} \; v(x - t_1) + v((1-\gamma)x - t_2 + \gamma t_1)$$

subject to

$$v(x - t_1) + v(x - t_2) > u_0 \tag{PC}$$

$$t_1 + t_2 = \rho \tag{ZPC}$$

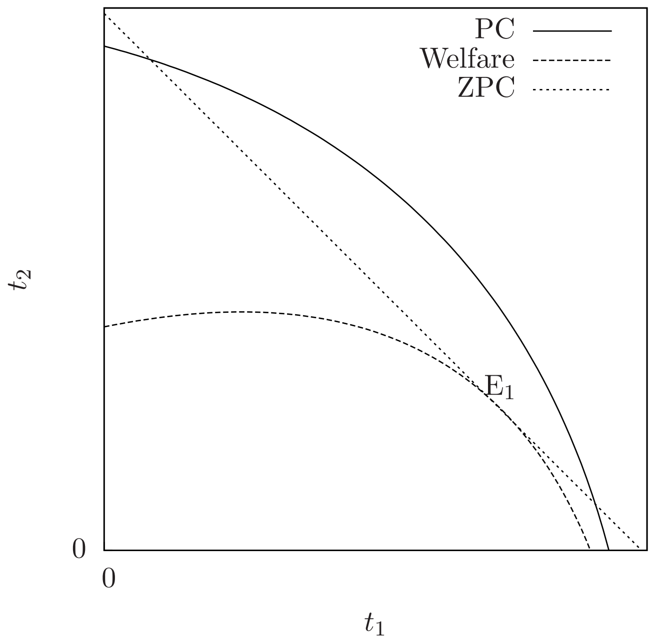
This constrained optimization problem is graphically represented in Figures 4.1 and 4.2. The first figure is drawn for the case in which the participation constraint of the borrower is not binding and the second is drawn for the case where it is binding. The borrower is willing to accept any contracts (t_1, t_2) such that they lie on the south-west of the participation constraint and the lender is able to break even for all contracts north east of the ZPC.

Result 1. *The optimal repayment schedule is such that the first instalment is larger than the second instalment, $t_1 > t_2$. Agents who are subject to projection bias, in contrast, prefer a flat repayment schedule such that the instalments are of equal size $t_1 = t_2$.*

As can be seen readily from the first diagram, the contract that maximizes borrower welfare has a higher repayment in the first period than in the second, $t_1 > t_2$. This is to induce the borrower to have an increasing consumption profile in which he consumes more in the second period than in the first. The borrower himself, on the contrary, would have chosen a flat consumption profile, such that the payments in either period would have been the same $(t_1 = t_2)$. As long as the borrower's participation constraint is not binding, this does not matter and the altruistic lender can induce the borrower to have the optimal consumption plan.

A straightforward extension of this result is that if projection bias is partial, that

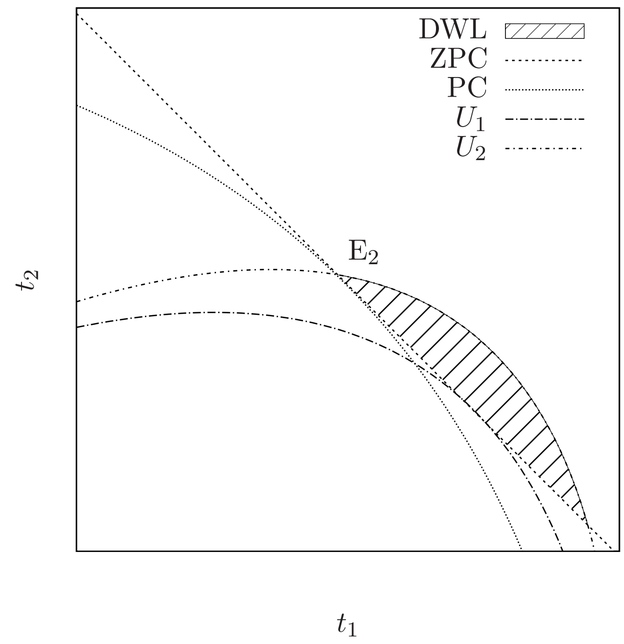
Figure 4.1: The optimal contract case 1: PC not binding



is if the agent has some idea that his habit will be changing over time, but underestimates the effect, the preferred consumption plan will be flatter than optimal. Given the particular modelling choice of projection bias, this is particularly easy to see. The agent suffering from partial projection bias will maximize a weighted average of the utility of an agent without any bias and one with complete projection bias.

In the case of a binding participation constraint, however, the borrower would refuse the optimal contract and would only be willing to accept one which offers a lower initial payment. The case shown in Figure 4.2 is one in which the participation constraint of the borrower and the participation constraint of the lender intersect in only one place and hence the altruistic lender has no choice as to what contract to offer. The shaded area depicts the range of contracts (t_1, t_2) which are pareto superior to the selected contract, but which are unfeasible as the borrower ex-ante would not accept such a contract. However, for all these contracts, both the lender's

Figure 4.2: The optimal contract case 2: PC binding



profit would be higher and/or borrower welfare would be greater. The result can be summarized as follows.

Proposition 8. *Under projection bias over habit formation the optimal contract may not be feasible and the second best contract is such that* $\frac{t_1}{t_2} < \frac{t_1^*}{t_2^*}$

Proof. The optimal contract (t_1^*, t_2^*) is given by $v'(x - t_1^*) = (1+\gamma)v'((1-\gamma)x - R + (1-\gamma)t_1^*)$ and the lender's zero profit condition $t_1^* + t_2^* = R$. Since $\gamma > 0$ and $v'' < 0$ this implies $t_1^* > t_2^*$.

