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THE EFFECT OF RISK, TIME PREFERENCE, AND POVERTY ON THE IMPACTS OF FOREST TENURE REFORM IN CHINA

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**THE EFFECT OF RISK, TIME PREFERENCE, AND POVERTY ON THE
IMPACTS OF FOREST TENURE REFORM IN CHINA**

BY

KAREN ANNE SULLIVAN

**A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY**

IN

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ABSTRACT

Forest degradation has steadily increased throughout much of the world. The cause of this continued degradation is complex and multifaceted but there is a growing realization that a key cause, especially in developing countries, is insecure rights to ownership and use of forest resources. This realization coupled with a call for pro-poor forestry policy has stimulated the recent trend in forest policy toward strengthening property rights for forest resources by transferring property rights from the state to communities and individuals, giving them defined rights to manage and extract forest resources. However, a big puzzle remains unsolved—such reforms on property rights have not consistently led to the intended sustainable resource use and management, particularly in developing countries.

The overall goal of this dissertation research is to offer insight into why forest tenure reforms may not always lead to their intended effects by focusing on how an individual's preferences over time and risk affect individual responses to forest tenure reforms. Since forest management involves dynamic decision making with uncertainty in future returns, individuals' forest management decisions, as well as their responses to forest tenure reforms, will depend on: 1) how an individual perceives preference for income today versus the future (time preference), and 2) an individual's attitude towards risk (risk preference). For example, even if individuals are given secure property rights, those with strong preference for current benefits (most commonly observed among the poor) may have the incentive to use forest resources faster. Failure to recognize the impacts of time and risk preferences of individuals may result in outcomes that policy maker sought to prevent. Furthermore, forest tenure reforms

are often implemented in areas where the poverty rate is high. Those living in poverty are often assumed to have both high discount rates (i.e., impatient) and high levels of risk aversion, which make them less likely to make investments. Such characteristics may also hinder the intended effects of forest tenure reforms.

This study examines these issues in the context of rural China, where a large-scale reform of forest property rights is being implemented in areas where the poverty rate is still high. To examine these issues, this dissertation research has three objectives: 1) identify the impact of forest property rights reforms on forest management decisions and how individual risk and time preferences may augment those impacts; 2) examine the correlation between time and risk preferences and poverty; and 3) identify the effect of the forest tenure reform on household wealth.

This dissertation research contributes to the literature on the effect of property rights reforms on natural resource management in developing countries in several ways. This study is the first to use a large-scale property rights reform to examine the heterogeneity of its impact on forest management due to risk and time preferences. Moreover, it integrates experimental economics methods into natural resource management, which is an innovative approach to test the behavioral reactions to policy alternatives. This study is unique because it tests the theory by integrating field experiments to capture risk and time preferences and panel survey data to capture poverty and forest management decisions.

To achieve the research objectives, I first designed experiments to capture individual time and risk preferences and then ran them in the field with farmers in China. Then I integrated data the field experiment data with a household panel data in

an econometric framework. In manuscript 1, I use this integrated data set to examine how preferences over time (present vs. future) and risk can affect households' forest management responses to strengthened forest property rights. I find that risk and time preferences impact households' forest management responses to forest plot certification. Specifically, in response to forest certification, more risk averse households used less labor for harvesting and more labor for applying inputs, while more loss averse households used more labor for harvesting. Households with higher discount rates (i.e., impatient) used less labor for applying inputs and spent less on forest inputs (chemical fertilizer, pesticides, and seeds) in response to receiving a forest certificate.

Manuscript 2 investigates the correlation between poverty and individual preferences for time and risk. The classic assumption is that the poor have both high levels of risk aversion and high discount rates. Contrary to this assumption, my research demonstrates that wealth does not have a significant effect on risk aversion or loss aversion (with the one exception that households with more forestland per capita are less loss averse). However, consistent with this assumption I find statistically weak evidence that households with lower wealth have higher discount rates (i.e., more impatient).

In manuscript 3, I examine the effect of forest tenure reform on household wealth. I find statistically weak evidence that the forest tenure reform has had a positive effect on household wealth, specifically, increased tenure security in the form of a forest certificate increased net worth per capita by 42% between 2000 and 2008. To further examine the source of increased wealth, I also examine the effect of the reform on

household forest use. Results suggest that forest certification increased bamboo revenue, while obtaining a new plot (without a forest certificate) increased non-timber forest product revenue, although these results are statistically weak. Overall manuscript 3 provides weak evidence that forest tenure reform garners potential for improving poor rural households' livelihoods in China.

Overall this dissertation research demonstrates that time and risk preferences matter for forest management and responses to forest tenure reforms. This suggests that policymakers designing and implementing tenure reforms should consider the particular context of the reform and consider coupling the reform with appropriate programs and instruments to alleviate poverty and to help households' to deal with risks and make long-term investments to further stimulate the intended effects of the reform—increased investment in forest resources and improved livelihoods.

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Gate (especially, Anni and Liz) for helping to keep me balanced; the Spino family (Cindy, Tim, Ashley, Katie and Carlos) and especially my family - my brother Matt, uncle Jimmy, aunt Eleanor, Dad, and Grandma.

DEDICATION

This dissertation is dedicated to my father, Matthew F. Sullivan III,
and my grandmother, Winifred E. Sullivan.

Dad, you taught me how to work hard.

Grandma, you taught me how to be strong.

I am truly grateful for these lessons and your belief in me.

PREFACE

This dissertation submitted in partial fulfillment of the requirements for the degree of doctor of philosophy in Environmental and Natural Resource Economics is in the manuscript style format. The dissertation is composed of three manuscripts.

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INTRODUCTION

Forests perform a multitude of ecosystem services and contribute directly to the livelihoods of more than one billion people living in extreme poverty (World Bank 2004). Despite the national and international efforts devoted to global problems of deforestation, forest degradation has steadily increased throughout much of the world (White et al. 2002).

The cause of this continued degradation is complex and multifaceted but there is a growing realization that a key cause, especially in developing countries, is insecure rights to ownership and use of forest resources (White et al. 2002; Sunderlin et al. 2005; FAO 2007; Sunderlin et al. 2008). Property rights to ownership and use of forest resources are often contested, overlapping or unenforced. This insecurity undermines sound forest management, for without secure rights forest holders have few incentives to invest in managing and protecting their forest resources. This realization coupled with a call for pro-poor forestry policy from international institutions, NGOs, and community organizations has stimulated the recent trend in forest policy toward strengthening property rights for forest resources by transferring property rights from the state to communities and individuals, giving them defined rights to manage and extract forest resources (Wunder 2001; Edmonds 2002; FAO 2003; Ellsworth et al. 2004; Sunderlin et al. 2005; Hobley 2007; FAO 2009). In the most forested developing countries, this trend has resulted in a doubling of the percent of forest owned or controlled by indigenous and rural communities between 1985 and 2000 (White et al. 2002). By 2050, 40% of the world's forest is expected to be managed or owned by communities and individuals (FAO 2003).

However, research to date presents conflicting conclusions regarding the impacts of tenure insecurity on forest management. For example, some empirical studies found that stronger land tenure facilitated investment in trees (e.g., Ghana (Besley 1995) and Ethiopia (Holden, Deininger, and Ghebru 2009)). At the same time, other examples illustrate that these reforms have not led to their intended consequence of sustainable resource management (Ecuador (Wunder 2000), Indonesia (Barr 2001), Russia (White and Martin 2001) and newly independent states of Eastern Europe (INDUFOR OY/ECO for the World Bank and World Wildlife Fund Alliance 2001) and others (Bromley 1989; Ostrom 1990; Bromley 1991; Alston, Libecap, and Mueller 1999)).

This dissertation research attempts to offer insight into why forest tenure reforms may not always lead to their intended effects by focusing on how an individual's preferences over time and risk affect individual responses to forest tenure reforms (Figure 0.1). Forest management involves decisions about investments with long time horizons and those decisions involve uncertainties (e.g., price uncertainty; uncertainty about future growth and quality of retained stands; uncertainty about property rights and expropriation; uncertainty associated with outbreaks of disease, pests, and forest fire and the occurrence of extreme weather events) (Newman 2002; Alvarez and Koskela 2004; Nielsen and Kristensen 2005; Wilson et al. 2011). Since forest management involves dynamic decision making with uncertainty in future returns, individuals' forest management decisions, as well as their responses to forest tenure reforms, will depend on: 1) how an individual perceives preference for income today versus in the future (time preference), and 2) an individual's attitude towards risk (risk preference). By taking individual preferences into account, we may find that forest

tenure reform has the intended effects on individuals with some characteristics, while it does not have the intended effects on others. This heterogeneity in policy effect may be masked in studies that find negligible effect of the reforms.

In a developing country context, the potential correlation between individual preferences and the effect of forest tenure reforms is also associated with poverty. The intended effect of forest tenure reforms is to increase tenure security. Economic theory predicts that increased tenure security will give households greater incentives to invest without fear of expropriation. This increased investment should raise productivity and cash flows, which in turn should stimulate incomes as well as land values and general levels of economic activity, helping the rural poor escape from poverty (Demsetz 1997; Besley 1995; World Bank 2003; Feder 1999; Conning and Deb 2007). This often-assumed premise is examined specifically in this dissertation. Moreover, households living in poverty are often assumed to be highly risk averse (Bardhan and Udry 1999; Stiglitz) and have high rates of discount rates (impatient), which keep them from making investments. This assertion is also tested in this dissertation. In sum, I examine four main hypotheses (Figure 0.1): H1) Forest property right reforms affect how individuals manage their forest resources; H2) Time and risk preferences affect forest management and therefore also augment individual forest management responses to forest property rights reforms; H3) Time and risk preferences are negatively correlated with wealth; and H4) Household wealth increases as a result of the forest tenure reforms.

Economic theory predicts that increased tenure security from tenure reform will increase households' investment in forest resources. However, because investment and

forest management decisions are dynamic, there are several possible paths by which households may reach a higher steady state investment level (I^*) in response to the tenure reform (Figure 0.2). Households' investment paths may depend on factors such as their available capital, access to credit, other investment opportunities, forest product market conditions, forest plot characteristics, and individual preferences. For example, line (a) depicts a trajectory in which a household instantaneously increases investment to the optimal level in response to the tenure reform. A household with abundant capital or ability to borrow such that it can invest as soon as its land tenure is strengthened may follow an investment path like (a). Alternatively, a household without access to capital or credit or that has a high discount rate (i.e., impatient) may not increase investment even with strengthened tenure, as depicted by line (d). Lastly, in response to the tenure reform households may exhibit a period of transition during which the household increases the investment level towards a new steady-state level. During the transition period, a household may increase investment gradually, as depicted by line (b) or in a series of steps (c), depending on their particular circumstances. A household's investment path may look like (c) if, for example, the household is risk averse and is unsure about the security of their new property rights, or if a household cannot access capital or credit quickly. Such a household may wait a period of time before increasing investment.

Increased investment should raise productivity and cash flows, which in turn should stimulate forest revenue. As with changes in investment, changes in forest revenue may take different paths towards a higher steady state level of forest revenue, R^* (Figure 0.3). Households' forest revenue depends on both their investment and

harvesting decisions, which in turn depend on a variety of factors such as their available capital, access to credit, other investment opportunities, forest plot characteristics, product market conditions, and personal preferences. For example, a household that is able to invest in its forest plot immediately following the reform may see a gradual increase in forest revenue over a transition period, as depicted by line (a), before it reaches the long-term steady state level of forest revenue, R^* .

Alternatively, a household that is unable to invest following the reform may not experience any increase in forest revenue, as depicted by line (b). Furthermore, a household may experience a temporary dip in forest revenue during the transition period, as depicted by line (c). This temporary dip may occur if a household with strengthened land tenure now waits until the new, longer optimal harvesting age is reached. The next subsection will explain how the three manuscripts in this dissertation investigate these hypotheses.

Outline of the three manuscripts

In Manuscript 1, I examine the relationships in H1 and H2. Specifically, I examine how forest tenure reform affects harvesting behavior and investment in forest plots. Increased tenure security gives households confidence that if they invest in their plot (planting, maintenance, etc.) then they will be able to obtain the benefits from those efforts in the future (Demsetz 1967; Besley 1995). As such, I hypothesize that households that were subject to forest tenure reform will have an incentive to invest in their forests resources and delay harvest until the optimal harvesting threshold is reached (H1).

Furthermore, in manuscript 1, I investigate the heterogeneity in the effects of the forest tenure reform by focusing on risk and time preferences as the source of heterogeneity (H2). Households making forest management decisions face many uncertainties. Furthermore, decisions about forest management often involve a long time horizon (Alvarez and Koskela 2006; Nielsen and Kristensen 2005; Wilson et al. 2011). As such, households' risk and time preferences take an important role in their forest management decisions (Newman 2002; Tahvonen et al. 2006; Couture et al. 2008), and may affect their responses to forest tenure reforms. Certain types of households' risk and time preferences may lead forest tenure reform to affect forest management in ways that are consistent with what policymakers intended. For example, assuming that with forest tenure reform a household believes that there has been a reduction in the risk of expropriation of its forest plot, then a household that is more risk averse may make more investments on the forest plots than a risk neutral or risk seeking household. Alternatively, households' risk and time preferences may cause them to respond to receiving a forest tenure reform in a way that is contrary to what policymakers intended. For example, in response to forest tenure reform, a household that has a high discount rate (impatient) may make less investment than a household with a low discount rate. Relatedly, a household that is more loss averse (i.e., has a tendency to strongly prefer avoiding losses to acquiring gains and to dramatically overweight losses relative to gains) may make less investment after a forest tenure reform than a household that is less loss averse. Therefore the intended effect (increased investment) that policymakers expected in response to a forest tenure

reform may be weak or may not be exhibited by households with high discount rates or a high degree of loss aversion.

In manuscript 2, I examine the association between poverty and individual preferences (H3). Households living in poverty are often assumed to be highly risk averse and have high discount rates (impatient), characteristics that keep them from making investments (Fisher 1930; Lipton 1968; Lumley 1997; Bardhan and Udry 1999; Fafchamps 2003). Since Binswanger's early use of experimental economics to capture risk preferences in India in the 1980s and Pender's work also in India in the late 1990's, economists have been examining the correlation between poverty, risk and time preferences. However, empirical findings on whether individual time and risk preferences vary with wealth have been mixed (e.g., Binswanger 1980; Pender 1996; Kirby et al. (2002) Nielsen 2001; Wik 2004; Mosley and Verschoor 2005; Chytilová and Morduch (2010)). Manuscript 2 offer new empirical evidence.

Finally, manuscript 3 examines whether or not household wealth has increased as a result of the forest tenure reform (H4). In addition to increasing investment in forest resources, an additional goal of the forest tenure reform in many developing countries is to improve households' livelihoods. Economic theory predicts that with more secure property rights, households will have a greater incentive to invest in their forest resources without fear of expropriation, which will stimulate income (Demsetz 1967; Besley 1995; Feder 1999; Coning and Deb 2007). There is growing evidence that forest tenure reforms cause changes in local livelihoods but those changes have been both positive and negative (Shackleton and Campbell 2001; Edmunds and Wollenberg 2003; Jagger, Pender and Gebremedhin 2005; Sikor and Nguyen 2007). Manuscript 3

offers new empirical evidence based on a large-scale forest property rights reform. Specifically, I examine how changes in forest land tenure affect households' net worth per capita, and further examine to see if the source of this effect is from changes in revenue from bamboo and non-timber forest products.

I examine these issues empirically in the context of China's collective forests, where a large-scale reform of forest property rights began in 2003 in rural areas where the poverty rate is still high. The reform was aimed at delegating responsibility of forest management from the collective (by townships and villages) to households and strengthening property rights with the distribution of forest certificates that establish the use of a specific forest plot for a period of 30-70 years and expand rights to include those of land transfer, inheritance, and mortgaging (Xu et al. 2009). An advantage of this study is that we utilize this actual change in forest property rights whereas previous studies have used proxy variables (e.g., number of conflict with abutters and duration of residence in a village) that are either subjective or indirect measures and may not accurately measure tenure security (Godoy et al 1998; Godoy et al. 2001; Hagos and Holden 2006). China's collectively owned forests total approximately 100 million hectares and are home to more than 400 million people, which arguably makes these reforms the largest one undertaken in modern times both in terms of forest area and people affected (Xu et al. 2010). In China, many people living in or near forests are poor (Zhou and Veeck 1999), and while there has been a dramatic reduction in the poverty rate in China over the last decades, poverty is still a serious problem, particularly in rural areas (Chen and Ravallion 2008; 2009). The recent rapid and dramatic changes in forest tenure in poor regions in China makes it an ideal context to

study how individual preferences affect forest management decisions and the implications for the effectiveness of strengthening property rights to stimulate investment in forest resources and improve households' livelihoods.

To test these hypotheses, I combine original field experiment data on risk and time preferences collected from among 103 households in 2009 in Fujian Province with an original panel survey data set collected from among the same 103 households in 2006 and 2009. The panel data set contains pre- and post-reform, quantitative and qualitative data for three years: 2000 (before the reform), 2005 and 2008 (after the reform). The major strength of the time and risk preference data is that I use experiments with real monetary rewards, which reduces hypothetical biases that exist in previous related studies (Godoy et al. 1998; Godoy et al. 2001; Hagos et al. 2006). Furthermore, our risk preference experiment design follows a recently developed methodology that expands the classic lottery experiment of Holt and Laury (2002) to allow for estimation of a more flexible and richer description of a person's risk preference as described under prospect theory—the degree of risk aversion, the degree of loss aversion, and a nonlinear probability weighting measure (Tanaka et al. 2010).

In examining these hypotheses there are econometric challenges that must be addressed. For example, in manuscript 1, I aim to identify how heterogeneity in households' time and risk preferences may impact the average effect of forest plot certification on household forest management (H1). To identify this effect, the ideal would be to compare forest management outcomes under the counterfactual of no forest certification. But plots cannot both receive a forest certificate and not receive a forest certificate, and so actual counterfactuals cannot be observed. Instead we need to

estimate the value of this unobserved counterfactual's outcomes by obtaining a comparison group of plots that did not receive a forest certificate. The identification problem is that it is difficult to identify a reliable comparison group for those receiving a forest certificate because of non-random placement of forest plot certification and/or self-selection of households into forest plot certification. Without a carefully selected comparison group, we risk incorrectly attributing differences in measured forest management outcomes between those plots for which households received a forest certificate and plots for which households did not receive a forest certificate to forest plot certification when in fact they may be due to initial differences in observed (e.g., education of the head of household) and unobserved characteristics (e.g., entrepreneurial ability) between the two groups (Conning and Deb 2007). To address these sources of biases, we use a variety of econometric techniques throughout the three manuscripts, including: preprocessed matched data in a difference-in-differences framework, fixed effects, and instrumental variable approach.

The outcome of this research has implications for policymakers in China and elsewhere by informing when they can expect property right reforms to stimulate investment in the resource and when they may not as a result of heterogeneity in households' risk and time preferences. The results may indicate that instruments to deal with risk, time preferences, and poverty need to be coupled with such reforms. Although this research is conducted in the context of forests, the general finding may also apply to other natural resources where lack of property rights have been recognized as a key barrier to sustainable management of natural resources.