The second best contract (t_1', t_2') must lie at an intersection of the PC and the ZPC. To see that this intersection must lie above (higher t_1) the first best contract, we note that the participation constraint is maximized at $t_1 = t_2$. The second best contract (t_1', t_2') must therefore lie on the line $t_1 + t_2 = \rho$ with $t_1' > t_1^*$.

□

It is worth noting at this point, that this result would *not* necessarily hold if the bias were of a different form. Hyperbolic discounting, for example, would, in fact, lead to the opposite result. This will be discussed at greater detail in section 4.8.1.

4.4.3 The Altruistic Lender and the For-Profit Coexist

Next, we consider what happens when the altruistic lender and the for-profit lender coexist and both offer their preferred contract. As will be shown in the next subsection, the borrower will prefer to borrow from the for-profit despite the higher interest charges, because he prefers the flatter repayment schedule. This can be seen as an explanation for why flat interest charges remain so popular despite the higher implied interest rate.

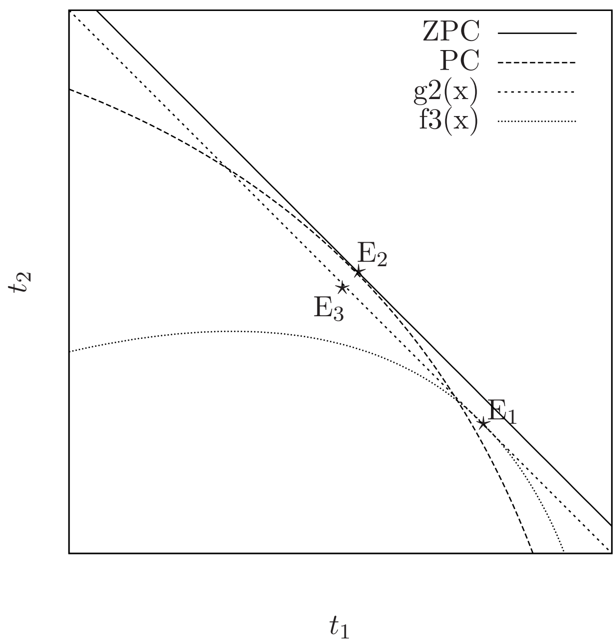
After the static comparison, we show that in equilibrium the two lenders will offer the same contract. The altruistic lender will accommodate the bias of the borrowers and offer a flat repayment schedule, but will drive down the interest rate, thereby eliminating the for-profit's ability to make positive profits by exploiting the borrower's desire for a flat consumption profile. As before, optimal welfare is below first best, despite the existence of an altruistic lender who would like to offer the optimal contract.

Static Comparison

As described above, the altruistic lender lends money at the break-even interest rate such that $t_1^* + t_2^* = \rho$ and such that $t_1^* > t_2^*$. The for-profit on the other hand lends at higher interest rate such that $t_1' + t_2' = \rho + \pi$ where π is the profit earned by the lender, but with $t_1' = t_2'$. The two contracts are depicted in Figure 4.3.

The case for which they are drawn illustrates that, while the altruistic lender's contract (E_1) maximizes borrower welfare, the borrower may well prefer the (more expensive) contract E_2 offered by the for profit because it does not require a high repayment in the first period.

Figure 4.3: The Altruistic Lender's and the For-Profit's Contract's Offered Simultaneously



Result 2. *For a certain range of interest rates, the borrower prefers the more expensive contract offered by the for-profit to the cheaper contract offered by the altruistic lender; overall welfare is hence lower.*

Proof. As depicted above and directly following from the fact that the borrower prefers a contract other than the first best contract. □

Once again, a hyperbolic discounter would have the opposite preferences and would, in this case, prefer the cheaper contract offered by the NGO.[5]

Of course, as the gap between the overall interest rates offered by the altruistic lender and the for-profit increases, the borrower will at some point prefer the altruistic lender's offer. However, this result can help explain why flat interest rate

[5] Of course, the for-profit would not be maximizing profits when offering this contract to hyperbolic discounters. In equilibrium, the for-profit would offer a more expensive contract with a small initial payment and a large future payment and the borrower would accept this over the contract offered by the NGO.

calculations are still so dominant among microfinance organizations and that their existence is not necessarily due to the fact that borrowers do not understand how to calculate interest rates, but due to the fact that they are willing to pay more for a flatter repayment schedule.

The Equilibrium

In the above analysis, the altruistic lender clearly has an incentive to respond to the contract offered by the for-profit. By slightly giving in to the temptation of the borrower and by making the repayment profile slightly flatter, the altruistic lender could again attract the borrower.

Proposition 9. *The unique equilibrium in the credit market is such that* $t_1 = t_2$ *and* $t_1 + t_2 = \rho$

Proof. For all $t_1 + t_2 < \rho$, the break-even condition is violated and lending is unfeasible. For all $t_1 + t_2 > \rho$, the altruistic lender can offer a contract preferred by the agent and associated with higher welfare by offering the contract above.

For all $t_1 > t_2$, the for-profit can offer a contract preferred by the borrower, but with lower welfare.

For all $t_1 < t_2$, both for-profit and altruistic lender can offer a contract that offers higher profits or higher welfare respectively and is preferred by the borrower. □

In Figure 4.3, this equilibrium corresponds to point E_3 and represents the point which maximizes the borrower's perceived utility in period 1. While this is not the first best contract, the existence of the altruistic lender has led to a reduction in the interest rate while maintaining the same repayment schedule, and has therefore led to a significant increase in borrower welfare.

It is important to note that the existence of an altruistic lender is not the only means to achieve this equilibrium. The same equilibrium results from either two for-profit lenders in Bertrand competition with each other or several lenders in perfect competition.

4.5 Frequency I - Transaction Costs

The previous section demonstrated that projection bias over habit formation can explain why flat interest calculations remain so popular among microfinance institutions. This section turns to demonstrating how projection bias can help explain the high frequency of repayments in microfinance. The analysis from the previous section already demonstrated that the optimal t_1 is never equal to zero, which implies that two, more frequent, payments are preferable to one single repayment in period 2. However, the odds were clearly stacked in favour of frequent repayment due to two assumptions: first, the agent did not have access to savings so the lender was offering to smooth consumption for the borrower. In fact, in the absence of a savings technology, concave utility alone is enough to give rise to a demand for frequent repayments as opposed to a single repayment. This section will show that in a model with savings, concave utility alone is not enough to reach this conclusion. Projection bias over habit formation, however, provides reason to have multiple payments as opposed to a single repayment.

Second, the previous section did not allow for any transaction costs associated with meetings. This section relaxes this assumption and shows that the altruistic lender and the for-profit lending institution will react differently to the presence of transaction costs. The altruistic lender is likely to stick with a multiple repayment schedule even for very high transaction costs, while the for-profit will find it optimal to switch to a single repayment under far smaller transaction costs.

If the borrower has to attend two meetings instead of one (if $t_1 \neq 0$), he bears an additional transaction cost τ which, for simplicity, enters his utility additively. The borrower perceives his utility to be given by $v(x-t_1)+v(x-t_2)-\tau\mathbf{1}(t_1 \neq 0)$, hence he will use his ability to save in order to smooth consumption as much as possible between periods. There are two possible cases:

1. $t_1 > t_2$: In this case the borrower is unable to completely smooth consumption between periods and will simply consume $x - t_1$ in the first period and $x - t_2$ in the second period. The analysis from the previous section therefore applies directly

2. $t_1 \leq t_2$: In this case the borrower will save the excess between each period and will therefore consume $x - \frac{1}{2}(t_1 + t_2)$ in period 1 and $x - \frac{1}{2}(t_1 + t_2)$ in period 2.

4.5.1 Borrowing from a For-Profit

As before, the for-profit lender maximizes profit subject to the borrower's participation constraint and the lender's break-even constraint:

$$\max_{t_1,t_2} t_1 + t_2$$

subject to

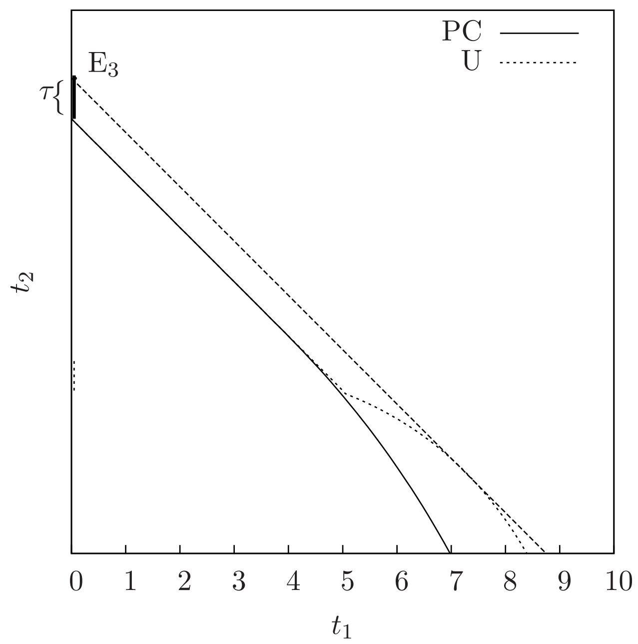
$$v(c_1^R) + v(c_2^R) - \tau\mathbf{1}(t_1 > 0) > u_0 \qquad \text{(B-PC)}$$

$$t_1 + t_2 \geq \rho \qquad \text{(L-PC)}$$

Where c_i^R is given by $c_i^R \equiv \text{argmax}_c\{v(c_1) + v(c_2)|c_1 \leq x - t_1 \ \ \& \ c_1 + c_2 \leq 2x - t_1 - t_2\}$, the optimal consumption plan in response to the contract offered by the lender and given the no-borrowing constraint, but in presence of a savings technology in order to transfer income from the first period to the second.

This straightforward maximization problem is once again depicted in Figure 4.4. As can be seen on the diagram, the point that maximizes profits is now given by the single repayment point E_3 for which $t_1 = 0$. The borrower derives equal perceived

Figure 4.4: In the presence of transaction costs, the For-Profit will prefer a single repayment over multiple repayments



utility from all points such that $t_1 \leq t_2$ and $t_1 \neq 0$, because he will be able to achieve his desired level of consumption smoothing ($c_1 = c_2$). However at $t_1 = 0$ in addition to achieving the desired level of consumption smoothing, he will also be able to save τ in transaction costs and hence is willing to pay the highest interest rate for this contract.