Figure 0.1 Main Hypotheses

Figure 0.2 Examples of investment paths following forest tenure reform

Notes: T^* indicates the optimal rotation age under well-defined property rights. This figure assumes that the optimal rotation time with well-defined property rights is longer than with weaker property rights and that prior to the reform the rotation is shorter than optimal. I^* is the optimal steady state investment level. (a) indicates a trajectory in which a household instantaneously increases investment to the optimal level after the tenure reform. (b) and (c) include a transition period after the tenure reform during which the investment level increases towards the new steady state level. (d) is a trajectory in which the tenure reform does not affect the investment level.

Figure 0.3 Examples of forest revenue paths following forest tenure reform

Note: T^* indicates the optimal rotation age under well-defined property rights. This figure assumes that the optimal rotation time with well-defined property rights is longer than with weaker property rights and that prior to the reform the rotation is shorter than optimal. R^* indicates the optimal steady state forest revenue level. (a) indicates a transition period after the tenure reform during which the forest revenue increases towards the new steady state level. (b) indicates a trajectory where the tenure reform does not affect forest revenue. (c) is a trajectory where forest revenue falls temporarily during the transition period.

MANUSCRIPT 1

**Impact of Risk and Time Preferences on Responses to Forest Land Tenure
Reform: Empirical Evidence from Fujian, China**

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Impact of Risk and Time Preferences on Responses to Forest Land Tenure Reform: Empirical Evidence from Fujian, China

1.1 Abstract

We examine how preferences over time (present vs. future) and risk can affect households' forest management responses to strengthened forest property rights. We investigate this question in the context of rural Fujian, China, where a large-scale reform of property rights began in 2003. The different extent of the reform and its different timing across villages provide a natural experiment to test how time and risk preferences affect households' forest management activities in response to the reform. Empirically, we combine original field experiment data on time and risk preferences collected from among 103 households with an original panel survey data set collected from among the same households. The panel data set contains data for three years: 2000 (before the reform), 2005 and 2008 (after the reform). We preprocess the data using matching methods and then use difference-in-differences to identify the impact of the reform and its sensitivity to risk and time preferences on three measures of household forest management: labor for applying forest inputs to each plot, expenditure on inputs for each forest plot and labor for harvesting forest products from each plot. The status of the forest tenure reform on each forest plot is captured by an indicator variable of whether or not the household has a forest certificate for the plot. Results show that risk and time preferences impact households' forest management responses to forest plot certification. Specifically, in response to forest certification,

more risk averse households used less labor for harvesting and more labor for applying forest inputs, while more loss averse households used more labor for harvesting. Households with higher discount rates (i.e., stronger preference for income today) used less labor for applying inputs and spent less on forest inputs in response to forest certification.

1.2 Introduction

Forest degradation has steadily increased throughout much of the world (White et al. 2002). The cause of this continued degradation is complex and multifaceted but there is a growing realization that a key cause, especially in developing countries, is the insecurity of rights to ownership and use of forest resources (White et al. 2002; Sunderlin et al. 2005; FAO 2007; Sunderlin et al. 2008). Property rights to ownership and use of forest resources are often contested, overlapping or unenforced. This insecurity undermines sound forest management, for without secure rights forest holders have few incentives to invest in managing and protecting their forest resources. This realization has stimulated the recent trend in forest policy toward strengthening property rights for forest resources by transferring property rights from the state to communities and individuals, giving them defined rights to manage and extract forest resources (Edmonds 2002; FAO 2003; Ellsworth et al. 2004). In the most forested developing countries, this trend has resulted in a doubling of the percent of forest owned or controlled by indigenous and rural communities between 1985 and 2000 (White et al. 2002). By 2050, 40% of the world's forest is expected to be managed or owned by communities and individuals (FAO 2003). However, a puzzle remains unsolved—such reforms on property rights have not consistently led to the

intended sustainable resource use and management, particularly in developing countries (Bromley 1989; Ostrom 1990; Bromley 1991; Alston et al. 1999; Bohn et al. 2000; Wunder 2000; Barr 2001; White et al. 2002; Jagger et al. 2005).

Despite the existence of this puzzle, a lack of attention has been given to understanding the heterogeneity in how people respond to property rights reforms depending on their individual preferences. In particular, given that forest management decisions need to be made by looking into the future and therefore inherently contain uncertainties (e.g., price uncertainty; uncertainty about future growth and quality of retained stands; uncertainty about property rights and expropriation; uncertainty associated with outbreaks of disease, pests, and forest fire and the occurrence of extreme weather events), the two key factors that would influence a forest management decisions are: 1) the household's preference for income today versus in the future (time preference), and (2) the household's attitude towards risk (risk preference).

In this paper, we examine how households' preferences over time (present vs. future income) and risk affect forest management responses to property rights reforms. For example, even if households are given secure property rights, those with strong preference for current benefits (commonly observed among the poor) may have the incentive to harvest forest resources faster. Given that resource management is a dynamic problem and thus inherently faces uncertainties, failure to recognize the impacts of households' time and risk preferences may result in outcomes that policymakers sought to prevent through the implementation of the reform.

We examine these issues by capitalizing on a large-scale reform of forest land tenure in Fujian Province, China that began in 2003. Under this reform, the responsibility of forest planting and management were transferred from collective management (by townships and villages) to households. The different extent of the reform, its different timing across villages and the resulting variation in the years households received forest certificates for plots provide a natural experiment to test how time and risk preferences affect households' forest management activities in response to the reform.

Empirically, we combine original field experiment data on risk and time preferences collected from among 103 households in 2009 in Fujian Province with an original panel survey data set collected from among the same 103 households in 2006 and 2009. The panel data set contains pre- and post-reform, quantitative and qualitative data for three years: 2000 (before the reform), 2005 and 2008 (after the reform). To capture household forest management, we examine labor used for applying forest inputs to each plot, expenditure on inputs (chemical fertilizer, pesticide and seeds) for each plot, and labor used for harvesting from each plot. The status of the forest tenure reform on each forest plot is captured by an indicator variable of whether or not the household has a forest certificate for the plot. The major strength of the time and risk preference data is that we use experiments with real monetary rewards, which reduces hypothetical biases that exist in previous related studies (Godoy et al. 1998; Godoy et al. 2001; Hagos et al. 2006). Our time preference experiment uses methods originally developed by Coller and Williams (1999) and Harrison and Lau (2002). The data are then used to estimate three parameters in a

general time discounting model using nonlinear least-squares (Benhabib et al. 2007; Tanaka et al. 2010). Furthermore, our risk preference experiment design follows a recently developed methodology that expands the classic lottery experiment of Holt and Laury (2002) to allow for the estimation of a more flexible and richer description of a person's risk preference as described under prospect theory (Liu 2008; Tanaka et al. 2010). To capture risk preferences, we use the data to estimate three parameters: the degree of risk aversion, the degree of loss aversion and a nonlinear probability weighting measure. The combined experiment and household survey data allow us to link behavior elicited in experiments to actual economic institutions and performance, which few studies have previously done (Cardenas et al. 2005).

To identify the effect of forest tenure reform and how risk and time preferences augment the effect, we use matching techniques to preprocess the data (Ho et al. 2007) and then use the preprocessed matched data in a difference-in-differences framework. The strategy capitalizes on the exogenous variation across villages of the starting year of the reform, and the resulting variation in the year households received a forest certificate for their plots. Results show that risk and time preferences impact households' forest management responses to forest plot certification. Specifically, in response to forest certification more risk averse households reduced labor for harvesting more and increased labor for applying inputs more, while more loss averse households increased labor for harvesting more. As such, the results of this paper have implications for policymakers in China and elsewhere by informing them about how heterogeneity in households' preferences may impact the outcomes of property right reforms.

This paper proceeds as follows. The first section gives an overview of the forest tenure reform history in China, with an emphasis on the recent tenure reforms in Fujian, China. The next section provides an overview of the most relevant literature, followed by the hypotheses to be tested. An explanation of the data collection procedures and a description of the data follow. Then the empirical framework is outlined, followed by the results and a conclusion.

1.3 China's Forest Tenure Reform

This paper examines changes in forest property rights in the context of China, specifically in Fujian Province. China's forest area accounts for 4.5 percent of the world's total. China has two main categories of forest landownership. Approximately 42 percent of forest land in China is owned by the state and the rest is owned by the collective (Liu and Lixia 2009). Since the early 1950s, forest tenure and management policies of China's collective forests have undergone fundamental changes.

Collectivization of non-state owned forests began in 1956, and remained dominant until the reforms of the 1980s (Xu et al. 2009). Under collectivization, administrative villages, usually comprised of a number of natural villages or clusters of families, functioned as the legal owners of collective forests, and households had little active participation in management. For households there were no links between or among their rights to forests, their responsibility for forest establishment and management, and their benefits from forests (Dachang 2001).

The first major wave of reforms in China's collective forests began in 1981, and was aimed at transferring the responsibility of forest planting and management from

the collective to households (Miao et al. 2004). By 1986, nearly 70% of collectively owned forest land had been transferred to rural household management (Xu et al. 2009). In 1987, however, due the occurrence of unsustainable logging the government reverted a large portion of forest land under household management back to collective management (Hyde et al. 2003).

By 1986, while 70% of the collectively owned forest land in China had been transferred to rural household management, in Fujian only 32% of the collective forest land had been distributed for household management (CFYB 1987). This low percentage of forest land under household management was due to the fact that Fujian had not fully participated in the first round of the tenure reforms in the 1980s. Instead, the provincial government in Fujian had implemented a shareholding system to keep forests under collective management while distributing “paper shares” of collective forests based on family population. In Fujian, forest land was not actually physically distributed, rather only dividends from the forest were distributed to households. At first Fujian’s shareholding system was highly regarded by forest administrators for its ability to maintain forests under collective management but fifteen years after establishment of the system, two issues became increasingly evident (Xu et al. 2009). First, forestry’s contribution to rural incomes was negligible in spite of the fact that forest land occupies more than 60% of the total provincial land area, and 80% of rural land area (Qin 2008). Second, enforcing forest conservation had become increasingly difficult for local forest authorities due to lack of cooperation from farmers. For example, the severity of forest fire incidents grew over the course of the 1990s, and

there is anecdotal evidence that many of the fires were caused by farmers (Xu et al. 2009).

Under these circumstances, in 2003 the second wave of reforms was officially approved by the provincial government in Fujian province.¹ In this second wave of reforms, Fujian, the largest but once resistant collective forest province, adopted forest tenure reforms aimed at individualization of forest land. The decisions regarding forest land reallocation during this reform required a 2/3 majority vote by the village representative committees or the village assemblies. Redistribution of plots was accompanied by legal contracts and forest certificates with extended contract periods of 30 to 70 years, whereas previously contract periods had only been 5 to 15 years (Liu and Lixia 2009). Furthermore, adoption of the Rural Land Contract Law allowed for the expansion of rights under the new forest certificates to include those of land transfer, inheritance, and mortgaging (Xu et al. 2009).

Since 2007, fourteen provinces have initiated reforms aimed at both delegating collectively owned forest land to direct household management and strengthening property rights with forest certificates for both households already managing forest plots individually and for new forest plots distributed to households. China's main objectives with this reform are to increase forest coverage, increase farmers' enthusiasm for forest management and investment, and improve farmers' livelihoods (Liu and Lixia 2009). However, China's extensive reform, may not achieve these desired outcomes. The primary recipients of forest certificates during China's reforms have been the rural poor. Individuals living in poverty often exhibit risk aversion and have relatively high rates of time preference (a preference for income and

consumption today), which keeps them from making long-term investments (Fisher 1930; Lawrance 1991; World Bank 2000). These common characteristics of the poor not only have traditionally been cited as reasons why the poor remain poor but they may also hinder the anticipated outcome of creating and strengthening forest property rights through the issuance of forest certificates for household forest plots. Therefore, it is of critical importance to understand the effect of time and risk preferences on household forest management responses to changes in forest property rights.

1.4 Property Rights, Individual Preferences, and Natural Resource Management

Economic theory predicts that if a natural resource is open access, individual extractors do not fully incorporate the resource cost associated with current extraction and thus the resource is overexploited (Gordon 1954; Hardin 1968). Moreover, without secure property rights, individuals lack long-term incentives to use their forest resources (White et al. 2002). In rural areas of poor countries, many forests are subject to open-access extraction even if the government has the property right for the forest because property rights are difficult and costly to enforce (Larson et al. 1990). This lack of secure property rights is recognized as one of the key underlying causes of continued forest degradation in many parts of the world. In response to this recognition, many governments have begun to reform forest ownership policies by devolving resource management to the local level, giving individuals or communities rights to manage and extract the resources (White et al. 2002; FAO 2003).

Research to date, however, presents conflicting conclusions regarding the impacts of tenure security reform on forest management decisions. For example, Besley (1995)

and Holden et al. (2009) find empirical evidence that better land rights facilitated investment in trees in Ghana and Ethiopia, respectively. At the same time, other examples illustrate that tenure reforms have not led to their intended consequence of sustainable resource management (e.g., Indonesia (Barr 2001), Russia (White et al. 2002) and newly independent states of Eastern Europe (INDUFOR OY/ECO for The World Bank and World Wildlife Fund Alliance 2001) and others (Bromley 1989; Ostrom 1990; Bromley 1991; Alston et al. 1999; Bohn et al. 2000).

This paper examines why tenure reforms may not work as intended from a microeconomics perspective, focusing on how risk and time preferences augment individual households' responses to forest property rights reforms. In forest management, households must make decisions about investments over a long time horizon. Furthermore, forest management decisions involve uncertainty over prices and about future growth and quality of retained stands and various production risks such as outbreaks of disease, pests, and forest fire; and the occurrence of extreme weather events (e.g., blizzards, flooding, earthquakes, etc.) as well as uncertainty about property rights and possible expropriation (Alvarez and Koskela 2004; Nielsen and Kristensen 2005; Wilson et al. 2011). Specifically in China, the problems of pests and disease are extremely serious with increasing types, expanding affected areas, and shortening of intervals between attacks, as well as threats from forest fire (Kunshan et al. 1997; Wenhua 2004; Dong et al. 2006). Between 2003 and 2007, China (along with the United States, the Russian Federation, India and Poland) reported the highest average number of forest fires at more than 10,000 per year (FAO 2010). China also has a history of extreme weather events causing severe damage to forest resources. For

example, storms and blizzards in January 2008 damaged 18.6 million hectares of forest in eight provinces in China (FAO 2010). Since forest management involves dynamic decision making with uncertainty in future returns, household forest management decisions, as well as responses to increased tenure security, will depend on households' time and risk preferences (Newman 2002; Nielsen and Kristensen 2005; Alvarez and Koskela 2006; Tahvonen et al. 2006; Couture et al. 2008; Wilson et al. 2011).

Failure to recognize the impact of risk and time preferences on individual responses to forest property rights reforms may result in outcomes policymakers sought to prevent. These factors become even more important in poor economies because risk and time preferences are often found to be correlated with wealth—the poor tend to be more risk averse and have a strong time preference for the present.² Yet to our knowledge, no previous study has directly examined how risk and time preferences affect household responses to property right reforms. This paper extends the literature on property rights reform by using a large-scale property rights reform to examine the heterogeneity of its impact due to risk and time preferences.

The most relevant set of previous work includes Godoy et al.'s (1998; 2001) studies in Bolivia on how tenure insecurity and rate of time preference affect forest resource harvesting and Hagos et al.'s (2006) study in Ethiopia on how tenure insecurity and time and risk preferences affect investment in land conservation. Godoy et al. (1998; 2001) use the duration of a household's residence in the village and the number of conflicts with abutters as proxies for tenure security, and find mixed results. The length of residence in the village was associated with a lower area of old-growth

forest cleared but with a greater area of fallow forest cleared, whereas the opposite was true for conflict with abutters. Conflict was associated with a smaller area of fallow forest cleared but with a greater area of old-growth forest cut. Hagos et al. (2006) find that neither the degree of tenure security nor individual time and risk preferences explains the differences in land conservation and investment decisions.

Although these studies are informative, the measures of risk and time preferences and tenure security need to be improved to achieve stronger confidence in the estimates. Hagos et al. (2006) elicited risk and time preferences from households using hypothetical questions. Results using this method to elicit risk and time preferences may suffer from hypothetical bias, which means that people respond differently when the situation is hypothetical than when the situation is real (Cardenas et al. 2005). By designing questions or experiments to elicit time and risk preferences that offer subjects real payoffs based on their choices, hypothetical bias can be reduced. (Smith et al. 1993; List et al. 2002). Godoy et al. (1998) elicited time preferences by asking subjects if they would prefer one piece of candy now (at the midpoint of an interview) or two at the end of the interview. Although this method involves a real reward, the authors acknowledge that the choice of candy to measure time preference over a very short time may not capture with accuracy time preference or commitment for economic investments, which take place over a longer stretch of time, such as for forest resources. Godoy et al. (2001) elicited risk preferences using hypothetical questions but elicited time preferences using a series of choices with real monetary payoffs. In this paper, we use risk and time preference parameters elicited using

economic experiments with real monetary payoffs; therefore the hypothetical bias is reduced.

In addition, the measures of tenure security also require improvement to achieve more reliable estimates. These studies use proxy variables such as number of conflicts with abutters and duration of residence in a village (Godoy et al. 1998; Godoy et al. 2001; Hagos and Holden 2006). These proxies are either subjective or indirect measures and may not accurately measure tenure security. In this paper, we utilize actual changes in forest property rights and use a more explicit and discrete measure of forest property right changes.

Furthermore, we estimate the joint effect of risk and time preferences on individual responses to changes in property rights, which none of these previous studies have done. Interacting the risk and time preferences with changes in forest property rights allows us to capture how risk and time preferences augment forest management decisions in response to changes in forest property rights.

1.5 Hypotheses

Hypothesis 1: The estimated forest certification effect (the conditional average difference in each forest management activity on plots for which a household has a forest certificate) will be positive when the dependent forest management variable is the value of labor used to apply inputs or expenditure on inputs and negative when it is the value of labor used for harvesting forest product.

Hypothesis (1) is based on the theory that increased tenure security gives households an incentive to invest in their forest resources; that is to increase labor allocation for applying inputs, to increase expenditure on inputs, and to delay harvest

until the optimal harvest time (Demsetz 1967; Besley 1995). A forest certificate increases a household's tenure security. Increased tenure security gives households confidence that if they invest in their plot (planting, maintenance, etc.) then they will be able to obtain the benefits from those efforts in the future. As such, households that receive a forest certificate for a plot will use more labor to apply inputs, spend more on inputs and will delay harvest until the optimal harvesting threshold is reached.

Hypothesis 2: Risk and time preferences augment households' responses to forest property right reforms.

Households making forest management decisions face many uncertainties such as those related to prices, growth and quality of retained stands, redistribution of forest land, outbreaks of disease, pest infestations, forest fire, and extreme weather events. Furthermore, decisions about forest management often involve a long time horizon (Alvarez and Koskela 2006; Nielsen and Kristensen 2005; Wilson et al. 2011). As such, households' risk and time preferences play an important role in their forest management decisions (Newman 2002; Tahvonen et al. 2006; Couture et al. 2008), and by extension will affect their responses to forest property right reforms.