When the borrower is able to smooth consumption by himself and when additional repayment meetings are costly, the for-profit will prefer a single repayment over multiple repayments. Welfare, however, will be significantly lowered by this. The welfare maximizing repayment schedule, *holding constant* the profits to the for-profit, is given by the tangency condition of the welfare indifference curve U and the profit line depicted in the diagram. Such a contract, however, is not within the borrowers participation constraint and would therefore never be accepted.

4.5.2 Borrowing from an Altruistic Lender

The altruistic lender solves:

$$\max_{t_1,t_2} v(x-t_1) + v((1-\gamma)x - t_2 + \gamma t_1)$$

subject to

$$v(c_1^R) + v(c_2^R) + \tau\mathbf{1}(t_1 > 0) > u_0 \quad \text{(B-PC)}$$

$$t_1 + t_2 = \rho \quad \text{(L-PC)}$$

Where again $c_i^R \equiv \text{argmax}_c\{v(c_1) + v(c_2)|c_1 \leq x - t_1 \;\; \& \; c_1 + c_2 \leq 2x - t_1 - t_2\}$ is the optimal consumption plan, given the contract offered by the lender.

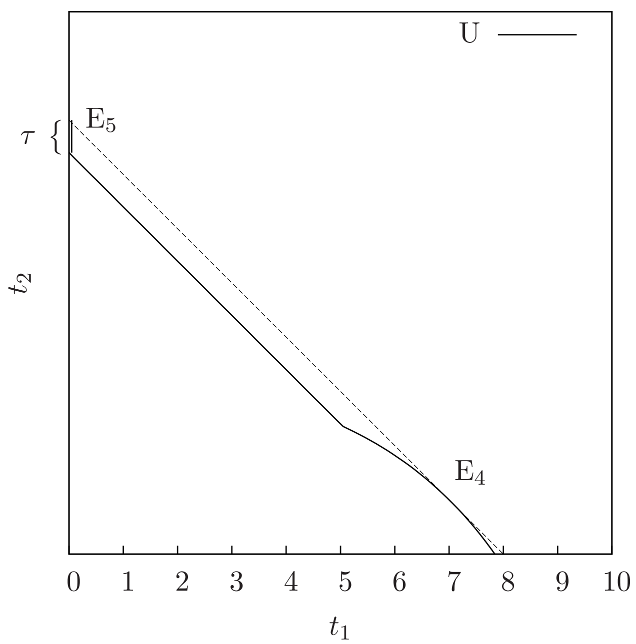
Again, we can differentiate between the two separate cases: 1) the PC does not bind and 2) the PC does bind. In the first case, the altruistic lender will either choose the same contract it did in the previous section, or if the transaction cost is prohibitively high, it will also reduce the number of repayments to 1. This is depicted in Figure 4.5: For transaction costs higher than the τ depicted in the figure, the lender will choose the single repayment plan E_5, but for all transaction costs smaller than that, the unconstrained first best contract E_4 with multiple payments will be selected. The fact that the borrower can save, however, has in no way affected the optimal contract because the altruistic lender would like to charge $t_1 > t_2$ and hence the borrower would not want to make use of his ability to save.

In the case of a binding participation constraint, the lender once again can only offer the contract lying at the intersection point between the participation constraint and the break-even line. In case of multiplicity, the contract with the highest t_1, and hence highest level of welfare, will be selected by the altruistic lender.

The results of this section can therefore be summarized as follows:

Result 3. *Under perfect contract enforcement, access to savings and a positive trans-*

Figure 4.5: For small transaction costs, the altruistic lender will select a repayment plan involving multiple repayments such as the one at E_4. For large transaction costs the altruistic lender will select the single repayment plan E_5.



action cost, a for-profit lender will offer a single repayment plan. An altruistic lender however, will offer multiple repayments unless the transaction cost is prohibitively high.

The high frequency of repayments often observed in microfinance should therefore not be seen as purely introducing high transaction costs, but it may also in fact be an important feature of the contract.

This section showed that when agents are subject to projection bias over habit formation, it can be welfare improving if they are forced to accept a frequent repayment contract instead of a single repayment contract. This result holds even when there are non-trivial transaction costs associated with attending more than one meeting. The intuition behind this is that by having early repayments, the contract can help the agent in achieving an optimal, upward sloping consumption profile.

4.6 Frequency II - Incomplete Contract Enforcement

The result in the previous section is driven by the fact that the altruistic lender has an informational advantage over the borrower. The lender knows the actual utility function of the borrower better than the borrower himself and wants to indirectly control the borrower's consumption plan by choosing the appropriate repayment schedule. This section is going to relax the assumption that contracts are always enforceable and will thereby introduce another reason why the lending institution might want to have frequent repayments, regardless of whether they are maximizing their own profit or the borrower's utility. This section is going to demonstrate this for the case of a for-profit, but the analysis is identical for the case of an altruistic lender.

The intuition behind the results in this section is that subsequent payments will be easier to enforce if they are smaller in size. In the case of a large final repayment, the temptation to not fulfil the repayment requirement is larger than if the final repayment is relatively smaller.

Formally, this section assumes that the lender has access to an incomplete non-monetary punishment of Ψ to threaten a defaulting borrower with. This punishment could take any form, ranging from legal prosecution to social stigma and ostracism. A borrower hence chooses to make a repayment by comparing the utility from repaying to the utility from defaulting.