To model risk preferences we use prospect theory because it allows for the estimation of a more flexible and richer description of a person's risk preferences than under expected utility theory. Most previous risk preference experiments conducted in the field are based on the expected utility theory notion of risk preferences but these models often fit experimental and field data less well than models with multiple components of risk preference (Camerer 2000; Cardenas et al. 2008). In expected utility theory, an individual's risk preferences are solely characterized by the

concavity of the utility function and are classified as risk averse, risk neutral or risk seeking. In contrast, prospect theory allows for the possibility that an individual may be risk averse, risk neutral or risk seeking, depending on whether choices involve gains or losses and whether the probabilities of gains or losses are large or small (Kahneman et al. 1979). Under prospect theory, an individual's risk preferences are described by three measures: the degree of risk aversion, the degree of loss aversion, and a nonlinear probability weighting measure. We use these three parameters to represent a household's risk preferences. Hypotheses 2a thru 2f describe our hypotheses regarding each of these parameters.

Hypothesis 2a: A more risk averse household will allocate less labor for application of forest inputs, spend less on forest inputs and allocate more labor to harvesting.

Hypothesis 2b: A more risk averse household will exhibit a stronger behavioral response to forest certification (allocate more labor to application of forest inputs, spend more on forest inputs, and allocate less labor to harvesting).

With regard to a household's degree of risk aversion, we hypothesize that a more risk averse household will be less likely to assume the risks associated with forest production (such as potential loss of forest stock due to pests, disease, illegal logging, natural disaster, redistribution of property, etc.) therefore, a more risk averse household will allocate less labor for application of forest inputs, spend less on forest inputs, and allocate more labor to harvesting. This hypothesis is based on the theory that higher risk aversion decreases the optimal harvesting threshold, which has been the main conclusion in most studies dealing with forest management under production risk (Alvarez and Koskela 2006; Couture and Reynaud 2008). However, it should be

noted that some studies have found that the effect of risk aversion on the optimal rotation is ambiguous and depends on economic and biological parameters, as well as how risk is modeled (Couture and Reynaud 2008).

Furthermore, we hypothesize that more risk averse households will exhibit a stronger behavioral response to forest certification. Assuming that a forest certificate reduces the risks associated with loss of forest stock due to redistribution of property, a more risk averse household that receives a forest certificate for a plot will respond to that reduction in risk by allocating more labor to application of forest inputs, spending more on forest inputs, and allocating less labor to harvesting forest products than risk neutral or risk-seeking households that receive a forest certificate.

Hypothesis 2c: A more loss averse household will allocate less labor for application of forest inputs, spend less on forest inputs, and allocate more labor to harvesting.
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Hypothesis 2d: A more loss averse household that receives a forest certificate for a plot will allocate less labor for application of forest inputs, spend less on forest inputs, and allocate more labor to harvesting

Loss aversion refers to an individual's tendency to strongly prefer avoiding losses to acquiring gains. Furthermore, people have a tendency to dramatically overweight losses relative to gains (Kahneman and Tversky 1979; Tversky and Kahneman 1991). In forest management, households make management decisions involving potential losses and gains. Psychologically, losses may overshadow objectively commensurate gains in evaluation of prospects (Kahneman, Knetsch and Thaler 1990). In general, individuals tend to be more reluctant to accept an uncertain gain over a more certain, albeit lower gain. As a result, households may not invest in forests or may harvest prior to the optimal harvesting threshold (when in actuality investments in the forest

resource and delaying harvest until the optimal harvesting threshold would be beneficial). We therefore hypothesize that a more loss averse household will allocate less labor for application of forest inputs, spend less on forest inputs, and allocate more labor to harvesting.

To understand how loss aversion may impact a household's response to forest certification we consider the potential endowment effect of forest certification. As described by Kahneman and Tversky (1991), an endowment effect "is produced, apparently instantaneously, by giving an individual property rights over a consumption good." As a result of the endowment effect, households may be more averse to loss of forest stock from the plot with a forest certificate than from a plot without a forest certificate. Therefore, we hypothesize that more loss averse households that receive a forest certificate for a plot will allocate less labor for application of forest inputs, spend less on forest inputs, and allocate more labor to harvesting because they will be more averse to potential loss of forest stock from a plot with a forest certificate than to loss from a plot without a forest certificate.

Hypothesis 2e: The effects of the probability weighting parameter on forest management are ambiguous.

Hypothesis 2f: The effects of the probability weighting parameter on forest management responses to receiving a forest certificate are ambiguous.

The probability weighting parameter indicates whether or not an individual puts excessive decision weight on small probabilities (Kahneman and Tversky 1979). Since we do not know whether the actual probabilities that households may lose their forest stock to such events as pest infestation, disease, illegal logging, natural disaster, or

redistribution of property rights are high or low, we cannot hypothesize about how a household's tendency to excessively weight small probabilities will affect its decision making process on its forest management decisions or on its responses to forest certification.

In addition to risk preferences, we examine how a household's time preference affects its forest management decisions and responses to receiving a forest certificate. To represent each household's time preference we use a discount rate. There are several competing models for time discounting that have received a significant amount of attention in both experimental psychology (e.g., de Villiers and Herrnstein (1976), Ainslie and Haslam (1992), etc.) and behavioral economics (e.g., Laisbons (1997), Lowenstein and Prelec (1992), O'Donoghue and Rabin(1999)).³ The competing models were developed to account for observed behavioral regularities that are not consistent with the classic exponential discounting model. For example, the most common documented behavioral regularity is called "reversal of preferences." It occurs, for example, when a subject prefers \$10 now rather than \$12 a day later, but also prefers \$12 in a year plus a day rather than \$10 in a year. This type of preference is not consistent with exponential discounting but would be consistent with a rate of time preference that declines with time such as hyperbolic discounting. We use a hyperbolic discounting parameter because we find that the hyperbolic discounting functional form fits our data better than the exponential discounting functional form (constant discount rate). Similar to our findings, other studies have found that the hyperbolic discounting functional form fits field data better than the exponential discounting functional form (Rachlin, Raineri and Cross 1991; Kirby and Marakovic

1995; Myerson and Green 1995; Kirby 1997). Hypotheses 2g and 2h describe our expectations related to a household's discount rate.

Hypothesis 2g: Households with higher discount rates will allocate less labor to applying inputs, spend less on forest inputs, and allocate more labor to harvesting.

Hypothesis 2h: Households with higher discount rates that receive a forest certificate for a plot will allocate less labor for application of inputs, spend less on forest inputs and allocate more labor to harvesting.

Forest management decisions often have a long time horizon, making households' time preferences (i.e., preference between immediate income and future income) important in the decision making process. In forest management, the Faustmann model is best known for providing a benchmark model for determining optimal timber rotation age (Newman 2002). In the model, a forest owner's goal is to choose the rotation period that maximizes the net present value of the forest. In the infinite rotation model, the decision rule is to harvest when the marginal benefit of delaying (new growth) is equal to the marginal cost of delaying (lost interest on the timber revenue and on future stands). An increase in the interest rate will tend to shorten the optimal rotation length. As such, we hypothesize that households with higher discount rates (i.e., impatient) will shorten the optimal rotation length and allocate labor to harvesting more frequently. Furthermore, we hypothesize that households with stronger preference for consumption or income today (i.e., higher discount rate) will allocate less labor to applying inputs and spend less on forest inputs, as other short-term return investment opportunities will be more attractive than the long-term returns from investing in forest resources. Additionally, households with a stronger preference for income today that receive a forest certificate for a plot will allocate less labor for

application of inputs, spend less on forest inputs, and allocate more labor to harvesting than households with weaker preferences for income today that receive a forest certificate.

1.6 Data, Definitions, and Descriptive Statistics

The household panel data set contains pre- and post-reform, quantitative and qualitative data for 104 households spanning two counties, Sanming City and Datian County, and 10 villages in Fujian Province for three years: 2000 (before the reform), 2005 and 2008 (after the reform). Survey data for the years 2000 and 2005 were collected in 2006 by a research team from Peking University, Gothenburg University and Forest Trends. The 2006 survey team conducted interviews in three townships, each with two villages and ten households in each village—for a total of 600 households. In 2009, two of the twelve counties were randomly chosen and efforts were made to conduct a follow-up survey with the 120 households in those counties that had been included in the previous survey.

During the 2009 follow-up survey, 104 of the 120 households included in the previous survey were located. The 104 located households were asked to complete the survey and to participate in two decision-making tasks (the risk and time preference experiments) during which they could earn a real monetary payoff. All households completed the survey but one household chose not to participate in the decision-making tasks due to lack of time. Each household was paid 15 yuan compensation to complete the survey plus their earning in the decision-making tasks.⁴

In the analysis, we construct a balanced panel data set by using only those forest plots that were managed by the household in 2000, 2005 and 2008, so that we have pre- and post- reform data for every plot in the analysis. This results in a sample size of 197 plots, owned by 69 households. The status of forest plot certification for each forest plot is captured by an indicator variable of whether or not the household has a forest certificate for the plot. In the year 2000, none of the plots in our balanced panel data set had forest certificates.⁵ By the year 2005, 36 of these plots had received forest certificates. And by the year 2008, 69 plots had received forest certificates.

To capture household forest management, we use the value of labor used for applying forest inputs to each plot, expenditure on inputs for each plot, and the value of labor used for harvesting from each plot. The expenditure on inputs includes expenditure on fertilizer, irrigation, animal or machinery rental fees, seeds and other forest inputs. The two labor-related outcome variables are based on the sum of the annual value of family and exchanged labor and the annual expenditure on hired labor for applying forest inputs and for harvesting forest products. The annual expenditure of hired labor is calculated based on responses to survey questions regarding the number of working days of hired labor and the wage per working day paid to hired labor for each forest management activity. For the annual value of family and exchanged labor, we sum the responses to the survey question regarding the number of working days of family and exchanged labor for each forest management activity. We then multiply the total number of family and exchanged labor working days times the average county wage paid to hired forest labor based our survey data, and use the resulting value as a proxy for the opportunity cost of a household's time. We

recognize that an estimated shadow wage would be a more accurate measure of a household's opportunity cost of time spent laboring on its forest plot; however, the data necessary to estimate a shadow wage are not available (Jacoby 1993).

Descriptive statistics for our balanced panel data set indicate that from 2000 to 2008 the value of labor used for applying forest inputs increased from 487 to 4,390 yuan per hectare (table 1.1). Likewise, the expenditure on forest inputs increased from 466 to 1,010 yuan per hectare from 2000 to 2008. From 2000 to 2005, there was an increase in the labor used for harvesting forest products from 148 to 525 yuan per hectare, and then a slight decrease to 489 yuan per hectare in 2008.

As a preview to more rigorous estimates of forest plot certification effects, we examine the descriptive statistics for the forest management variables by whether or not a household has received a forest certificate for its plot. Interestingly, we find that the change in the mean value of labor used for harvesting forest products and for applying forest inputs is statistically different at the 1% and 10% significance level, respectively, indicating that forest plot certification had an effect on households decisions regarding allocation of labor to their forest plot (table 1.2). Specifically, the change between 2000 and 2008 in the mean value of labor used for harvesting forest products was 558 yuan per hectare for those plots for which households never received a forest certificate and 61 yuan per hectare for those plots for which households received a forest certificate. However, the change between 2000 and 2008 in the mean expenditure on forest inputs by forest plot certification status was not statistically significant, indicating that forest plot certification has not had an effect on the trend in households' expenditure on forest inputs.

Table 1.3 identifies the household and forest plot control variables that will be used in this analysis and provides descriptive statistics for the year 2000. In 2000, an average household had 4.9 household members; a head of household, who was 46 years old and has had 4.7 years of education; and total assets of 10,430 yuan. On average each household held a total of 2.3 hectares of forest land. The average forest plot had an area of 0.59 hectares, was 1.43 kilometers from home, and was 0.87 kilometers from the road. Bamboo was the primary forest type of 52% of the plots.

Risk Preference Data

To elicit a measure of risk preference, we follow the experimental design developed by Tanaka et al. (2010) and later modified by Liu (2008), both of whom expand the classic Accept/Reject lottery experiments of Holt and Laury (2002) to incorporate prospect theory. We use cumulative prospect theory and a non-linear probability weighting measure extended from the one-parameter form of Drazen Prelec's (1998) axiomatically-derived weighting function (Kahneman and Tversky 1979). Following Liu (2008), we assume a utility function of the following form:

$$U(x, p; y, q) = \begin{cases} v(y) + \pi(p)(v(x) - v(y)) & x > y > 0 \text{ or } x < y < 0 \\ \pi(p)v(x) + \pi(q)v(y) & x < 0 < y \end{cases}$$

$$\text{where } v(x) = \begin{cases} x^{(1-\sigma)} & \text{for } x > 0 \\ -\lambda(-x)^{(1-\sigma)} & \text{for } x < 0 \end{cases}$$

$$\text{and } \pi(p) = \exp[-(-\ln p)^\alpha] \quad (1)$$

where $U(x, p; y, q)$ denotes the expected prospect value over binary prospects consisting of the outcomes x and y with the probability of p and q , respectively. The function $v(x)$ denotes a power value function.⁶ The parameter σ describes the curvature of an individual's value function. An individual's risk preferences are described as risk

averse when $\sigma > 0$, risk neutral when $\sigma = 0$, and risk loving when $\sigma < 0$. The parameter λ describes the curvature of an individual's value function above zero relative to the curvature of the value function below zero. The higher the value of λ , the more loss averse the individual is. The parameter α is a non-linear probability weighting measure, which is extended from a model by Prelec (1998). The probabilities are weighted by the function $\pi(p)$. When $\alpha < 1$, $\pi(p)$ has an inverted S-shape, indicating that an individual tends to overweight low probabilities and underweight high probabilities, as shown by Tversky and Kahneman (1992). This model reduces to expected utility theory when $\alpha = 1$ and $\lambda = 1$.

In the experiment, participants were asked to choose between sets of lottery options. For example, Figure 1.1 illustrates one set of options that a subject was asked to choose between. In this example, Option A offers a 30% chance of receiving 20 yuan and a 70% chance of receiving 5 yuan. Option B offers a 10% chance of receiving 34 yuan and a 90% chance of receiving 2.5 yuan. A total of 35 choices, divided between three series were asked. The payoffs ranged from a loss of 10 yuan to a gain of 850 yuan, which is roughly half a months pay in rural China (CSY 2009). If a subject was illiterate (27% of our sample), then the enumerator read the choice to the subject and recorded the subject's answers on the record sheet. Monotonic switching was enforced, meaning that once the subject switched to option B they were not allowed to switch back to option A.⁷ By enforcing monotonic switching, we eliminate the possibility of inconsistent choices within each series and also make the task more clear and concise for participants, as they only need to identify one switch point in

each series.⁸ Once the subject had completed the entire series of choices, one question was chosen randomly for payoff.

In our sample, the average derived values for α and λ are 0.73 and 6.02, respectively, and both are statistically different from 1 at the 1% significance level by t-test, implying that our experimental results reject expected utility theory in favor of prospect theory's inverted S-shaped probability weighting and loss aversion.⁹ The average derived value of σ is 0.42, indicating on average rural individuals in China exhibit risk aversion.¹⁰ Figure 1.2, Panel A, B and C illustrate the distribution of σ , α , λ , respectively. While the distributions for σ and α in Panel A and B exhibit a rather normal distribution, the distribution for λ in Panel C is bimodal with a share of subjects exhibiting low degrees of loss aversion and another share of subjects showing high degrees of loss aversion.

We use the individual values for σ (degree of risk aversion), λ (degree of loss aversion) and α (nonlinear probability weighting measure) to represent the risk preferences of each household in our empirical model, which will be discussed in section 1.7.¹¹

Time Preference Data

Our time experiment design follows the methods originally developed by Coller and Williams (1999) and Harrison, Williams and Lau (2002). The data are then used to estimate three parameters—the conventional time discounting parameter (r), present-bias (β), and hyperbolicity of the discount function (θ)—in a general time discounting model using nonlinear least-squares, which allows us to test which

discounting model fits the data best—exponential, hyperbolic, quasi-hyperbolic, or a more general form (Benhabib et al. 2007; Tanaka et al. 2010).

In the time preference experiment subjects were asked to choose between, for example, a real monetary payoff today or a larger payoff six months from now. The hypothetical bias of earlier studies that aim to capture time preferences is addressed here because participants received a real monetary payment based on their choices. Choices were always posed as a choice between a monetary payoff today versus a larger monetary payoff in the future.¹²

To ensure the credibility of a future payment, subjects were told that the future payments would be delivered by China Post, which is the official postal service of the Peoples Republic of China, an agency with which rural households are very familiar and comfortable using for the delivery of money. Furthermore, we believed the credibility problem to be minimal because our participants were part of a panel survey and this was the second time that the household had been visited by a research team from Peking University. Repeat visits by our research team built trust with and provided reassurance to the participants.

Following the experimental design of Tanaka et al. (2010), the subjects were asked a total of 75 questions divided into 15 series of 5 questions each.¹³ A single series of questions is depicted in Figure 1.3. In this example, the subject was asked to choose Plan A or Plan B for each of the 5 questions. Plan A, the future payoff plan remained the same for each question in the series, while the immediate option increased as the subject moved down the column from 25 yuan to 125 yuan, at 1/6 increments of the future payoff. As in the risk experiment, monotonic switching within each series was

also enforced here. The point at which an individual switches from choosing the more immediate reward to taking the delayed reward provides a bound on his or her discount rate. The discount rate indicates the rate that would make a person indifferent between the immediate and the delayed reward. An individual with a high discount rate has a preference for the present, whereas an individual with a low discount rate has a preference for the future.

We used 15 combinations of future payoff and time in the experiments; that is 15, 60 and 150 yuan with delays of 2 weeks, 3 months, and 6 months and 30 and 120 yuan with delays of 1 week, 2 months and 4 months.¹⁴ The maximum payoff of 150 yuan is equal to roughly 2 to 3 days pay in rural China (CSY 2009). For each future payoff-time combination, we asked 5 questions, with the immediate payoff equal to 1/6, 1/3, 1/2, 2/3, and 5/6 of the future payoff in the 5 question series. Once the subject had completed all 75 questions, one question was randomly chosen for payment. The subject's choices on the selected question, determined how much money and when it was to be delivered. The average payoff in the time experiment was 59 yuan. Fifty-eight of the subjects received payment immediately, while 45 subjects received a future payment. The average delay for future payments was 68 days.