In the first period, the borrower decides to make the first repayment if and only if his expected utility from repaying is greater than his expected utility from defaulting:

$$v(c_1^R) + v(c_2^R) > v(c_1^D) + v(c_2^D) - \Psi \tag{IC-1}$$

where

$$c_i^R \equiv \underset{c}{\text{argmax}}\{v(c_1) + v(c_2) | c_1 \leq x - t_1 \ \ \& \ c_1 + c_2 \leq 2x - t_1 - t_2$$

is the optimal consumption plan if the borrower decides to repay and

$$c_i^D \equiv \underset{c}{\text{argmax}}\{v(c_1) + v(c_2) | c_1 \leq x \ \ \& \ c_1 + c_2 \leq 2x\}$$

is the optimal consumption plan if the borrower chooses to default.

Note that for this first period incentive constraint (IC-1), the borrower is not aware of his habit changing over time. He weighs his utility from repaying the loan against the utility of defaulting on the loan under the assumption that his habit level remains unchanged. In the second period, however, the borrower's incentive constraint has adapted to the new habit level:

$$v(c_2^R - \gamma c_1^R) \geq v(c_2^{DD} - \gamma c_1^R) - \Psi \tag{4.1}$$

where

$$c_2^{DD} \equiv \underset{c}{\operatorname{argmax}}\{v(c_2 - \gamma c_1^R) | c_2 \leq 2x - c_1^R - t_1\}$$

is the level of consumption in period 2 if the borrower defaults on the second instalment, after having repaid the first. In this second period, consumption would simply be all the funds left to the borrower after having repaid the first instalment and after having consumed c_1^R in the first period. Hence we can rewrite the second period incentive constraint as:

$$v(c_2^R - \gamma c_1^R) \geq v(2x - c_1^R - t_1 - \gamma c_1^R) - \Psi \tag{IC-2}$$

A for-profit lender hence maximizes profit subject to 4 constraints: the borrower's and the lender's participation constraint, the borrower's first period incentive constraint (IC-1) and the borrower's second period incentive constraint (IC-2).

Formally, the lender solves the following problem:

$$\max_{t_1, t_2} t_1 + t_2$$

subject to

$$v(c_1^R) + v(c_2^R) > u_0 \tag{B-PC}$$

$$t_1 + t_2 \geq \rho \tag{L-PC}$$

$$v(c_1^R) + v(c_2^R) > v(c_1^D) + v(c_2^D) - \Psi \tag{IC-1}$$

$$v(c_2^R - \gamma c_1^R) \geq v(2x - c_1^R - t_1 - \gamma c_1^R) - \Psi \tag{IC-2}$$

Closer examination of these constraints reveals that the first period incentive constraint and the participation constraint can never bind at the same time. The right hand side of either constraint is identical and equal to the expected utility, as perceived in the first period, of borrowing from the lender and repaying the loan. The right hand side of either constraint is independent of t_1 and t_2. For the participation constraint it is simply the outside option and for the incentive constraint it is the utility from defaulting on the repayments. The utility of neither of these depends on the contract offered by the lender and hence both are constants in this maximization problem.

The IC-1 and the PC therefore can be combined into one single constraint of the form

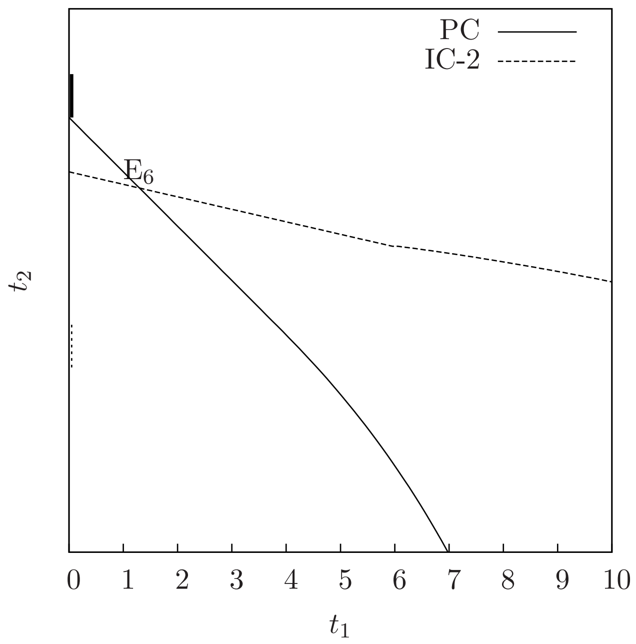
$$v(c_1^R) + v(c_2^R) \geq u_0' \qquad \text{(PC')}$$

where $u_0' = \max\{u_0, v(c_1^D) + v(c_2^D) - \Psi\}$. The combined constraint resembles the original participation constraint in shape and form, with the exception that the parameter Ψ, the ability to enforce contracts, can shift this constraint outward up until the point of the original participation constraint.

The simplified maximization problem is depicted in Figure 4.6 below. The only addition relative to previous figures is the second period incentive constraint (IC-2). This constraint, potentially, imposes an upper limit on the second period repayment t_2 above which repayment in the second period will no longer be incentive compatible. This works through two separate channels.

First, it is easier to repay a smaller amount in the second period because the benefit of defaulting is smaller. A borrower who has saved up large sums of money and has to choose between spending them on consumption or repayment will have a higher gain from defaulting. The second channel is that a borrower who has repaid a higher amount in the past has accumulated a lower habit stock and the marginal

Figure 4.6: Imperfect enforcement introduces another constraint, IC-2. If the second instalment is too large, the borrower will find it optimal to default instead of repaying since his marginal utility of consumption has, unexpectedly, increased in the second period. The new equilibrium is E_6 at the intersection of the participation constraint and the incentive compatibility constraint.



utility of consumption is therefore smaller.