Table 1.4 compares the aggregate results of the estimations. Estimating the full model with unrestricted θ gives a relatively high value of $\theta=5.16$, which is similar to Tanaka et al.'s (2010) estimate of $\theta=5.07$, and influences the estimates of r and β but does not improve the R^2 compared with estimations from the quasi-hyperbolic model. While quasi-hyperbolic discounting model seems to fit the aggregate sample best, at the individual level the quasi-hyperbolic model has convergence problems for 32

subjects (31% of our sample), whereas there are no convergence problems for the exponential and hyperbolic models when estimating each subject's time parameters. Therefore, we focus on the estimates from the hyperbolic model and use those parameters to represent the time preference of each household in our empirical model, which will be discussed in section 1.7. Figure 1.4 depicts the distribution of the hyperbolic discounting parameter, from our experiment. Surprisingly, the figure shows that the hyperbolic time preference parameter was relatively low for the majority of our subject, indicating that they have a relatively weak preference for income today. In the hyperbolic discounting model, we find that on average a subject would be willing to trade 92 yuan today for 100 in 1 week, 74 yuan today for 100 yuan in 1 month and 32 yuan today for 100 yuan in 6 months.

1.7 Empirical Framework

Our objective is to identify how heterogeneity in households' time and risk preferences may impact the average effect of forest plot certification on household forest management. The ideal would be to compare forest management outcomes under the counterfactual of no forest certification. But plots cannot both receive a forest certificate and not receive a forest certificate, and so actual counterfactuals cannot be observed. Instead we need to estimate the value of this unobserved counterfactual's outcomes by obtaining a comparison group of plots that did not receive a forest certificate. The identification problem is that it is difficult to identify a reliable comparison group for those receiving a forest certificate because of non-random placement of forest plot certification and/or self-selection of households into

forest plot certification. Without a carefully selected comparison group, we risk incorrectly attributing differences in measured forest management outcomes between those plots for which households received a forest certificate and plots for which households did not receive a forest certificate to forest plot certification when in fact differences may be due to initial differences in observed (e.g., education of the head of household) and unobserved characteristics (e.g., entrepreneurial ability) between the two groups (Conning and Deb 2007).

Identification Strategy

In this study we use a two-step approach to reduce estimator bias caused by potential self-selection of households into forest plot certification. In the first step, we preprocess the data set with nonparametric matching methods so that the treated group (plots for which a household received a forest certificate) is as similar as possible to the control group (plots for which a household did not receive a forest certificate) to reduce estimator bias caused by potential self-selection of households into forest plot certification based on observed characteristics (Ho et al. 2007). The goal of matching is to create a data set that looks closer to one that would result from a randomized experiment. When we get close, we break the link between the treatment variable and the pretreatment controls, which makes the parametric form of the analysis model less relevant or irrelevant entirely. To break this link, we need the distribution of covariates to be the same within the matched treated and control groups.

Specifically, we divide all the plots into two groups: plots that received a forest certificate and plots that did not receive a forest certificate. We then use 1-to-1 nearest neighbor matching (without replacement) to match each plot that received a forest

certificate (“treated plot”) with a plot that did not receive a forest certificate (“control plot”) based on the propensity score (the predicted probability of forest plot certification). The variables used to estimate the propensity score in a logistic regression include three household level variables (age of household head, household head’s education level, and the household’s total land holdings) and four plot level variables (distance from plot to home, distance from plot to the road, slope of the plot, and whether the plot’s forest type is primarily bamboo). Once the propensity score is estimated, a comparison observation for each treated observation is created by choosing the “nearest neighbor”, which is the untreated household with the closest propensity score. Control observations that are not matched are discarded. This reduced our sample to 134 plots owned by 69 households. Following Ho et al. (2007), we selected the matching method that produced the best covariate balance with each treated plot. As a result, in the preprocessed data set, the treatment variable is closer to being independent of other covariates, which helps us obtain more accurate causal effect estimates in the parametric model.

In the second step, using the preprocessed matched data we exploit plot-level variation in the year that households received a forest certificate for a plot in a difference-in-differences framework. The variation in the year that the household received a forest certificate is the result of exogenous variation across villages of the starting year of the reform. Using this framework, we can compare the before-after changes in forest management activities on those plots for which households received a forest certificate (the treatment group) to the before-after changes in forest management activities on those plots that households did not receive forest certificates

(the control group). The difference-in-differences framework allows us to difference out any common trends between the treatment and the control group.

In summary, we use a two-step approach in which we preprocess the data using matching methods and then use that preprocessed data in a difference-in-differences framework in order to obtain more robust estimates of the forest plot certification effect on households' forest management and how that effect may vary depending on heterogeneity in time and risk preferences of each household.

Empirical Model

The base estimate of the forest certification effect is obtained from the difference-in-differences estimation using the preprocessed data:

$$\begin{aligned} forest\ management_{ijt} = & \beta_0 + \beta_1(fc_{ij}) + \beta_2(year2005_t) + \beta_3(year2008_t) \\ & + \beta_4(AfterReform_{ijt}) + e_{ijt} \end{aligned} \quad (2)$$

where $forest\ management_{ijt}$ refers to each of the three forest management related dependent variables: the value of labor used for applying inputs ($input\ labor_{ijt}$); expenditure on forest inputs including chemical fertilizer, pesticide and seeds ($inputs_{ijt}$); and the value of labor used for harvesting ($harvest\ labor_{ijt}$) by household i on forest plot j at time t . All forest management variables are measured in yuan per hectare at the plot level. fc_{ij} is a dummy variable that is equal to one if household i had a forest certificate for plot j in any year. The coefficient on fc_{ij} controls for characteristics that may differ between plots that received forest certificates during the recent tenure reform and plots that did not. $year2005_t$ and $year2008_t$ are dummy variables that take the value one if the observation is for the year 2005 and 2008, respectively. The coefficients on $year2005_t$ and $year2008_t$ control for any systematic

differences for years 2005 and 2008, respectively. $AfterReform_{ijt}$ is a dummy variable that takes the value one when household i has a forest certificate for plot j in a post-reform year. The coefficient on $AfterReform_{ijt}$ is the estimated forest certification effect, which provides a measure of the conditional average difference in forest management activities on plots for which a household has a forest certificate.

To test our main hypothesis that time and risk preferences affect how households respond to property right reforms, we add the risk and time preference parameters and their interaction variables to equation (2) to capture the interaction effects between the risk and time preference variables and the change in forest certification status ($AfterReform_{ijt}$). Our main difference-in-differences model is:

$$\begin{aligned} forest\ management_{ijt} = & \beta_0 + \beta_1(fc_{ij}) + \beta_2(year2005_t) + \beta_3(year2008_t) \\ & + \beta_4(AfterReform_{ijt}) + \beta_5(risk_i) + \beta_6(loss_i) + \beta_7(probweight_i) \\ & + \beta_8(timepref_i) + \beta_9(risk * AfterReform_{ijt}) \\ & + \beta_{10}(loss * AfterReform_{ijt}) + \beta_{11}(probweight * AfterReform_{ijt}) \\ & + \beta_{12}(timepref * AfterReform_{ijt}) + \sum X_i + \Omega P_{ijt} + V_v + e_{ijt} \quad (3) \end{aligned}$$

$risk_i$ is the risk aversion parameter; $loss_i$ is the loss aversion parameter; $probweight_i$ is a dummy variable that takes the value one if the probability weighting parameter is greater than one, indicating that individuals place excessive decision weight on small probabilities; and $timepref_i$ is the hyperbolic time discounting parameter for household i . The interaction terms ($risk * AfterReform_{ijt}$, $loss * AfterReform_{ijt}$, $probweight * AfterReform_{ijt}$, and $timepref * AfterReform_{ijt}$) capture heterogeneity of the treatment effect due to households' risk and time preferences. For example, $risk * AfterReform_{ijt}$ picks up any differential patterns in changes in household forest management activities

on plots that receive a forest certificate relative to plots that do not receive a forest certificate that may be correlated with the households' risk preferences. The interaction term $timepref*AfterReform_{ijt}$, picks up any differential patterns in changes in household forest management activities on plots that receive a forest certificate relative to plots that do not receive a forest certificate that may be correlated with households' time preferences. X_i is a vector of demographic controls, P_{ijt} is a vector of plot characteristic controls, and V_v is village fixed effects. Table 3 identifies each of the control variables used in this analysis.¹⁵ For a better fit, we estimate a log transformation of equations (2) and (3) for each of the three forest management dependent variables. Table 1.5 summarizes our hypotheses from section 1.5 in terms of the sign of the estimated coefficients in equation (3).

1.8 Empirical Results

Overall we find that there is evidence that risk and time preferences impact households' forest management responses to forest plot certification (tables 1.6, 1.7 and 1.8; columns 3 and 4).¹⁶

Impact on labor used for harvesting forest products

We hypothesized that the estimated certification effect (the conditional average difference in labor used for harvesting from plots with forest certificates) would be negative because increased tenure security from plot certification allows a household to have greater confidence towards future benefits, and hence delay harvest to allow the forest stock to grow larger. We do not find evidence of the hypothesized negative certification effect on labor used for harvesting (table 1.6). In all models the

coefficient on *AfterReform* is negative but not statistically significant (columns 1-4).

When we allow the certification effect to vary with households' risk and time preferences, include both household and plot controls and village effects, and evaluate the estimate at the median values of the time and risk preferences parameters, the implied total certification effect on labor for harvesting is -2.64% but is not statistically significant (column 4).¹⁷

Interestingly, when we allow the certification effect to vary with households' risk and time preferences, we find that the negative effect of certification on the value of labor allocated to harvest is larger for households that are more risk averse and smaller for those households that are more loss averse (column 3-4). Specifically, the interaction term between $\ln(risk)$ and *AfterReform* is -1.37%, suggesting that for a household with a risk parameter that is 10% higher (more risk averse), the certification effect on value of labor for harvesting is 14% less. And the coefficient on the interaction term between $\ln(loss\ aversion)$ and *AfterReform* is 1.34%, suggesting that for a household with a loss aversion parameter that is 10% higher (suggesting more loss averse), the certification effect on labor for harvesting is 13% more. This result implies that the intended effect of certification (reduce or delay harvest) is actually larger for more risk averse households and smaller for more loss averse households. The certification effect did not vary statistically significantly with households' degree of time preference or their tendency to place excessive decision weight on small probabilities.

More generally, results indicate that households that are more risk averse or that tend to place excessive decision weight on small probabilities allocate more labor to harvesting forest products (table 1.6, columns 2-4).

Impact on expenditure and labor used for applying forest inputs

We find no evidence of a certification effect on either the expenditure on forest inputs or on labor used to apply forest inputs (tables 1.7 and 1.8). The implied total effect of certification is insignificant for both dependent variables and the signs are mixed.

However, when the estimation effect is allowed to vary with households' risk and time preferences, we find that for a household with a risk parameter that is 10% higher (more risk averse), the certification effect on labor used for applying inputs is 5.6% lower (table 1.7, columns 3 and 4). Also, we find that for a household with a time preference parameter that is 10% higher (stronger preference for income today), the forest certification effect on labor for applying inputs and expenditure on forest inputs is 9% and 14% lower, respectively (table 1.7 and 1.8, columns 3 and 4).

More generally, results indicate that households that are more risk averse tend to use less labor for applying inputs and have lower expenditure on forest inputs (tables 1.7 and 1.8, columns 2-4).

Robustness Checks

To check the robustness of our results, we run three additional variations of equation (3). First, we estimate the model using the number of days rather than the value of labor used for applying inputs and for harvesting (appendix tables 1.3 and

1.4). Second, we estimate the model using the exponential time discounting parameter instead of the hyperbolic time discounting parameter (appendix tables 1.5, 1.6 and 1.7). Third, we estimate the model using the number of years since the household received a forest certificate for a plot rather than the dummy variable, *AfterReform_{ijt}*, that takes the value one when household *i* has a forest certificate for plot *j* in a post-reform year (appendix tables 1.8, 1.9 and 1.10). We find that the results are robust to these alternative specifications with one exception. The exception is that when we estimate the model using the number of years since the household received a forest certificate for a plot rather than the dummy variable, the coefficient on the interaction variable between the years since the household received a forest certificate for a plot and the hyperbolic discounting parameter becomes insignificant in the full model.

1.9 Conclusion

Despite their potential importance, the heterogeneity in response to property rights reforms due to individual preferences has not been studied adequately. Progress is constrained by a lack of data. Measures of outcomes (such as forest investment, harvesting of timber, etc.) are difficult to come by and eliciting measurement of risk and time preferences is difficult (Frederick et al. 2002; Cardenas et al. 2008). Furthermore, previous studies on tenure issues often use proxies to measure tenure security that are either subjective or indirect and may not accurately measure tenure security (Godoy et al. 1998; Godoy et al. 2001; Hagos and Holden 2006).

In this paper, we examined how preferences over time and risk affect household forest management responses to property rights reforms by capitalizing on a large-

scale reform of forest land tenure in Fujian Province, which began in 2003.

Empirically, we combined original field experiment data on time and risk preferences collected among 103 households in 2009 in Fujian Province with an original panel survey data set collected among the same households in 2006 and 2009. We examined three dependent variables as measures of household forest management activities, and the status of the forest tenure reform on each forest plot was captured by an indicator variable of whether or not the household has a forest certificate for the plot in an after reform year. To identify how risk and time preferences augment the effect of forest plot certification on forest management activities, a two step approach in which we preprocess the data using matching methods and then use that preprocessed data in a difference-in-differences framework in order to obtain more robust estimates of the forest plot certification effect on households' forest management and how that effect may vary depending on heterogeneity in the time and risk preferences of households.

Results suggest that more secure tenure as a result of forest certification affects households' forest management decisions. Although forest certification led to a decrease in labor allocated to harvesting as expected, surprisingly there was no evidence that forest plot certification led to an increase in labor used to apply forest inputs nor in forest input expenditure. The insignificant certification effect on labor used to apply forest inputs and forest input expenditure suggests that further research should examine whether or not households face credit constraints that prevent them from increasing investment on their forest plots in response to increased tenure security.

Results suggest that household preferences, particularly households' degree of risk aversion, affect the impacts of forest tenure reforms. According to our results, the negative impact of forest certification on labor allocated to harvesting was smaller for households that were more risk averse. This indicates that when households are risk averse, forest certification will be more likely to have the intended effect of households reducing or delaying forest product harvests. Furthermore, we find that the certification effect on labor for applying inputs is positive for households that are more risk averse.

The results indicate that households with a higher preference for income today that received a forest certificate used less labor for applying inputs and spent less on forest inputs than those with a lower preference for income today that received a forest certificate. Time preferences did not significantly augment labor for harvesting. The insignificant effect of time preference on labor for harvesting may be a result of the short time frame for which our time preference parameter can account, relative to the longer time frame over which forestry decisions are made. Recall that the longest period of time that participants were asked to consider in the time preference experiment was 6 months. A time preference parameter collected based on a 6-month time frame may not accurately capture time preferences concerning longer term decisions, such as those decisions made in forest management. The insignificance of the time preference parameter suggests that further research should be done in designing experiments that could more accurately capture households' time preferences when decisions are over a longer time horizon.

The results of this paper have implications for policymakers in China and elsewhere by informing how heterogeneity among households may impact the outcomes of property right reforms. Although this research is conducted in the context of forests, the general finding may also apply to other natural resources such as fisheries or groundwater where strengthening property rights have not always shown success in the manner intended.

Endnotes

¹ While the Fujian provincial government formally approved the reform in 2003, precedents had already been established in 1998 in Hongtian Village, Yongan County of Fujian Province when a rural village suffering from severe deforestation due to ineffective collective management, decided to reform forest tenure. Another village, in 2002 individualized user rights to villagers (those who accepted the forest user rights were required to pay a land rental fee to the villages) and sold some of the forest to people outside the village to help eliminate village debt (Xu and Jiang 2009).

² For a review of literature studying the correlation between poverty and preferences over risk and time see manuscript 2, section 2.3.

³ For a critical review of time discounting and time preference see Frederick, Loewenstein, and O'Donoghue (2002).

⁴ 1 USD $\approx$ 6.83 yuan at the time of the survey, August 1, 2009.

⁵ The year 2000 is pre-reform, however; for 21 plots households reported that they had a forest certificate, which they had received as early as 1978. These “forest certificates” are not equivalent to the forest certificates distributed during the recent reform which began in 2002. Likely, these 21 “forest certificates” are not forest certificates at all but rather they are household responsibility land certificates, and the household has converted barren or cropland to forest, and so were confused about their forest certificate status when asked by enumerators. We exclude these 21 plots from the analysis, so as to not contaminate the effect of household having a certificate on forest management with the changes in forest management on plots with the earlier type of “forest certificate.”

⁶ In Tanaka et al. (2010), the value function has the form: $v(x)=x^\sigma$ for $x>0$ and $v(x)=-\lambda(-x)^\sigma$. For ease of comparison with respect to the conventional form of expected utility under constant relative risk aversion, where $u(x)=x^{1-\sigma}/(1-\sigma)$, Liu (2008) rewrites the value function as $v(x)=x^{1-\sigma}$. We follow Liu's choice of value function for ease of understanding.

⁷ Three examples were given in the instructions to help ensure that the subjects did not feel that they must make a switch within the series. In one example, the subject never switches to Option B. In another example, the subject switches at question 7 to Option B. And in a third example, the subject switches to Option B at question 1.

⁸ Inconsistent choices within series of questions (in both risk and time preference experiments of the type reported on in this paper) are problematic for identifying parameters when structures are imposed on the subject's responses but the theory underlying those structures does not justify the subject's responses. In risk and time preference experiments, where subjects have been allowed to switch back and forth between A and B, often only a small percentage of individuals do so. Using experiments where in some rounds subjects are given an added option of indicating indifference between Option A and B, researchers have found that subjects who switch back and forth between Option A and B are not actually making inconsistent choices but rather the subjects are expressing their indifference over a range of choices (Holt and Laury 2002; Andersen et al. 2006). In our experiments, we follow the methods of Tanaka et al. (2010) and Liu (2008), both of whom enforce mono-tonic switching.

⁹ For more details on the methods used to estimate the risk preference parameters see manuscript 2 and its appendix.

¹⁰ For comparison to other studies, Liu (2008) in a sample of Chinese farmers found values for $(\sigma, \alpha, \lambda)$ of (0.48, 0.69, 3.47) and Tanaka et al. (2010) in a sample of Vietnamese farmers found values of (0.40, 0.75 and 3.0). The values for σ and α across the studies are very similar; however, our value for λ is approximately twice as much as the values in the previous comparable studies, indicating that our sample exhibits on average a higher degree of loss aversion.

¹¹ In the experiment, 77% of our subjects identified themselves as the head of their households. Since the head of households are those who likely have the most weight in forest management decisions, we believe that the individual risk preferences elicited in the experiments can accurately represent the preferences of the household.

¹² Our design differs from the time preference experiments of Collier and Williams (1999) and Harrison et al. (2002) in that we do not frame the choices with a front-end delay. An example of using a frontend delay, is a choice between money one month from today and more money seven months from now, rather than asking participants to choose between money today and more money six months from now, as we did. A frontend delay is used in time preference experiments to control (at least partially) for the credibility problem. The credibility problem is that participants may not believe that they will receive future payments, and therefore will be biased toward choosing the immediate payoff. However, in much of the behavior economics literature, a significant proportion of the action seems to revolve around payoffs that are truly immediate versus payoffs that are not immediate (Frederick et al. 2002). By using a

front-end delay, we would lose information about how individuals treat choices between payoffs that are truly immediate versus payoffs that are not immediate. Ideally, to address the credibility problem, while still having a way to capture the information about choices between immediate payoffs and future payoffs, an experimental design would include both questions with and without front-end delays. Due to time constraints, in that participants may become exhausted with too many questions, we choose to only use questions without a front-end delay.

¹³ To see the entire set of payoff-time combinations that were used in the experiment and more details regarding the estimation of the time discounting parameters see Manuscript 2 and its appendix.

¹⁴ The 15 combinations of future payoff and time as described in the text were used in 9 of the 10 villages. In the first village, we used the same payoffs but shorter timeframes. Specifically, in the first village we used payoffs of 15, 60 and 150 yuan with delays of 1 week, 1 month, and 3 months and 30 and 120 yuan with delays of 1 week, 2 weeks and 2 months. In the first village, 5 out of 10 households always choose the future payoff. We thought that this high degree of preference for the future amongst the households might be due to the timeframes being too short, and so in the remaining villages we increased the timeframes.

¹⁵ Appendix table 1.1 describes each of the variables used in this analysis.

¹⁶ Tables 1.6, 1.7 and 1.8 summarize results for the variables of interest. Appendix table 1.2 shows results with coefficients for all plot and household level control variables for the full models (column 4 in tables 1.6, 1.7 and 1.8).

¹⁷ The median value of the risk aversion parameter is 0.4 (risk averse), the loss aversion parameter is 2.04 (very low level of loss aversion), the probability weighting dummy is 1 (tends to put excessive decision weight on small probabilities), and the hyperbolic time discounting parameter is 0.012 (weak preference for income today).

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Table 1.1 Forest management variables descriptive statistics by year

Variable	Year	Mean	Std. Dev.	Min	Max
Value of labor for harvesting forest	2000	148	461	0	3222
	2005	525	1113	0	5911
	2008	489	1326	0	11087
Value of labor for applying inputs	2000	487	2564	0	29165
	2005	704	4298	0	54643
	2008	4390	7569	0	53355
Expenditure on forest inputs	2000	466	2319	0	30000
	2005	775	3308	0	34972
	2008	1010	2696	0	21641

Notes: n=197 plots. All values are in yuan per hectare. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009).

Source: Authors' data.

Table 1.2 Forest management variables means by forest certification status

Variable	Plots that do not receive a forest certificate	Plots that receive a forest certificate	Statistical significance of difference in means (t-test)
No. of observations	128	69	
In 2000:			
Value of labor for harvesting forest	166	116	0.295
Value of labor for applying inputs	447	560	0.720
Expenditure on forest inputs	283	807	1.520
Between 2000 and 2008:			
Δ Value of labor for harvesting forest	558	-61	1.686 ***
Δ Value of labor for applying inputs	4605	2599	3.111 *
Δ Expenditure on forest inputs	425	762	1.018

Notes: t-stat is absolute value. *, ** and *** denote significant difference in the means at the 10%, 5% and 1% level, respectively. All values are in yuan per hectare. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009).

Source: Authors' data

Table 1.3 Comparison of means for year 2000 (before reform)

Variable	All Plots	Plots for which households do not receive a forest certificate	Plots for which households receive a forest certificate	Statistical significance of difference in means (t-test)
No. of observations	197	128	69	
<i>Household Characteristics</i>				
Age of head of household	46.22	45.84	46.91	0.599
Household head education (years)	4.68	4.54	4.94	0.999
Household size (age 5 to 59)	4.22	4.20	4.25	0.184
Household assets (yuan)	10430	11888	7725	1.456
Total area of households forest land (ha)	2.30	2.07	2.74	1.121
<i>Plot Characteristics</i>				
Area of plot (ha)	0.59	0.59	0.60	0.022
Distance of plot to home (km)	1.43	1.43	1.44	0.041
Distance of plot to road (km)	0.87	0.90	0.83	0.450
Bamboo (=1 if bamboo)	0.52	0.59	0.39	2.752 ***
Slope of plot (=1 if gradient is > 25')	0.71	0.73	0.67	0.877

Source: Authors' data

Table 1.4 Comparison of exponential, hyperbolic, quasi-hyperbolic and full discounting models

	Exponential		Hyperbolic		Quasi-hyperbolic		Equation(1)
μ	0.010	***	0.012	***	0.015	***	0.015 ***
	(0.001)		(0.001)		(0.001)		(0.001)
r	0.009	***	0.018	***	0.002	***	0.006
	(0.001)		(0.002)		(0.000)		(0.005)
β	$\beta=1$		$\beta=1$		0.573	***	0.601 ***
					(0.032)		(0.039)
θ	$\theta=1$		$\theta=2$		$\theta=1$		5.162
							(3.514)
Observations	3090		3090		3090		3090
Adjusted R^2	0.510		0.512		0.517		0.517

Notes: *, ** and *** denote significant at the 10%, 5% and 1% level, respectively.

Robust standard errors are in parentheses.

Source: Authors' data.

Table 1.5 Summary of hypothesized sign for each coefficient of interest

Variable of Interest	Coefficient	Hypothesis	<i>harvest labor</i>	<i>input labor</i>	<i>inputs</i>
<i>AfterReform</i>	β_4	1	-	+	+
<i>Risk aversion</i>	β_5	2a	+	-	-
<i>Loss aversion</i>	β_6	2c	+	-	-
<i>Probability weighting dummy</i>	β_7	2e	ambiguous	ambiguous	ambiguous
<i>Time preference</i>	β_8	2g	+	-	-
<i>Risk aversion*AfterReform</i>	β_9	2b	-	+	+
<i>Loss aversion*AfterReform</i>	β_{10}	2d	+	-	-
<i>Probability weighting *AfterReform</i>	β_{11}	2f	ambiguous	ambiguous	ambiguous
<i>Time preference*AfterReform</i>	β_{12}	2h	+	-	-
Implied certification effect			ambiguous	ambiguous	ambiguous

Table 1.6 The effect of forest plot certification on labor used for harvesting forest products

Dependent Variable: Logged value of labor used for harvesting forest products (yuan/ha)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	-2.091 (1.03)	-2.255 (1.28)	-0.682 (0.24)	-2.175 (1.04)
<i>ln(risk aversion)</i>		0.729 (2.92)***	0.445 (4.94)***	0.969 (4.07)***
<i>ln(loss aversion)</i>		-0.062 (0.12)	-0.96 (2.31)**	-0.449 (0.86)
<i>ln(probability weighting dummy)</i>		2.36 (2.03)**	4.482 (2.63)**	2.649 (1.76)*
<i>ln(time preference)</i>		0.101 (0.54)	-0.058 (0.18)	0.112 (0.55)
<i>ln(risk aversion)*AfterReform</i>			-1.126 (3.90)***	-1.374 (11.70)***
<i>ln(loss aversion)*AfterReform</i>			1.119 (1.99)*	1.336 (3.67)***
<i>ln(probability weighting dummy)*AfterReform</i>			-2.638 (1.02)	-2.031 (1.11)
<i>ln(time preference)*AfterReform</i>			-0.05 (0.11)	0.025 (0.08)
Constant	-9.624 (8.07)***		-11.991 (6.22)***	-5.304 (0.56)
Implied certification effect	-2.091 (1.03)	-2.255 (1.28)	-1.712 (0.90)	-2.643 (1.50)
N	414	414	414	414
R ²	0.03	0.37	0.09	0.40
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Note: Difference-in-differences regressions. Absolute value of t-stat in parentheses. Robust standard errors account for sample clustering. Plots with missing data excluded. Implied certification effects evaluated at the median $\ln(\text{risk aversion}) = -0.523$, $\ln(\text{time preference}) = -4.394$, $\ln(\text{loss aversion}) = 0.713$, and $\text{probweightdum} = 1$. Household characteristic control variables include: $\ln(\text{risk})$, $\ln(\text{loss})$, $\ln(\text{probweight})$, $\ln(\text{r_hyp})$, $\ln(\text{agehead})$, $\ln(\text{hhtotarea})$, $\ln(\text{hhnewplot})$, $\ln(\text{num5and59age})$, and $\ln(\text{assets})$. Forest characteristic control variables include: $\ln(\text{fcert})$, $\ln(\text{area})$, $\ln(\text{disthome})$, $\ln(\text{distroad})$, and slope25over . All include controls for the year 2005 and 2008. Significance at the 10%, 5% and 1% level denoted by *, **, and ***, respectively.

Source: Authors' data.

Table 1.7 The effect of forest plot certification on labor used for applying forest inputs

Dependent Variable: Logged value of labor used for applying forest inputs (yuan/ha)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	0.117 (0.06)	0.369 (0.20)	-7.809 (2.29)**	-7.773 (2.51)**
<i>ln(risk aversion)</i>		-0.685 (3.78)***	-0.673 (10.38)***	-0.719 (4.41)***
<i>ln(loss aversion)</i>		0.013 (0.03)	0.150 (0.39)	0.001 (0.00)
<i>ln(probability weighting)</i>		0.589 (0.26)	-1.300 (0.69)	-1.147 (0.59)
<i>ln(time preference)</i>		-0.266 (1.37)	-0.046 (0.28)	-0.086 (0.34)
<i>ln(risk aversion)*AfterReform</i>			0.571 (2.72)***	0.555 (2.19)**
<i>ln(loss aversion)*AfterReform</i>			-0.431 (0.57)	-0.356 (0.44)
<i>ln(probability weighting)*AfterReform</i>			6.015 (1.57)	6.915 (1.92)*
<i>ln(time preference)*AfterReform</i>			-1.206 (2.68)***	-0.943 (1.68)*
Constant	-11.417 (15.49)***	-5.36 -0.48	-11.359 (5.97)***	0.944 (0.10)
Implied certification effect	0.117 (0.06)	0.369 (0.20)	2.900 (1.42)	2.741 (1.14)
N	414	414	414	414
R ²	0.32	0.40	0.38	0.42
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Note: Same notes as table 1.6.

Source: Authors' data.

Table 1.8 The effect of forest plot certification on expenditure on forest inputs

Dependent Variable: Logged value of expenditure on forest inputs (yuan/ha)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	-1.380 (0.50)	0.661 (0.23)	-7.651 (1.85)*	-6.708 (1.78)*
<i>ln(risk aversion)</i>		-1.045 (5.09)***	-0.430 (3.44)***	-0.999 (5.13)***
<i>ln(loss aversion)</i>		-0.830 (1.92)*	-0.313 (0.46)	-0.735 (1.23)
<i>ln(probability weighting)</i>		2.266 (1.63)	0.208 (0.09)	1.390 (0.85)
<i>ln(time preference)</i>		0.026 (0.11)	0.262 (0.89)	0.287 (0.84)
<i>ln(risk aversion)*AfterReform</i>			-0.122 (0.42)	-0.010 (0.03)
<i>ln(loss aversion)*AfterReform</i>			-0.878 (0.77)	-0.887 (0.79)
<i>ln(probability weighting)*AfterReform</i>			2.575 (0.54)	3.925 (0.90)
<i>ln(time preference)*AfterReform</i>			-1.468 (2.46)**	-1.376 (2.06)**
Constant	-9.783 (8.15)***	-37.127 (2.15)**	-8.794 (3.26)**	-29.73 (1.73)*
Implied certification effect	-1.38 (0.50)	0.661 (0.23)	0.812 (0.25)	2.635 (0.80)
N	414	414	414	414
R ²	0.05	0.24	0.11	0.26
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Note: Same notes as table 1.6.

Source: Authors' data.

Figure 1.1 Example of risk preference experiment choice

N o.	Option A		Option B	
	Tokens in the bag you will draw from if you choose A:		Tokens in the bag you will draw from if you choose B:

1	Option	Description	Option	Description
	A	If , then receive 20 yuan If , then receive 5 yuan	B	If , then receive 34 yuan If , then receive 2.5 yuan

Figure 1.2 Distribution of risk preference parameters

Panel A. Distribution of σ (curvature of the value function, risk aversion parameter)

Panel B. Distribution of α (probability weighting parameter)

Panel C. Distribution of λ (loss aversion parameter)

Figure 1.3 Example of time preference experiment choice set

	Plan A	Plan B
6-1	Receive 150 yuan in 6 months	Receive 25 yuan today
6-2	Receive 150 yuan in 6 months	Receive 50 yuan today
6-3	Receive 150 yuan in 6 months	Receive 75 yuan today
6-4	Receive 150 yuan in 6 months	Receive 100 yuan today
6-5	Receive 150 yuan in 6 months	Receive 125 yuan today

I choose A for questions 26 to .

I choose B for questions to 30.

Figure 1.4 Distribution of hyperbolic discounting parameter

Appendix 1

Appendix Table 1.1 Variable descriptions

Variable	Description
Dependent Variables	
<i>input labor</i>	Value of labor allocated to application of forest inputs (yuan/hectare)
<i>harvest labor</i>	Value of labor allocated to harvesting (yuan/hectare)
<i>inputs</i>	Expenditure on forest inputs, including chemical fertilizer, pesticide and seeds (yuan/hectare)
Variables of Interest	
<i>AfterReform</i>	Dummy for plot has a forest certificate in data year after the reform (1 yes, 0 no)
<i>risk aversion</i>	Risk aversion parameter
<i>risk aversion*AfterReform</i>	<i>risk aversion</i> and <i>AfterReform</i> interaction variable
<i>loss aversion</i>	Loss aversion parameter
<i>loss aversion*AfterReform</i>	<i>loss aversion</i> and <i>AfterReform</i> interaction variable
<i>probability weight dummy</i>	Dummy for the nonlinear probability weighting (1 tends to overweight small probabilities, 0 otherwise)
<i>r_hyp</i>	Hyperbolic time discounting parameter
<i>r_hyp*AfterReform</i>	<i>r_hyp</i> and <i>AfterReform</i> interaction variable
Control Variables	
<i>year2005</i>	Dummy for year 2005
<i>year2008</i>	Dummy for year 2008
Demographic Control Variables	
<i>agehead</i>	Age of head of household
<i>yeduhead</i>	Years of education of head of household
<i>num5and59age</i>	Number of household members between age 5 and 59
<i>assets</i>	Household's total assets
<i>hhtotarea</i>	Household's total forest plot area (ha)
<i>hhnewplot</i>	Household received a new forest plot in forest tenure reform (1 yes, 0 no)
Plot Characteristic Control Variables	
<i>fcert</i>	Dummy for plot has had a forest certificate (in any year) (1 yes, 0 no)
<i>area</i>	Forest plot area (hectares)
<i>disthome</i>	Distance of plot from home (km)
<i>distroad</i>	Distance of plot from road (km)
<i>slope25over</i>	Dummy for gradient of plot is greater than 25 (1 yes, 0 no)
<i>bamboo</i>	Dummy for bamboo plot (1 bamboo, 0 other)

Appendix Table 1.2 The effect of forest plot certification on forest management

Dependent Variable:	<i>ln(harvest labor)</i>	<i>ln(input labor)</i>	<i>ln(inputs)</i>
<i>fcert</i>	-0.018 (0.02)	0.08 (0.05)	-2.575 (1.16)
<i>year2005</i>	2.539 (2.24)**	0.538 (0.60)	2.535 (1.61)
<i>year2008</i>	0.330 (0.18)	12.133 (7.17)***	4.960 (2.24)**
<i>AfterReform</i>	-2.175 (1.04)	-7.773 (2.51)**	-6.708 (1.78)*
<i>ln(risk aversion)</i>	0.969 (4.07)***	-0.719 (4.41)***	-0.999 (5.13)***
<i>ln(loss aversion)</i>	-0.449 (0.86)	0.001 (0.00)	-0.735 (1.23)
<i>ln(probability weighting)</i>	2.649 (1.76)*	-1.147 (0.59)	1.39 (0.85)
<i>ln(time preference)</i>	0.112 (0.55)	-0.086 (0.34)	0.287 (0.84)
<i>ln(risk aversion)*AfterReform</i>	-1.374 (11.70)***	0.555 (2.19)**	-0.010 (0.03)
<i>ln(loss aversion)*AfterReform</i>	1.336 (3.67)***	-0.356 (0.44)	-0.887 (0.79)
<i>ln(probability weighting)*AfterReform</i>	-2.031 (1.11)	6.915 (1.92)*	3.925 (0.90)
<i>ln(time preference)*AfterReform</i>	0.025 (0.08)	-0.943 (1.68)*	-1.376 (2.06)**
<i>ln(agehead)</i>	-2.602 (1.11)	-3.004 (1.22)	3.817 (0.88)
<i>ln(yreducehead)</i>	-0.296 (1.84)*	-0.156 (1.14)	0.100 (0.66)
<i>ln(num5and59age)</i>	-0.107 (0.95)	0.054 (0.48)	0.159 (0.84)
<i>ln(assets)</i>	0.155 (0.78)	0.102 (0.53)	-0.111 (0.58)
<i>ln(hhtotalarea)</i>	-0.348 (0.75)	-0.116 (0.19)	-0.456 (0.81)
<i>hhnewplot</i>	0.373 (0.30)	-0.404 (0.26)	-2.280 (1.46)

Table continued on the next page.

Appendix Table 1.2 [Continued] The effect of forest plot certification on forest management

Variable	$\ln(\text{harvest labor})$	$\ln(\text{input labor})$	$\ln(\text{inputs})$
<i>lnarea</i>	0.919 (2.70)***	0.580 (1.05)	0.404 (0.89)
<i>lndisthome</i>	0.116 (0.54)	-0.108 (0.23)	-0.422 (0.84)
<i>lndistroad</i>	0.090 (0.83)	0.073 (0.54)	-0.078 (0.47)
<i>slope25over</i>	1.072 (1.14)	1.207 (1.09)	-0.071 (0.05)
<i>bamboo</i>	6.797 (6.01)***	0.767 (0.68)	0.128 (0.09)
Constant	-5.304 (0.56)	0.994 (0.10)	-29.73 (1.73)*
Implied certification effect	-2.643 (1.50)	2.741 (1.14)	2.635 (0.80)
N	414	414	414
R ²	0.40	0.42	0.26

Note: Difference-in-differences regressions. Village fixed effects included. Absolute value of t-stat in parentheses. Robust standard errors account for sample clustering. Plots with missing data excluded. Implied certification effects evaluated at the median $\ln(\text{risk aversion}) = -0.523$, $\ln(\text{time preference}) = -4.394$, $\ln(\text{loss aversion}) = 0.713$, and $\text{probweightdum} = 1$. $\ln(\text{disthome})$, $\ln(\text{distroad})$, and slope25over . Significance at the 10%, 5% and 1% level denoted by *, **, and ***, respectively.

Source: Authors' data.