Proposition 10. *Under incomplete contract enforcement, a for-profit lending institution will prefer multiple repayments over a single repayment because this weakens the repayment incentive constraint of the borrower.*

Proof. If the second period incentive constraint (IC-2) is not binding, the problem is identical to the one outlined in the previous section and the for-profit lender will choose a single repayment schedule.

If, however, the second period incentive constraint is binding, the optimal contract lies on the line between the corner solution (intersection between IC-2 and PC) and the point $t_1 = t_2$. The borrower is indifferent between all contracts along this line because he will be able to smooth consumption by saving between periods 1 and 2. □

4.7 Over-investing

Projection bias over habit formation may also explain the phenomenon of over-borrowing and investing as borrowers anticipate their investments and purchases to give more future utility than they actual will. This will induce borrowers to take on larger loans than they should optimally opt for. This effect is similar to that of hyperbolic discounting which may also induce borrowers to over-invest, but the mechanism at play is different. Instead of undervaluing the future cost of repaying, as hyperbolic discounters might, the agent is too optimistic about the future benefits.

Assume again that the agent lives for 2 periods and receives an exogenous income of w in both periods of his life. His utility function remains the same as in the previous sections. In period 1, he has the option of buying a bulky consumption good valued $b(y)$ at y units of capital invested into it with $b'() > 0, b''()$. An example of such a consumption good could be a wedding or a funeral, for which the utility is increasing in the amount of money spent.

The agent has the opportunity of borrowing funds i in addition to his per-period income of w from a lender at rate r. The agent suffering from projection bias will choose the amount to borrow i such that his perceived life-time income

$$\tilde{U} = v(b(w+i)) + v((w - i(1+r))) \tag{4.2}$$

is maximized. Of course the agent will only borrow from the lender if the optimal investment is greater than the per period income w. In other words, the marginal benefit of investing in $b()$ has to be sufficiently high for the agent to want to borrow money. For the remainder of the analysis we assume this to be the case.

Assumption 4. $v'(b(w))b'(w) > v'(w)$

Under this assumption the agent will borrow amount i' given by the first order condition

$$v'(b(w+i'))b'(w+i')) = (1+r)v'(w - i'(1+r)) \tag{4.3}$$

The borrower's actual life-time utility after borrowing i units of capital, however, is given by

$$U = v(b(w+i)) + v(w - i(1+r) - \gamma b(i)). \tag{4.4}$$

Once again the only difference between $\tilde{U}$ and U is the fact that one includes the habit term, in this case $\gamma b(i)$, and the other does not. The agent suffering from projection bias does not understand that high consumption in the first period of his life will make it more painful to consume little in the second period. By ignoring this effect he will choose an excessively high level of consumption in the first period and will over-invest.

The optimal level of investment, i^*, taking account of the effects current consumption has on future consumption, is given by the first order condition

$$v'(b(w+i^*))b'(w+i^*)) = (1+r+\gamma b'(i^*))v'(w-i^*(1+r)-\gamma b(i^*)) \tag{4.5}$$

Proposition 11. *A borrower suffering from projection bias will borrow more than optimal, $i' > i^*$*

Proof. Follows directly from comparing equations 4.4 and 4.5. The left hand sides of both equations are identical and strictly increasing in i and the right hand side is strictly decreasing in i. For a given i, the right hand side of equation 4.5 is unambiguously greater than the right hand side of equation 4.4. Hence $i^* < i'$. □

Intuitively this result is straightforward. The agent suffering from projection bias is unaware of the negative externality of borrowing i and hence overborrowers.

4.8 Discussion and Comparison To Hyperbolic Discounting

Many of these features in the credit market have previously been explained by *hyperbolic discounting*, the tendency to be impatient now and patient later. Fischer and Ghatak (2009), for example, show how this can explain the high frequency in repayments. While I am not aware of any formal theory linking flat interest calculations to hyperbolic discounting, it would be straightforward to write down such a model.

Hence, it is important to understand why there is a need for yet another behavioural theory and exactly how these two differ in their interpretations. As will be shown in more detail below, one major difference between the two theories is their welfare implication. For example, hyperbolic discounting may be able to explain why flat interest calculations remain common, but unlike projection bias over habit formation, the flat shape of the repayment schedule itself does not imply any welfare cost. While hyperbolic discounting can lead to over-borrowing or to borrowing at a higher than optimal interest rate, it cannot explain the prevalence of flat repayment schedules. In fact, a hyperbolic discounter would prefer to opt for a payment schedule with higher repayments in future periods and lower repayments in the current period.

4.8.1 A Small Model on Hyperbolic Discounting

In order to formalize the intuition outlined above, consider an agent who discounts the future hyperbolically. Formally, the borrower discounts utility in t periods in the future according to:

$$\delta(t) = \frac{1}{1+kt} \tag{4.6}$$

In our two period model, we have only two different discount rates. In period zero, the agent discounts utility in period 1 with $\delta_1 = \frac{1}{1+k}$ and in period 2 with $\delta_2 = \frac{1}{1+2k}$. However, once the agent is in period 1, he will discount utility in period 2 with δ_1 again.

This section will outline a partial analysis of the lending market, by looking only at the borrower participation constraint and welfare, which are the only components in which the two models differ. To keep matter simple, we are going to assume once again that the agent cannot save. As before, the borrower has the option to borrow from a lender and repay in two instalments such that $t_1 + t_2 = R$ and in return he can undertake a project that yields x in each period.

The utility maximizing choices of the agent in period zero are usually interpreted as the welfare maximizing choices of the agent. This is what the agent would like to commit to, but may find himself unable to, because in period 1 he will renegotiate his decision. Despite its obvious weaknesses, we will follow this approach and treat the period zero utility maximizing contract to be the welfare maximizing contract. The contract which is actually chosen in period 1 will then be compared relative to this benchmark.

The Period Zero Agent - The Welfare Maximizing Contract

As in the previous section, the agent in period zero will choose the contract that equalizes his marginal utilities from either period.

$$\delta_1 v'(x - t_1^*) - \delta_2 v'(x - t_2^*) = 0 \tag{4.7}$$

$$\Rightarrow \quad \frac{\delta_1}{\delta_2} = \frac{v'(x - t_2^*)}{v'(x - t_1^*)} \tag{4.8}$$

which implies that the optimal contract is involves $t_1^* < t_2^*$. This is the first difference to the model on projection bias: the optimal contract should imply a decreasing consumption profile, not an increasing one.

The Period One Agent - The Chosen Contract

While the above contract is optimal from the eyes of a period zero agent, in period one the optimality condition is given by:

$$v'(x - t_1^*) - \delta_1 v'(x - t_2^*) \tag{4.9}$$

$$\Rightarrow \quad \frac{1}{\delta_1} = \frac{v'(x - t_2)}{v'(x - t_1)} \tag{4.10}$$

The first thing to note is that the optimal contract and the actually chosen contract will only coincide if $\delta_2 = \delta_1^2$, that is if the agent is a traditional, exponential discounter.

We can then compare the two expressions to understand in which direction hyperbolic discounting biases the chosen contract relative to the optimal contract.

Since $\delta_1^2 = \frac{1}{(1+k)^2} < \frac{1}{1+2k} = \delta_2$, we know that the agent will not choose the optimal contract, but will in fact choose a contract in which the first instalment is smaller than the optimal first instalment $t_1 < t_1^*$. To see this more precisely, note that

$$\frac{\delta_1}{\delta_2} < \frac{1}{\delta_1} \quad \Rightarrow \quad \frac{v'(x - t_2^*)}{v'(x - t_1^*)} < \frac{v'(x - t_2)}{v'(x - t_1)} \tag{4.11}$$

Combined with the fact that $t_1 + t_2 = R$, it follows that $x - t_1 > x - t_1^*$ and hence $t_1' < t_1^*$.

This is the well known result that agents who hyperbolically discount the future will over-consume in the current period relative to the welfare maximizing $t = 0$ consumption plan. Once the current period begins, the marginal utilities between the current period and the future period are no longer the same as they were initially and the agent revises his current consumption upwards.

In this, projection bias and hyperbolic discounting agree in their prediction that borrowers will choose a contract leading to period 1 consumption which is too high relative to the optimal, welfare maximizing level.

The results in this section can be summarized as follows:

Result 4. 1. *The optimal contract for an agent who discounts the future hyperbolically is one in which $t_1^{**} < t_2^{**}$. The optimal contract for someone who suffers from projection bias is one in which $t_1^* > t_2^*$.*

2. *Both hyperbolic agents and agents suffering from projection bias over habit formation will select a contract such that the first instalment t_1 is less than the*

optimal instalment (t_1^* and t_1^{**}) respectively.

The two models may therefore be able to explain some of the same phenomena observed in microfinance and other credit markets; however, they are not observationally equivalent and may even call for different policy interventions.

Banning flat interest calculations and flat repayment schedules, for example, would improve the welfare of someone suffering from projection bias over habit formation, but would harm the utility of a hyperbolic discounter. Other innovative interventions, such as commitment saving products, would increase the welfare of either borrower.

4.9 Conclusion

Projection bias is the tendency to underestimate to what extent future tastes and preferences may differ from current tastes and preferences, a phenomenon that has been frequently observed in many economic and non-economic situations (see Ariely and Loewenstein (2005) on sexual arousal, Read and Loewenstein (1999) on pain, Loewenstein and Van Boven (2003) on thirst, Badger et al. (2007) on heroin and Acland and Levy (2010) on gym attendances).

This paper has shown that projection bias over habit formation, as first formally modelled by Loewenstein et al. (2003), can theoretically explain many features observed in microfinance. These include the prevalence of flat interest calculations, frequent repayments and over-borrowing, all of which are difficult to reconcile with standard economic theory.

Appendix to Chapter 2

4.10 Proof of Proposition 4

- $\overline{x} \in [2r, \tilde{x}) : \pi_{seq} \geq \pi_{sim}$ if

$$1 - \beta^2(r/\overline{x})^2 - 2\beta(r/\overline{x})^2 \leq 1 - r/\overline{x} + \frac{r/\overline{x}(1-(1+\beta)r/\overline{x}}{2 - r/\overline{x}}$$
$$\Rightarrow \beta^2\left(2(r/\overline{x}) - (r/\overline{x})^2\right) + \beta\left(3(r/\overline{x}) - 2(r/\overline{x})^2\right) - 1 \geq 0$$

For $\beta = 1$ the above expression holds for all $\overline{x} < \tilde{x}$ hence it also holds for all $\beta \geq 1$ and $\overline{x} < \tilde{x}$.