Appendix Table 1.3 Robustness Check 1: The effect of forest certification on labor days for harvesting forest products

Dependent Variable: Logged labor used for harvesting forest products (days/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	-1.598 (0.97)	-1.753 (1.23)	-0.428 (0.18)	-1.702 (1.00)
<i>ln(risk aversion)</i>		0.590 (2.97)***	0.361 (4.89)***	0.780 (4.10)***
<i>ln(loss aversion)</i>		0.056 (0.13)	-0.770 (2.29)**	-0.361 (0.86)
<i>ln(probability weighting dummy)</i>		1.913 (2.02)**	3.605 (2.59)**	2.124 (1.74)*
<i>ln(time preference)</i>		0.089 (0.58)	-0.050 (0.19)	0.095 (0.57)
<i>ln(risk aversion)*AfterReform</i>			-0.888 (3.83)***	-1.093 (11.27)***
<i>ln(loss aversion)*AfterReform</i>			0.907 (2.01)**	1.06 (3.62)***
<i>ln(probability weighting dummy)*AfterReform</i>			-2.068 (0.99)	-1.548 (1.05)
<i>ln(time preference)*AfterReform</i>			-0.019 (0.05)	0.032 (0.12)
Constant	-10.336 (10.48)***	-7.897 (1.09)	-12.257 (7.80)***	-6.743 (0.89)
Implied certification effect	-1.598 (0.97)	-1.753 (1.23)	-1.300 (0.83)	2.741 (1.14)
N	414	414	414	414
R ²	0.03	0.37	0.09	0.40
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Note: Difference-in-differences regressions. Absolute value of t-stat in parentheses. Robust standard errors account for sample clustering. Plots with missing data excluded. Implied certification effects evaluated at the median $\ln(\text{risk aversion}) = -0.523$, $\ln(\text{time preference}) = -4.394$, $\ln(\text{loss aversion}) = 0.713$, and $\text{probweightdum} = 1$. Household characteristic control variables include: $\ln(\text{risk})$, $\ln(\text{loss})$, $\ln(\text{probweight})$, $\ln(\text{r_hyp})$, $\ln(\text{agehead})$, $\ln(\text{hhtotarea})$, $\ln(\text{hhnewplot})$, $\ln(\text{num5and59age})$, and $\ln(\text{assets})$. Forest characteristic control variables include: $\ln(\text{fcert})$, $\ln(\text{area})$, $\ln(\text{disthome})$, $\ln(\text{distroad})$, and slope25over . All include controls for the year 2005 and 2008. Significance at the 10%, 5% and 1% level denoted by *, **, and ***, respectively.

Source: Authors' data.

Appendix Table 1.4 Robustness Check 1: The effect of forest certification on labor days for applying inputs

Dependent Variable: Logged labor used for applying inputs (days/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	0.117 (0.08)	0.259 (0.17)	-6.470 (2.28)**	-6.559 (2.60)**
<i>ln(risk aversion)</i>		-0.559 (3.72)***	-0.549 (10.11)***	-0.585 (4.31)***
<i>ln(loss aversion)</i>		0.008 (0.02)	0.138 (0.43)	-0.019 (0.05)
<i>ln(probability weighting dummy)</i>		0.358 (0.19)	-1.211 (0.77)	-1.066 (0.65)
<i>ln(time preference)</i>		-0.234 (1.45)	-0.044 (0.32)	-0.080 (0.39)
<i>ln(risk aversion)*AfterReform</i>			0.473 (2.85)***	0.461 (2.28)**
<i>ln(loss aversion)*AfterReform</i>			-0.32 (0.52)	-0.244 (0.37)
<i>ln(probability weighting dummy)*AfterReform</i>			4.908 (1.54)	5.671 (1.93)*
<i>ln(time preference)*AfterReform</i>			-1.011 (2.74)***	-0.811 (1.78)*
Constant	-11.806 (19.20)***	-7.135 (0.78)	-11.686 (7.33)***	-1.76 (0.21)
Implied certification effect	0.117 (0.06)	0.259 (0.17)	2.404 (1.45)	2.261 (1.17)
N	414	414	414	414
R ²	0.32	0.39	0.37	0.41
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Note: Same notes as appendix table 1.3.

Source: Authors' data.

Appendix Table 1.5 Robustness Check 2: The effect of forest plot certification on labor for harvesting forest products

Dependent Variable: Logged value of labor used for harvesting forest products (yuan/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	-2.091 (1.03)	-2.274 (1.30)	-0.653 (0.24)	-2.015 (0.99)
<i>ln(risk aversion)</i>		0.726 (2.92)***	0.449 (4.94)***	0.961 (4.09)***
<i>ln(loss aversion)</i>		-0.055 (0.11)	-0.975 (2.35)**	-0.429 (0.84)
<i>ln(probability weighting)</i>		2.361 (2.03)**	4.494 (2.63)**	2.648 (1.76)*
<i>ln(exponential discounting parameter)</i>		0.127 (0.69)	-0.030 (0.09)	0.124 (0.61)
<i>ln(risk aversion)*AfterReform</i>			-1.126 (3.90)***	-1.37 (12.15)***
<i>ln(loss aversion)*AfterReform</i>			1.114 (2.04)**	1.319 (3.70)***
<i>ln(probability weighting)*AfterReform</i>			-2.638 (1.02)	-2.044 (1.10)
<i>ln(exponential discounting parameter)*AfterReform</i>			-0.048 (0.09)	-2.044 (1.10)
Constant	-9.624 (8.07)***	-6.741 (0.74)	-11.837 (6.42)***	-5.554 (0.59)
Implied certification effect	-2.091 (1.03)	-2.274 (1.30)	-1.721 (0.86)	-2.744 (1.50)
N	414	414	414	414
R ²	0.03	0.37	0.09	0.40
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Note: Difference-in-differences regressions. Absolute value of t-stat in parentheses. Robust standard errors account for sample clustering. Plots with missing data excluded. Implied certification effects evaluated at the median $\ln(\text{risk aversion}) = -0.5232$, $\ln(\text{time preference} - \text{exponential discounting parameter}) = -3.932$, $\ln(\text{loss aversion}) = 0.713$, and $\text{probweightdum} = 1$. Household characteristic control variables include: $\ln(\text{risk})$, $\ln(\text{loss})$, $\ln(\text{probweight})$, $\ln(r_exp)$, $\ln(\text{agehead})$, $\ln(\text{hhtotarea})$, $\ln(\text{hhnewplot})$, $\ln(\text{num5and59age})$, and $\ln(\text{assets})$. Forest characteristic control variables include: fcert , $\ln(\text{area})$, $\ln(\text{disthome})$, $\ln(\text{distroad})$, and slope25over . All include controls for the year 2005 and 2008. Significance at the 10%, 5% and 1% level denoted by *, **, and ***, respectively.

Source: Authors' data.

Appendix Table 1.6 Robustness Check 2: The effect of forest plot certification on labor for applying inputs

Dependent Variable: Logged value of labor used for applying inputs (yuan/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	0.117 (0.06)	0.363 (0.19)	-7.861 (2.38)**	-8.076 (2.75)***
<i>ln(risk aversion)</i>		-0.674 (3.76)***	-0.671 (10.41)***	-0.704 (4.37)***
<i>ln(loss aversion)</i>		-0.023 (0.06)	0.142 (0.38)	-0.035 (0.08)
<i>ln(probability weighting)</i>		0.604 (0.27)	-1.297 (0.69)	-1.133 (0.58)
<i>ln(exponential discounting parameter)</i>		-0.245 (1.20)	-0.035 (0.21)	-0.052 (0.20)
<i>ln(risk aversion)*AfterReform</i>			0.588 (2.76)***	0.562 (2.23)**
<i>ln(loss aversion)*AfterReform</i>			-0.481 (0.64)	-0.378 (0.48)
<i>ln(probability weighting)*AfterReform</i>			6.112 (1.63)	7.042 (2.00)*
<i>ln(exponential discounting parameter)*AfterReform</i>			-1.469 (2.83)***	-1.222 (1.96)*
Constant	-11.417 (15.49)***	-4.754 (0.43)	-11.270 (6.06)***	1.955 (0.19)
Implied certification effect	0.117 (0.06)	0.363 (0.19)	2.582 (1.33)	2.548 (1.14)
N	414	414	414	414
R ²	0.32	0.40	0.38	0.42
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Notes: Same notes as appendix table 1.5.

Source: Authors' data.

Appendix Table 1.7 Robustness Check 2: The effect of forest certification on expenditure on forest inputs

Dependent Variable: Logged value of expenditure on forest inputs (yuan/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>AfterReform</i>	-1.380 (0.50)	0.649 (0.23)	-7.836 (1.97)*	-6.752 (1.85)*
<i>ln(risk aversion)</i>		-1.046 (5.06)***	-0.433 (3.53)***	-1.001 (5.12)***
<i>ln(loss aversion)</i>		-0.831 (1.96)*	-0.291 (0.44)	-0.715 (1.20)
<i>ln(probability weighting)</i>		2.268 (1.64)	0.213 (0.09)	1.403 (0.86)
<i>ln(time preference - exponential discounting parameter)</i>		0.044 (0.17)	0.283 (0.91)	0.314 (0.84)
<i>ln(risk aversion)*AfterReform</i>			-0.106 (0.37)	0.016 (0.05)
<i>ln(loss aversion)*AfterReform</i>			-0.929 (0.82)	-0.96 (0.84)
<i>ln(probability weighting)*AfterReform</i>			2.66 (0.58)	4.047 (0.95)
<i>ln(time preference – exponential discounting parameter)*AfterReform</i>			-1.833 (2.67)**	-1.664 (2.19)**
Constant	-9.783 (8.15)***	-37.028 (2.15)**	-8.894 (3.45)**	-29.541 (1.73)*
Implied certification effect	-1.38 (0.50)	0.649 (0.23)	0.436 (0.14)	2.246 (0.72)
N	414	414	414	414
R ²	0.05	0.24	0.11	0.26
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Notes: Same notes as appendix table 1.5.

Source: Authors' data.

Appendix Table 1.8 Robustness Check 3: The effect of forest plot certification on labor for harvesting forest products

Dependent Variable: Logged value of labor used for harvesting forest products (yuan/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>YearsPostFC</i>	-0.874 (1.57)	-0.912 (1.75)*	-0.213 (0.32)	-0.484 (0.85)
<i>ln(risk aversion)</i>		0.759 (2.92)***	0.44 (4.91)***	0.962 (3.85)***
<i>ln(loss aversion)</i>		-0.131 (0.25)	-0.891 (2.32)**	-0.455 (0.84)
<i>ln(probability weighting)</i>		2.259 (2.17)**	4.520 (2.99)***	2.945 (2.27)**
<i>ln(time preference)</i>		0.120 (0.64)	-0.071 (0.23)	0.135 (0.66)
<i>ln(risk aversion)* YearsPostFC</i>			-0.398 (3.38)***	-0.506 (8.57)***
<i>ln(loss aversion)* YearsPostFC</i>			0.234 (1.56)	0.351 (2.75)***
<i>ln(probability weighting)* YearsPostFC</i>			-0.802 (1.59)	-0.763 (1.64)
<i>ln(time preference)*YearsPostFC</i>			0.06 (0.53)	0.029 (0.24)
Constant	-9.702 (8.04)***	-5.869 (0.66)	-12.314 (6.61)***	-4.126 (0.44)
Implied certification effect	-0.874 (1.57)	-0.912 (1.75)*	-0.905 (1.47)	-0.860 (1.34)
N	414	414	414	414
R ²	0.04	0.37	0.09	0.40
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Note: Difference-in-differences regressions. Absolute value of t-stat in parentheses. Robust standard errors account for sample clustering. Plots with missing data excluded. Implied certification effects evaluated at the median $\ln(\text{risk aversion}) = -0.5232$, $\ln(\text{time preference} - \text{exponential discounting parameter}) = -3.932$, $\ln(\text{loss aversion}) = 0.713$, and $\text{probweightdum} = 1$. Household characteristic control variables include: $\ln(\text{risk})$, $\ln(\text{loss})$, $\ln(\text{probweight})$, $\ln(r_exp)$, $\ln(\text{agehead})$, $\ln(\text{hhtotarea})$, $\ln(\text{hhnewplot})$, $\ln(\text{num5and59age})$, and $\ln(\text{assets})$. Forest characteristic control variables include: fcert , $\ln(\text{area})$, $\ln(\text{disthome})$, $\ln(\text{distroad})$, and slope25over . All include controls for the year 2005 and 2008. Significance at the 10%, 5% and 1% level denoted by *, **, and ***, respectively.

Source: Authors' data.

Appendix Table 1.9 Robustness Check 3: The effect of forest plot certification on labor for applying inputs

Dependent Variable: Logged value of labor used for applying inputs (yuan/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>YearsPostFC</i>	-0.331 (0.51)	-0.460 (0.73)	-3.057 (2.48)**	-3.214 (2.72)***
<i>ln(risk aversion)</i>		-0.657 (3.55)***	-0.66 (9.55)	-0.662 (3.73)***
<i>ln(loss aversion)</i>		0.015 (0.04)	0.074 (0.19)	-0.109 (0.23)
<i>ln(probability weighting)</i>		0.492 (0.23)	-1.261 (0.71)	-0.852 (0.46)
<i>ln(time preference)</i>		-0.24 (1.23)	-0.07 (0.42)	-0.064 (0.26)
<i>ln(risk aversion)* YearsPostFC</i>			0.206 (2.51)**	0.199 (1.87)*
<i>ln(loss aversion)* YearsPostFC</i>			-0.038 (0.17)	0.061 (0.23)
<i>ln(probability weighting)* YearsPostFC</i>			2.121 (1.86)*	2.180 (2.03)**
<i>ln(time preference)*YearsPostFC</i>			-0.407 (1.85)*	-0.353 (1.41)
Constant	-11.664 (15.64)***	-4.732 (0.42)	-11.617 (6.25)***	1.837 (0.17)
Implied certification effect	-0.331 (0.51)	-0.460 (0.73)	0.717 (0.88)	0.456 (0.50)
N	414	414	414	414
R ²	0.32	0.40	0.38	0.42
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Notes: Same notes as appendix table 1.8.

Source: Authors' data.

Appendix Table 1.10 Robustness Check 3: The effect of forest certification on expenditure on forest inputs

Dependent Variable: Logged value of expenditure on forest inputs (yuan/hectare)				
Variable	(1)	(2)	(3)	(4)
<i>YearsPostFC</i>	-0.630 (0.86)	-0.145 (0.21)	-3.08 (2.08)**	-2.56 (1.73)*
<i>ln(risk aversion)</i>		-1.032 (5.01)***	-0.422 (3.48)***	-0.976 (4.94)***
<i>ln(loss aversion)</i>		-0.817 (1.83)*	-0.468 (0.76)	-0.831 (1.48)
<i>ln(probability weighting)</i>		2.17 (1.56)	-0.006 (0.00)	1.284 (0.77)
<i>ln(time preference)</i>		0.04 (0.16)	0.227 (0.83)	0.25 (0.75)
<i>ln(risk aversion)*YearsPostFC</i>			-0.026 (0.28)	0.015 (0.11)
<i>ln(loss aversion)*YearsPostFC</i>			-0.172 (0.58)	-0.098 (0.33)
<i>ln(probability weighting)*YearsPostFC</i>			1.239 (0.86)	1.422 (1.05)
<i>ln(time preference)*YearsPostFC</i>			-0.478 (1.86)*	-0.420 (1.43)
Constant	-9.872 (8.12)***	-36.868 (2.18)**	-8.74 (3.37)***	-29.90 (1.71)*
Implied certification effect	-0.630 (0.86)	-0.145 (0.21)	0.150 (0.15)	0.628 (0.62)
N	414	414	414	414
R ²	0.05	0.24	0.10	0.25
Household characteristics	No	Yes	No	Yes
Plot characteristics	No	Yes	No	Yes
Village fixed effect	No	Yes	No	Yes

Notes: Same notes as appendix table 1.8.

Source: Authors' data.

MANUSCRIPT 2

Poverty, Risk, and Time Preferences: A Study of Rural Chinese Households

Prepared for submission to Economic Development and Cultural Change

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Poverty, Risk, and Time Preferences: A Study of Rural Chinese Households

2.1 Abstract

Those living in poverty are often assumed to have both high levels of risk aversion and high rates of impatience, preferences that make it difficult for these households to save and take the risks necessary to begin to accumulate capital. In this paper, we investigate the relationship between poverty and individual preferences for time and risk. To meet this objective, we use field experiment data collected in Fujian, China to measure the time and risk preferences of 103 rural households combined with household survey data. Specifically, we use net worth per capita as the primary measure of wealth, and also use alternative variables as proxies for wealth (forest land area, house value, assets, and liabilities) to check for robustness. To address the problem of endogeneity of wealth, we use households' net worth rank within their village as an instrumental variable for net worth per capita. On average we find that participants are risk averse, moderately loss averse and have relatively low discount rates (i.e., patient). Contrary to the classic assumption, we find that wealth does not have a significant effect on risk aversion or loss aversion (with the one exception that households with more forest land per capita are less loss averse). However, consistent with this assumption we find statistically weak evidence that households with lower wealth have higher discount rates (i.e., more impatient).

2.2 Introduction

In 2005 there was an estimated 1.4 billion people in the world that still lived below the poverty line of \$1.25 a day. And in China, while there has been a dramatic reduction in the poverty rate over the last two decades, falling from 84% to 15.9% over 1981 to 2005, the number living on less than \$1.25 a day was still at 106.1 million people in 2005 (Chen and Ravallion 2008; 2009).¹ A multitude of factors contribute to the ongoing existence of poverty in the world: physical geography; lack of government investment in public goods and services like primary health care, education and infrastructure; governance failures; political conflicts and cultural barriers (Sachs 2005). And at a more fundamental level, the ongoing existence of poverty has been attributed to the idea that the poor remain poor because attempts to escape poverty are hindered by the fact that they are poor (Fisher 1930; Myrdal 1957; World Bank 2000; Mosley and Verschoor 2005). This argument, often referred to as the ‘vicious circle of poverty’, is that poverty persists as a result of those characteristics of poverty that make escape difficult including: poor health, lack of skill, lack of support mechanisms, remoteness from markets and institutions, social exclusion and lack of physical assets or access to credit (Mosley and Verschoor 2005).

This paper investigates the correlation between poverty and individual preferences for time and risk. Specifically, we use field experiment data collected in Fujian, China to measure the time and risk preferences of 103 rural households combined with household survey data to examine the correlation between wealth and risk and time preferences. This relationship is important in understanding this ‘vicious circle’ because two key elements in many versions of this ‘vicious circle’ are that those living

in poverty have both high levels of risk aversion and high rates of impatience (Fisher 1930; Lipton 1968; Lumley 1997; Fafchamps 2003). For example, regarding time preferences, Irving Fisher wrote,

A small income, other things being equal, tends to produce a high rate of impatience, partly from the thought that provision for the present is necessary both for the present itself and for the future as well, and partly from lack of foresight and self-control. (Fisher 1930, p.73)

And with regard to risk preferences, Michael Lipton wrote, “The risk premium is an increasing function of risk and a decreasing function of assets.”(Lipton 1968, p.335) In other words, the poorer a household, the more impatient they are and the more they seek to avoid risk. This makes it difficult, if not impossible, for these households to save and take the risks necessary to begin to accumulate capital. Therefore, the manner in which individuals discount the future and make decisions that involve risks are important for understanding behavior in developing countries.