- $\overline{x} < 2r : \pi_{seq} \geq \pi_{sim}$ if

$$1 - (r/\overline{x}) - (r/\overline{x})^2\beta^2 + \beta(r/\overline{x})^2 \leq 1 - (r/\overline{x})$$
$$\Rightarrow \beta^2(r/\overline{x})^2(1-\beta) \leq 0$$

  which holds for all $\beta \geq 1$.

- $\overline{x} \geq \tilde{x} : \pi_{seq} \geq \pi_{sim}$ if

$$\beta^2\left(2(r/\overline{x}) - (r/\overline{x})^2\right) + \beta\left(3(r/\overline{x}) - 2(r/\overline{x})^2\right) - 1 \geq 0 \tag{4.12}$$

  which has as solution for β:

$$\beta = \frac{\left((r/\overline{x})^2 - (r/\overline{x})\right) \pm y\sqrt{((r/\overline{x}) - 1)((r/\overline{x}) - 9/5)}}{2(2(r/\overline{x}) - (r/\overline{x})^2)} \tag{4.13}$$

Hence for all β greater than the positive root above, sequential group lending has a higher repayment rate than simultaneous or individual lending regardless of distribution of output.

□

4.11 Proof of Proposition 5

The minimum amount of official penalty required for individual lending is lower than for simultaneous group lending iff

$$\frac{(r-\rho)\overline{x}}{r^2} \geq -1 \geq \sqrt{1+\frac{(r-\rho)\overline{x}^2}{r^3}} \tag{4.14}$$

choosing the positive root for the quadratic for β_{sim}^{min}. For simplicity define $y \equiv \frac{(r-\rho)\overline{x}}{r^2}$ the above inequality becomes:

$$\begin{aligned} 1+y &\geq \sqrt{1+y\overline{x}/r} \\ 1+2y+y^2 &\geq 1+y\overline{x}/r \\ y(2-\overline{x}/r+y) &\geq 0 \end{aligned}$$

since $y > 0$ and substituting back for y this gives:

$$\overline{x} \geq \frac{2r}{\rho}. \tag{4.15}$$

Hence for all $\overline{x} \geq \frac{2r}{\rho}$ we have $\beta_{ind}^{min} \geq \beta_{sim}^{min}$ and hence the minimum penalty required for simultaneous group lending is greater than for individual lending.

□

Appendix to Chapter 3

Figure 4.7: The mean number of patient choices does not vary significantly across treatments in the first multiple price list ($\beta\delta$). This is robust to controlling for demographic characteristics.

	(1) Patient Choices	(2) Patient Choices
Treatment 2	0.08	-0.07
	(0.50)	(0.48)
Treatment 3(a)	-0.41	-0.48
	(0.54)	(0.53)
Treatment 3(b)	0.80	0.17
	(1.51)	(1.46)
Education		0.16
		(0.16)
Literate		-1.67*
		(0.99)
IQ		0.02
		(0.13)
Income		-0.00
		(0.00)
CRRA		-0.38**
		(0.16)
Hindu		0.78
		(1.15)
Constant	3.28***	3.80**
	(0.41)	(1.46)
Observations	102	99
R-squared	0.01	0.14

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 4.8: The mean number of patient choices varies significantly across treatments in the second multiple price list (δ). This is robust to controlling for demographic characteristics.

VARIABLES	(1) Patient Choices	(2) Patient Choices
Treatment 2	0.94**	0.94*
	(0.45)	(0.51)
Treatment 3(a)	0.37	0.34
	(0.50)	(0.53)
Treatment 3(b)	-2.54***	-2.81***
	(0.45)	(0.43)
Education		0.31***
		(0.11)
Literate		-2.09***
		(0.73)
IQ		-0.14
		(0.12)
Income		0.00
		(0.00)
CRRA		-0.18
		(0.16)
Hindu		-0.38
		(0.72)
Constant	2.50***	3.61***
	(0.36)	(1.00)
Observations	102	99
R-squared	0.10	0.16

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Figure 4.9: The mean number of patient choices varies significantly across treatments in the second multiple price list (δ). This holds specifically only for those participants with $\delta < 1$.

	(1) δ	(2) δ
$\mathbf{1}(\delta > 1)$		0.21***
		(0.04)
Treatment 2	0.06*	0.05**
	(0.03)	(0.02)
Treatment 2 $\times\mathbf{1}(\delta > 1)$		-0.03
		(0.06)
Treatment 3(a)	0.02	0.03
	(0.03)	(0.02)
Treatment 3(a) $\times\mathbf{1}(\delta > 1)$		0.06
		(0.07)
Treatment 3(b)	-0.14***	-0.07***
	(0.03)	(0.02)
Constant	0.96***	0.89***
	(0.02)	(0.02)
Observations	117	117
R-squared	0.06	0.52

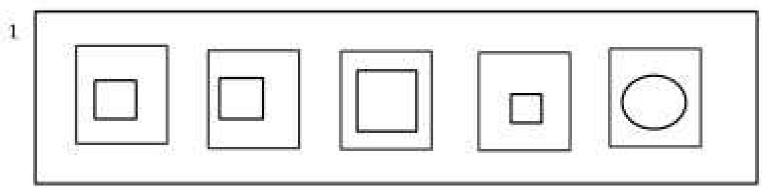
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 4.10: This was the handout received by participants in treatment 1

Figure 4.11: This was the handout received by participants in treatment 2

Figure 4.12: This was the handout received by participants in treatment 3

Figure 4.13: Sample IQ Question



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