The ‘vicious circle of poverty’ also has implications for the linkages between poverty and the environment. People everywhere consume water, food, energy and other natural resources in order to live, and these productive activities deplete the same natural resources upon which people depend. This is particularly true for poor communities in developing countries where livelihoods are often entirely dependent upon the local environment. When basic needs cannot be met with resources derived from the local environment, or when those resources are used in an unsustainable manner, subsistence communities expand into other areas to meet their needs, often drawing on those resources until they too are depleted. Thus the downward cycle continues (WCED 1987; UNCED 1993; World Bank 1996). Furthermore, since the poor are characterized as risk averse and impatient (meaning a short planning time

horizon), they may be less likely to invest in conservation and new technologies to protect their natural resource base (Mink 1993; Perring 1996).

Since Binswagner's early use of experimental economics to capture risk preferences in India in the 1980s and Pender's work also in India in the late 1990s, economists have been examining the correlation between poverty, risk and time preferences. However, empirical evidence on whether individual time and risk preferences vary with wealth has been inconclusive (Binswanger 1980; Pender 1996; Cardenas and Carpenter 2008).² Furthermore, most studies have focused on correlations, with few aiming to identify the direction of causality (Tanaka, Camerer, and Nguyen 2010). Is one impatient and risk averse because they are poor? Or is one inhibited from escaping poverty because they are risk averse and impatient? As such, there is a need to examine the direction of causality between wealth and risk and time preferences. In this paper, we address the potential endogeneity of wealth and begin to explore the direction of causality by using an instrumental variable for wealth.

We believe that this paper has several contributions. First, we add to the empirical literature aimed at understanding the linkages between risk and time preferences and poverty. Second, this is one of the few papers to examine risk preferences of rural Chinese households (Liu 2008; Carlsson et al. 2009; Gong et al. 2010).³ Third, to our knowledge, this is the first paper to measure time preferences of rural Chinese households using field experiments with real monetary rewards.

Overall, we find that on average participants exhibited risk aversion, moderate loss aversion and relatively low discount rates (i.e., patience). There is little evidence that wealth, measured by net worth per capita, affects risk and loss aversion. However,

there is weak evidence that households with more forest land per capita are less loss averse. Also, we find weak evidence that net worth per capita has a negative significant effect on the discount rate, indicating that households with higher net worth per capita have lower discount rates (i.e., more patient).

2.3 Previous Literature: Methods and Findings

Over the last three decades researchers have used a variety methods to measure both time and risk preferences. Binswagner (1980) was the first to use experimental economic methods in the field to measure risk preferences. Binswagner used an *Ordered Lottery Selection* design in which each participant is presented with a series of lotteries. Participants are then asked to choose one lottery from the list. Each lottery is determined by the toss of a fair coin. While the probability is a 50/50 chance, the payouts in each lottery pair are varied. The variation in payoffs causes the expected payoffs to vary. A participant should trade off expected return for less variability, depending on how risk averse the participant is.

Since the 1980's several other researchers have followed Binswagner's *Ordered Lottery Selection* design to elicit risk preference measures from rural households in developing countries (e.g., Nielsen (2001) in Madagascar; Barr (2003) in Zimbabwe; Yesuf and Bluffstone (2009) in Ethiopia, etc.), while others have used the *Accept/Reject Lotteries* experiment methods of Holt and Laury (2002) (e.g., Liu (2008) and Gong et al. (2010) in China, Tanaka et al. (2010) in Vietnam).⁴ In an *Accept/Reject Lotteries* design, participants are given an ordered array of binary lottery choices to make. The lotteries are presented in two columns. Initially, the first

column has a higher expected payoff and variance in payoffs but eventually as the probability of the high payoff in the second column increases, the expected value of the second column becomes higher than the expected value of the first column. More risk averse individuals will choose the first column for longer. After all choices have been made, typically one row is randomly chosen for play and payment is made depending on the participants choice on that row.

Contrary to the ideas of Lipton (1968) and others that risk aversion would increase with poverty, Binswanger found no statistically significant correlation between wealth and risk aversion. However, results of empirical studies after Binswanger have been mixed. In these studies, researchers have typically used either wealth or income (or in some cases both) as an indicator of poverty, and a variety of assets have been used in these studies to proxy for wealth. For example, Binswanger (1980) uses total gross sales value of a household's physical assets, whereas, Nielsen (2001) and Yesuf and Bluffstone (2009) use a variety of livestock measures (such as number of oxen or changes in cattle holdings) to proxy for wealth (and poverty). Similar to Binswanger (1980), Mosley and Verschoor (2005) and Liu (2008) found no significant correlation between wealth and risk aversion. Also, Mosley and Verschoor (2005) and Tanaka et al. (2010) found that household income is not significantly correlated with risk aversion. However, Tanaka et al. (2010) found that mean village income had a significant negative relationship with risk aversion, indicating that households living in wealthy villages are less risk averse. Yesuf and Bluffstone (2009) found a significant positive relationship between income and risk aversion, while

Neilson (2001) and Wik (2004) found a significant negative relationship between income and risk aversion.⁵

While many researchers have explored the correlation between poverty and risk aversion, few have examined the relationship between poverty and loss aversion (Liu 2008; Tanaka et al. 2010). In expected utility theory, risk attitudes are solely described by the degree of risk aversion (the concavity of the utility function). Prospect theory allows for a broader description of risk attitudes by allowing for the possibility that individuals may be loss averse. Loss aversion refers to an individual's tendency to strongly prefer avoiding losses to acquiring gain, and describes the curvature of an individual's value function above zero relative to the curvature of the value function below zero (Kahneman and Tversky 1979). In China, Liu (2008) found that wealth is not significantly correlated with loss aversion. Similarly, Tanaka et al. (2010) found in Vietnam that household income is not significantly correlated with loss aversion but that mean village income is highly correlated with loss aversion, indicating that households in poorer villages are more loss averse.

Time preference and poverty

Over the last three decades, researchers have also endeavored to measure time preferences by estimating a discount rate. Some discount rates have been derived from "real-world" behaviors while others have been derived from experimental elicitation procedures. Some questions were hypothetical, while others involved real monetary rewards. Furthermore, a variety of different protocols have been used to conduct time preference experiments, making it difficult for comparison across studies. Here we will only review findings from those studies most relevant to examining the

relationship between time preferences and poverty in developing countries.⁶ For a complete review of this literature see Frederick, Loewenstein and O'Donoghue (2002).

As with the relationship between risk preferences and poverty, empirical findings related to the relationship between time preferences and poverty have also been mixed. Again, as indicators of poverty, studies have used either wealth or income, or in some cases both.⁷ Most studies use exponential discounting, however this model often does not fit experimental and field data well (Frederick et al. 2002). Pender (1996) found weak evidence in India that wealthier respondents had lower discount rates. Also, Nielsen (2001) in Madagascar and Yesuf and Bluffstone (2008) and Holden, Shiferaw, and Wik (1998) in Ethiopia both found that wealthier households had significantly lower discount rates, indicating that the poorer a household is, the more impatient they are. However, Bauer, Chytilová, and Morduch (2010) and Kirby et al. (2002) found that wealth was not correlated with the discount rate in India and Bolivia, respectively.

Findings in studies that use income rather than wealth as an indicator of poverty are also mixed. Tanaka et al. (2010) in Vietnam found that both households with higher income and households that live in villages with higher mean incomes have significantly lower discount rates. Kirby et al. (2002) and Gunatilake, Wickramasinghe, and Abeygunawardena (2007) also find a negative significant relationship between income and the discount rate in Bolivia and Sri Lanka, respectively. However, Nielsen (2001), Anderson et al. (2004), and Bauer and Chytilová (2008) found that there was no statistically significant relationship between income and time preferences.

2.4 Survey Procedure and Data Description

The household and village survey, as well as the risk and time preference field experiments were conducted in late July and early August of 2009. The household data set contains year 2008 data for 104 households spanning two counties, Sanming City and Datian County, and 10 villages located in the northwest area of Fujian Province. The data is part of a larger panel data set collected in 2006 (for the years 2000 and 2005) by a research team from Peking University, Gothenberg University and Forest Trends. In 2006, the survey team completed a survey in three townships, each with two villages and ten households in each village—for a total of 600 households. At that time, data was collected for the years 2000 and 2005. In 2009, two of the twelve counties were randomly chosen and efforts were made to conduct a follow-up survey with the 120 households in those counties that had been included in the previous survey.

During the 2009 follow-up survey, 104 of the 120 households from the previous survey were located. These 104 households were asked to complete the survey and to participate in two decision-making tasks (the risk and time preference experiments) during which they could earn a real monetary payoff. All subjects completed the survey but one subject choose not to participate in the decision-making tasks due to lack of time. Each subject was paid 15 yuan compensation to complete the survey plus its earning in the decision-making tasks.⁸

Enumerators visited households in pairs on the first day and individually each day after that. Each visit began with the enumerators interviewing the household to

complete the household survey. When the survey was fifty percent complete, the risk decision-making task was completed and the appropriate payoff for the risk task was delivered. Then, the enumerator continued with the household survey. Following the completion of the survey, the participant completed the time decision-making task. A final short survey was conducted that included self-rating risk preference questions and hypothetical time preference questions. In total, the survey and decision-making tasks took between 3 and 4 hours to complete. The risk decision-making task took between 45 minutes and 1 hour. The time decision-making task took a little less time, on average between 30 and 45 minutes. During each decision-making task, enumerators carefully explained the task instructions to the participants and were instructed to only begin the task when they felt confident that the participant understood. For those participants who were illiterate (27% of subjects), enumerators read each choice in the decision task out loud to the participant, the participant stated his or her answer, and the enumerator recorded the answer on the record sheet.

Sample description

The sample consisted of 103 individuals, of which 81 identified themselves as head of household. These individuals most likely are those who are faced with day-to-day consumption and investment decisions over different time horizons and with varying degrees of risk and who have the primary responsibility for sustaining the household. Eighty-six percent of the subjects were male and 46% had worked off farm during 2008 (table 2.1). The mean age was 51.5 year old, and on average subjects had 5.4 years of education. Average household size was 4.5 people, with a mean dependency ratio (number of children divided by number of adults) of 0.15, which is

indicative of China's 1979 one child policy and the tradition that the oldest son and his spouse are responsible for caring for elderly parents (Zhang and Goza 2006). The typical household managed 0.07 hectares of farmland per capita and 0.59 hectares forest land per capita.

We are primarily interested in the relationship between poverty and risk and time preferences. As a proxy for poverty, we choose to examine household wealth levels, as measured by net worth per capita, defined as total assets minus liabilities. Household assets include: the value of the household's house, consumptive assets, productive assets, and livestock; savings held in bank accounts; loans provided to others; and other investments and deposits. Note that a real housing market does not exist in rural China and that house values are those estimated by the interviewee, rather than the market price. Household liabilities include both productive and non-productive loans. The mean net worth per capita in 2008 was 25936 yuan (table 2.2), approximately USD \$3373. House value constitutes the largest share of household wealth. This is not surprising, as it is common for households in China to spend a large share of their income on their homes (McKinley and Wang 1992; Wu 1997). Culturally, the idea of "face" (or honor) is very important in the Chinese culture. In rural Chinese villages, the family home, which is visible to the local villagers, is an important signal of wealth. The home plays an important role for the person who is concerned with face. A person can gain more face by having a beautiful house (Carlsson and Qin 2010). In our empirical work, we will use net worth per capita to measure household wealth. Furthermore, we use both forest land per capita and sub-categories of net worth to check the robustness of our results.

Risk Experiment Design

To elicit a measure of risk preference, we follow the experimental design developed by Tanaka et al. (2010), who expands the classic *Accept/Reject Lotteries* of Holt and Laury (2002) to incorporate prospect theory. Following, Tanaka et al. (2010) we use cumulative prospect theory and a non-linear probability weighting measure extended from the one-parameter form of Drazen Prelec's axiomatically-derived weighting function (Kahneman and Tversky 1979; Tversky and Kahneman 1992; Prelec 1998). We assume a utility function of the following form:

$$U(x, p; y, q) = \begin{cases} v(y) + \pi(p)(v(x) - v(y)) & x > y > 0 \text{ or } x < y < 0 \\ \pi(p)v(x) + \pi(q)v(y) & x < 0 < y \end{cases} \quad (1)$$

$$\text{where } v(x) = \begin{cases} x^{(1-\sigma)} & \text{for } x > 0 \\ -\lambda(-x)^{(1-\sigma)} & \text{for } x < 0 \end{cases}$$

$$\text{and } \pi(p) = \exp[-(-\ln p)^\alpha]$$

$U(x, p; y, q)$ denotes the expected prospect value over binary prospects consisting of the outcomes x and y with the probability of p and q , respectively. The function $v(x)$ denotes a power value function.⁹ The parameter σ describes the curvature of an individual's value function. An individual's risk preferences are described as risk averse when $\sigma > 0$, risk neutral when $\sigma = 0$, and risk loving when $\sigma < 0$. The parameter λ describes the curvature of an individual's value function above zero relative to the curvature of the value function below zero. The higher the value of λ , the more loss averse the individual is. The parameter α is a non-linear probability weighting measure, which is extended from a model by Prelec (1998). The function $\pi(p)$ weights the probabilities. When $\alpha < 1$, $\pi(p)$ has an inverted S-shape, indicating that an individual tends to overweight low probabilities and underweight high

probabilities (Kahneman and Tversky 1979). This model reduces to expected utility theory when $\alpha = 1$ and $\lambda=1$.

In our experiment, participants were asked to choose between two sets of lottery options. For example, Figure 1.1 illustrates one set of options that a subject was asked to choose between. In this example, Option A offers a 30% chance of receiving 20 yuan and a 70% chance of receiving 5 yuan. Option B offers a 10% chance of receiving 34 yuan and a 90% chance of receiving 2.5 yuan. A total of 35 choices, divided between three series were asked. Monotonic switching was enforced, meaning that once the subject switched to option B they were not allowed to switch back to option A.¹⁰ By enforcing monotonic switching, we eliminate the possibility of inconsistent choices within each series and also make the task more clear and concise for participants, as they only need to identify one switch point in each series.¹¹ Once the subject had completed the entire series of choices, one question was chosen randomly for payoff. The choices in the risk experiment were designed so that any combination of choices in the three series determine a particular combination of prospect theory parameter values.

Table 2.3 shows the entire payoff matrix for the experiment. The payoffs range from a loss of 10 yuan to a gain of 850 yuan.¹² We use a relatively high maximum payoff of 850 yuan, which is roughly half a months pay in rural China. The average payoff in the risk experiment was 27 yuan (inclusive of the 10 yuan participation compensation), which is roughly half a single days wage in the survey area in 2008.

In the payoff matrix note that at first, the first column (Option A) dominates the second column (Option B) in terms of expected payoff and variance in the payoffs, but

eventually, as the value of the high outcome in the second column increases, the expected value of the second column begins to dominate (table 2.3). The more risk averse individual would choose option A longer before switching to option B. The point at which participants switch from option A to option B in series 1 and 2 allows for the classification of an individual's risk preferences as risk adverse, risk neutral or risk seeking (the curvature of the value function) and to identify if the subject tends to overweight low probabilities and underweight high probabilities (the non-linear probability weighting parameter). The points at which participants switch from option A to option B in series 1, 2 and 3, together allow for the identification of the loss aversion parameter.¹³

Risk preferences description

In our sample, the average derived values for α and λ are 0.73 and 6.02, respectively, and both are statistically different from 1 at the 1% significance level by t-test. This implies that our experimental results reject expected utility theory in favor of prospect theory's inverted S-shaped probability weighting and loss aversion. The average derived value of σ is 0.42, indicating on average rural individuals in China exhibit risk aversion. For comparison to other studies, Liu (2008) in a sample of Chinese farmers found values for $(\sigma, \alpha, \lambda)$ of (0.48, 0.69, 3.47) and Tanaka et al. (2010) in a sample of Vietnamese farmers found values of (0.40, 0.75 and 3.0). The values for σ and α across the studies are very similar; however, our value for λ is approximately twice as much as the values in the previous comparable studies, indicating that our sample exhibits on average a higher degree of loss aversion. Figure 1.2, Panel A, B and C illustrate the distribution of σ , α , λ , respectively. While the

distributions for σ and α in Panel A and B exhibit a rather normal distribution, the distribution for λ in Panel C is bimodal with a share of subjects exhibiting low degrees of loss aversion and another share of subjects showing high degrees of loss aversion.

Comparability of self-rated risk survey questions

Dohmen et al. (2005) find that a general risk question can be used to predict actual risk-taking behavior, while Liu (2008) find that self-reported risk attitude does not predict risk aversion. Yesuf and Bluffstone (2009) find that risk aversion is lower when the rewards are hypothetical rather than real. To further investigate the comparability of self-rated risk questions to risk preference measures from field experiments with monetary rewards, we also asked participants two questions to allow the participants to self-rate their risk preferences. The first question was “How do you see yourself: Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?” Participants were asked to circle a number on a scale of 0 to 10, where the value 0 indicates that you are unwilling to take risks and the value 10 means that you are fully prepared to take risks. While the first question was asked about taking risks in general, the second question was more specific, asking about taking risks in investment, such as in agricultural investment.

Figure 2.1, a box plot of the quartile level of the risk aversion parameter given the level of self-rated risk aversion in each of these two questions, shows that the self-reported risk aversion levels are noisy measures. Simple regressions using self-rated risk aversion (general) as the independent variable and risk aversion as measured in the experiments as the dependent variable, reveal that the self-rated risk aversion predicts the experiment risk aversion measure at a 5% significance level. However, the

self-rated risk aversion in the context of taking risks in investment is not correlated with the experiment risk aversion measure.

Time Preference Experimental Design

There are several competing models for time discounting that have received a significant amount of attention in both experimental psychology (e.g., de Villiers and Herrnstein (1976), Ainslie and Haslam (1992), etc.) and behavioral economics (e.g., Laisbons (1997), Lowenstein and Prelec (1992), O'Donoghue and Rabin (1999)).¹⁴ The competing models were developed to account for observed behavioral regularities that are not consistent with the classic exponential discounting model. For example, the most common documented behavioral regularity is called “reversal of preferences”. It occurs, for example, when a subject prefers \$10 now rather than \$12 in one day, but also prefers \$12 in a year plus a day rather than \$10 in a year. This type of preference is not consistent with exponential discounting but would be consistent with a rate of time preference that declines with time. There are a variety of specifications of discounting with this property of rates of time preference that decline with time, most notably hyperbolic discounting and quasi-hyperbolic discounting.

Our time experiment design follows procedures similar to those originally developed by Collier and Williams (1999) and Harrison, Lau and Williams (2002). The data are then used to estimate three parameters—the conventional time discounting parameter (r), present-bias (β), and hyperbolicity of the discount function (θ)—in a general time discounting model using nonlinear least-squares, which allows us to test which discounting model fits the data best—exponential, hyperbolic, quasi-hyperbolic, or a more general form (Benhabib, Bisin, and Schotter 2007; Tanaka et al. 2010).¹⁵

In the time preference experiment subjects were asked to choose between, for example, a real monetary payoff today or a larger payoff six months from now. The hypothetical bias typically found in earlier time preference studies is addressed here because participants received a real monetary payment based on their choices. Choices were always posed as a choice between a monetary payoff today or a larger monetary payoff in the future.¹⁶

To ensure the credibility of a future payment, subjects were told that the future payments would be delivered by China Post, which is the official postal service of the Peoples Republic of China, an agency with which rural households are very familiar and comfortable using for the delivery of money. Furthermore, we believed the credibility problem to be minimal because our participants were part of a panel survey and this was the second time that the household had been visited by a research team from Peking University. Repeat visits by our research team built trust and reassurance with the participants.

Following the experimental design of Tanaka et al. (2010), the subjects were asked a total of 75 questions divided into 15 series of 5 questions each.¹⁷ A single series of questions is depicted in Figure 1.3. In this example, the subject was asked to choose Plan A or Plan B for each of the 5 questions. Plan A, the future payoff plan remained the same for each question in the series, while the immediate option increased as the subject moved down the column from 25 yuan to 125 yuan, at 1/6 increments of the future payoff. As in the risk experiment, monotonic switching within each series was also enforced here. The point at which an individual switches from choosing the more immediate reward to taking the delayed reward provides a bound on his or her

discount rate. The discount rate indicates the rate that would make a person indifferent between the immediate and the delayed reward. An individual with a high discount rate has a preference for the present, whereas an individual with a low discount rate has a preference for the future.

We used 15 combinations of future payoff and time in the experiments; that is 15, 60 and 150 yuan with delays of 2 weeks, 3 months and 6 months and 30 and 120 yuan with delays of 1 week, 2 months and 4 months.¹⁸ For each future payoff-time combination, we asked 5 questions, with the immediate payoff equal to 1/6, 1/3, 1/2, 2/3 and 5/6 of the future payoff in the 5 question series. Once the subject had completed all 75 questions, one question was randomly chosen for payment. The subject's choices on the selected question, determined how much money and when it was to be delivered. The average payoff in the time experiment was 59 yuan. Fifty-eight of the subjects received payment immediately, while 45 subjects received a future payment. The average wait time for future payments was 68 days.

Time Preferences Description

Table 1.4 compares the aggregate results of the estimations. Estimating the full model with unrestricted θ gives a relatively high value of $\theta=5.16$, which is similar to Tanaka et al.'s (2010) estimate of $\theta=5.07$, and influences the estimates of r and β but does not improve the R^2 compared with estimations from the quasi-hyperbolic model. While quasi-hyperbolic discounting model seems to fit the aggregate sample best, at the individual level the quasi-hyperbolic model has convergence problems for 32 subjects (31% of our sample), whereas there are no convergence problems for the exponential and hyperbolic models when estimating each subject's risk parameters.

Therefore, we focus on the estimates from the hyperbolic model and use those parameters to represent the time preference of each household in our empirical model. The estimated values of r is 0.018. Since the delay is measured in days, the hyperbolic discounting parameter, multiplied by 100, can approximately be interpreted as expressing the percent decrease per day. It is an approximation because for a hyperbolic function the percent decrease gets smaller as the delay increases. On average, we find (based on the hyperbolic model estimates) that a subject would be willing to trade 89 yuan today for 100 in 1 week, 65 yuan today for 100 yuan in 1 month, and 24 yuan today for 100 yuan in 6 months.

Figure 1.4 depicts the distribution of the hyperbolic discounting parameter, from our experiment. Surprisingly, the figure shows that the hyperbolic time preference parameter was relatively low for the majority of our subject, indicating that they have a relatively weak preference for income today.

Comparability of hypothetical time preference questions

Several experimenters have compared discount rates derived from questions with hypothetical and real rewards. Johnson and Bickel (2002), Madden et al. (2003), Hamoudi and Thomas (2006) did not find differences between hypothetical and real rewards in their experiments. However, Kirby and Marakovic (1996) and Coller and Williams (1999) found that hypothetical choices resulted in lower discount rates than real choices. To further examine the comparability of discount rates estimated from experiments with real monetary rewards to those with hypothetical rewards, we asked participants two hypothetical contextualized time preference questions. Specifically, we asked subjects:

Imagine that you were given 10 yuan and told that you can use it to buy two types of tree seedling to plant on your forest plot. Imagine that your plot currently has no trees growing on it. Type 1 tree seedling costs 1 yuan and will grow into a tree that can be harvested and sold for 10 yuan in 5 years. Type 2 tree seedling costs 1 yuan each and will grow into a tree that can be harvested and sold for 30 yuan in 10 years. How much of the 10 yuan would you like to invest in Type 1 tree seedling? How much of the 10 yuan would you like to invest in Type 2 tree seedling?

The mean investment in Type 1 trees (faster growing, lower return species) was 4 yuan, and in type 2 trees (slower growing, higher return species) was 6 yuan. Figure 2.2 shows a box plot of the quartile level of the hyperbolic time discounting parameter given the level of investment in the Type 2 tree (slower growing, higher return species). The hypothetical parameter is a rather noisy parameter, although there is a similar pattern to the distribution of the time preference parameter (Figure 2.2). A regression with the hyperbolic discounting parameter as the independent variable and the investment in the type 2 tree (slower growing, higher return species) as the dependent variable indicates that investment in type 2 tree is negatively correlated with the experimental hyperbolic time discounting parameter, indicating that higher investment in the slower growing, higher return species is correlated with individuals who displayed a lower discount rate (i.e., more patient) in the time preference experiment. However, the coefficient on investment in type 1 trees is not significant ($t=1.62$).

2.5 Correlations

We begin our empirical analysis of the determinants of risk and time preferences by estimating ordinary least squares regressions for the risk aversion, loss aversion and hyperbolic time discounting parameter. In each regression, we include individual and

household level characteristics. At the individual level, we control for the subjects gender, age and whether or not the subject has off farm employment. At the household level, we include net worth per capita (1000s of yuan), which is the variable of interest. We also control for household size, a dependency ratio that equals the number of children divided by the number of adults, the number of household members who work and the distance to both the post office and county seat.

Additionally, in the regressions where the dependent variable is the hyperbolic time discounting parameter we include two additional control variables: the subject's degree of risk aversion as measured from our risk decision-making task and the subject's earnings in the risk preference experiment. Participants were told that future payments in the time decision-making task would be delivered via China Post. If risk averse participants viewed receiving the future payments in the time decision-making task as "risky", then their risk aversion may impact their decisions in the time task; that is risk averse participants may choose the immediate reward, which they view as "safer". To control for this potential bias, we include risk aversion in the regressions where time preference is the dependent variable. If this was a potential source of bias in the time decision-making task, then we would expect to find a significant positive relationship between risk aversion and the time discounting parameter. In addition, earnings from the risk decision-making task were distributed to the participant prior to their participation in the time decision-making task. We might expect that higher earnings in the risk decision-making task might influence decisions in the time decision-making task. Individuals with higher earnings in the risk decision-making task may exhibit more patience in the time decision-making task (choosing the larger

future reward more often than they would have if they had not just received a sum of money). To control for this potential bias, we include the earnings in the risk experiment in the regressions where the dependent variable is the time preference parameter. If this is a source of bias, we would expect to see a significant negative relationship between the two variables.

We also estimate each model with township fixed effects to control for unobservable factors that may be correlated with an individual's risk and time preferences, such as access to formal credit and insurance markets.

Correlations with risk preferences

Interestingly, we do not find a statistically significant correlation between any of the characteristics and risk aversion (table 2.4, columns 1 and 2). However, we do find a statistically significant negative correlation between net worth per capita and loss aversion (table 2.4, columns 3 and 4). This indicates that wealthy individuals are less loss averse. Also, we find a significant negative relationship between loss aversion and the dependency ratio, indicating that those from households with a higher dependency ratio (relatively more children than adults) tend to be less loss averse.

Correlations with time preferences

We find a significant negative correlation between net worth per capita and the discount rate, indicating that poorer individuals have a higher discount rates (i.e., more impatient) (table 2.5). Additionally, we find a significant positive relationship between the discount rate and both age and off farm employment. Those individuals who are older or who have off farm employment tend to have higher discount rates (i.e., impatient). There is also weak evidence that the discount rate is positively correlated

with years of education and the number of household members who work, indicating that more education and more workers in a household are associated with higher discount rates.

Consistent with previous studies (Holden et al. 1998; Nielsen 2001; Gunatilake et al. 2007; Yesuf and Bluffstone 2008), there is weak evidence that more risk averse individuals have higher discount rates. Earnings from the risk experiment were not significantly correlated with the time preference parameter, indicating that choices in the time preference decision-making task were not influenced by earnings in the previous risk preference decision-making task.

2.6 Instrumental Variable for Wealth

While we find that low levels of wealth are associated with higher levels of loss aversion and impatience, we cannot conclude that wealth causes these preferences because of the endogeneity of wealth. Unobservable or omitted variables that affect wealth may also affect a household's risk and time preferences, making the estimated coefficient on net worth per capita biased. For example, if an individual's profession is risky (such as mining), then the individual may be wealthier (assuming higher pay for higher risk work) and also being in such a risky environment may decrease their risk aversion (growing more comfortable with taking risks). In this case, the profession affects both the risk preferences and wealth, and we would falsely attribute decreases in risk aversion to increases in wealth, when in fact it was the individual growing more comfortable taking risks due to employment as a miner, which was causing a decline

in their aversion to risk. In this case, the coefficient on wealth would be biased upward.

To address potential endogeneity of wealth and omitted variables bias, we use an instrumental variable approach.¹⁹ Instrumental variable estimation solves the omitted variable problem by using only part of the variability in the endogenous variable that is uncorrelated with the omitted variables to estimate the relationship between the endogenous regressor, wealth, and the dependent variable (Angrist and Krueger 2001). Following Godoy et al. (2009), we use households' wealth rank in the village as an exogenous instrumental variable for wealth. Specifically, we assign a value of 1 to the household with the highest net worth per capita in a village. The rank of each other household in the village is expressed as a share of the net worth per capita of the wealthiest household in the village. For example, if a village had 3 households, one household with a net worth per capita of i.) 200000 yuan (the richest household); ii) 100000 yuan (second richest household); and iii.) 40000 yuan (the poorest household), then the three households would have the following ranks: i.) 1 (200000/200000), ii.) 0.5 (100000/200000), and iii.) 0.2 (40000/200000). We calculate households' wealth rank in the village for each household in each of the survey years.

Households' rank in the village according to net worth per capita is highly correlated with net worth per capita but is not directly correlated with the risk and time preference parameters. Risk and time preferences could only influence household rank in net worth through households' net worth per capita. Furthermore, rank is not a variable over which a household has control and therefore is exogenous to the household. A household might decide that it wants to change its wealth rank in the

village by increasing its net worth but a household's final rank in the village will depend on the decisions of other households over which this household has no control.

We conduct tests to validate the use of households' net worth per capita rank in the village as an instrumental variable for household net worth per capita. An instrumental variable should be highly correlated with the endogenous regressor (Angrist and Krueger 2001). We find that this condition is supported by the results from the first stage regression, in which the instrumental variable shows strong and statistically significant correlation with net worth per capita in each model (appendix tables 2.4 and 2.5). Second, we compute an F statistic to test the null hypothesis that the coefficient on the instrumental variable is equal to zero in the first stage regression. A general rule of thumb is that if the F statistic value is greater than 10, then the instruments do not seem to be weak. In our case, this is a test on net worth per capita rank in the village, and the F statistics equals 27.45 in the first stage of the risk and loss aversion structural models and 25.81 in the first stage of the hyperbolic discounting model. From these tests, we conclude that households' net worth per capita rank in the village is a valid instrumental variable for net worth per capita.

2.7 Empirical Results

When we use the instrumental variable approach in 2SLS, the effect of net worth per capita on risk aversion remains insignificant, consistent with the OLS estimate (table 2.6, columns 1 and 2). In contrast, the effect of net worth per capita on loss aversion, which was negative and significant in the OLS regressions, becomes insignificant (table 2.6, columns 3 and 4). This indicates that after addressing the

endogeneity of wealth problem by using an instrumental variable approach, wealth no longer has a statistically significant relationship with risk or loss aversion. Our result that wealth is not correlated with risk aversion is consistent with the classic results of Binswanger (1980) and with the more recent results of Tanaka et al. (2010) who also uses an instrumental variable approach to deal with the endogeneity problem. The result that loss aversion is not correlated with household wealth is also consistent with previous findings by Liu (2008) and Tanaka et al. (2010) in China and Vietnam, respectively.

We find weak evidence that net worth per capita has a negative significant effect on the discount rate, indicating that households with higher net worth per capita have lower discount rates (i.e., more patient, table 2.7). When we use the instrumental variables approach in 2SLS, the effect of net worth per capita on the hyperbolic discounting parameter remains negative; however, the statistical significance of the coefficient on net worth per capita falls to the 10% level in the model without township fixed effects and the 15% level when we use township fixed effects. This result, although weaker, is consistent with the findings in earlier studies that do not address the endogeneity of wealth or income (Pender 1996; Holden et al. 1998; Nielsen 2001; Gunatilake et al. 2007; Yesuf and Bluffstone 2008), as well as with the findings of Tanaka et al. (2010), who uses an instrumental variable approach to deal with the problem of income endogeneity. These results are contrary to Bauer et al. (2010), Kirby et al. (2002), Nielsen (2001), Anderson et al. (2004), and Bauer and Chytilová (2008), all of whom do not find a significant relationship between wealth and time preferences.

Robustness Checks

As a robustness check, we examine alternative measures of wealth, including: 1) forest land area per capita, 2) house value per capita, 3) assets per capita and 4) liabilities per capita. House value, asset, and liabilities are sub-categories of the net worth per capita measure. We use forest land per capita rather than total land per capita or farm land per capita because we believe the former will be more indicative of a household's wealth than the latter. This is because responsibility land, the main tenure type of agricultural land in China, has traditionally been allocated on the basis of the number of family members, the number of laborers in each family, or the desire and/or ability of the household to engage in agricultural production, resulting in little variation in agricultural land holdings across households (Brandt et al. 2002). However, during the recent 2003 forest tenure reform the method of allocation was decided on by farmers through their voting representatives on village committees. This resulted in greater variance in forest land holdings per capita, making forest land area per capita a potentially better proxy for household wealth than agricultural land area per capita.²⁰

We find again that each of these alternative proxies for wealth is not correlated with risk aversion, and this result remains even after addressing the endogeneity of wealth with respective instrumental variables (table 2.8). In agreement with our main result that there is no significant relationship between net worth per capita and risk or loss aversion, we find that there is no evidence that house value, assets or liabilities per capita affects risk or loss aversion (table 2.8 and 2.9, rows 2 to 4). However, we find that there is a negative relationship between forest land per capita and loss

aversion, and this result is statistically significant at the 1% level in three of the four models (table 2.9, row 1). This indicates that wealth in the form of forest land per capita effects loss aversion. This may indicate that increases in forest land per capita decrease loss aversion, although we should be careful not to put too much weight to the direction of causality in a cross-sectional study like this one, as it hinges on the validity of our choice of an instrument variable for wealth.

With regards to the relationship between wealth and time preferences, robustness checks indicate that house value, assets, and forest land per capita each have a significant negative relationship with the discounting parameter, however, in the instrumental variable approach in 2SLS and control for township fixed effects each of these wealth categories becomes insignificant (table 2.10).

We also check the robustness of our results to the statistical significance of the individual hyperbolic discounting parameters. When we estimate the hyperbolic discounting parameter for each individual in the sample, only 41 subjects have an estimated parameter that is statistically significant between the 1% and 10% level. Using only those subjects that had a statistically significant hyperbolic discounting parameter, we estimate the regressions in tables 2.5 and 2.7 again. These results (table 2.11) are consistent with the main results. Again, we find a statistically significant negative relationship between net worth per capita and the discount rate when using OLS. However, when we use the instrumental variable approach in 2SLS and control for township fixed effects, the significance level falls to 12%, indicating that there is only weak evidence that an increase in net worth per capita makes individuals more

patient (i.e., lower discount rate). This finding concurs with the classic assumption that households with low wealth have high discount rates (i.e., more impatient).

2.8 Conclusion

In this paper we investigate the correlation between poverty and individual preferences for time and risk. Specifically, we use field experiment data collected in Fujian, China to measure the time and risk preferences of 103 rural households combined with household survey data to examine the correlation between risk and time preferences and wealth. We find little evidence that wealth is correlated with risk aversion and loss aversion, however there is evidence that wealth is correlated with time preferences. Ordinary least squares regressions indicated that those who have a lower net worth per capita, lower house value per capita, or lower forest land per capita (poorer) tend to be more loss averse, as well as exhibit a higher discount rate (i.e., impatient). Those with lower assets per capita (poorer) also exhibit significantly more impatience.

To address the problem of endogeneity of wealth, we use households' net worth rank within their village as an instrumental variable for net worth. When we use the instrumental variable in 2SLS, we find that the wealth proxy variables no longer have a statistically significant effect on risk and loss aversion with the one exception that households with more forest land per capita are less loss averse. This suggests that forest land plays a significant role as a safety net for negative shocks. When a household experiences a negative shock, a household with more forest land per capita may be able to recover more quickly by harvesting from its forest land. Knowing that

they have this safety net, a household may be less averse to loss. We find weak evidence that net worth per capita has a negative significant effect on the discount rate, indicating that households with higher net worth per capita have lower discount rates (i.e., more patient). However, caution should be taken in concluding the direction of causality in a cross-sectional study like this one, as it depends on the validity of our choice of instrumental variable for wealth. To better identify the direction causality between poverty and time and risk preferences, future research on this topic should include collecting a panel data set that includes both household characteristics and time and risk preference experiment data for multiple years, so that changes in wealth and time and risk preferences overtime can be examined.

Endnotes

¹ China participated in the International Comparison Program (ICP) for this first time in 2005. The ICP collects data across countries on the prices of an internationally comparable list of goods and services, in 2005. The ICP is used to derive Purchasing Power Parity (PPP) rate, which is the basis for the international poverty line. Based on this new data, Chen and Ravallion (2008) find a substantially higher poverty rate for China than past estimates. Using an international poverty line of \$1.25 at 2005 PPP, Chen and Ravallion estimate that 15% of the population was living in consumption poverty in 2005. While this implies that about 130 million more people in poverty by the new standard, the new ICP data also suggest an even larger reduction in the number of poor since 1981.

² See Cardenas and Carpenter (2008) for a review of the literature.

³ Kachelmeir and Shehata (1992) examined risk preferences of college students at Beijing University, as well as at both a Canadian and American university.

⁴ See appendix table 2.7 for a review of risk preference elicitation in developing countries.

⁵ See appendix table 2.8 for a review of previous findings on the relationship between poverty and risk preferences.

⁶ See appendix table 2.9 for a review of time preference elicitation in developing countries.

⁷ See appendix table 2.10 for a review of previous findings on the relationship between poverty and time preferences.

⁸ 1 USD $\approx$ 6.83 yuan (August 1, 2009).

⁹ In Tanaka et al. (2010), the value function has the form: $v(x)=x^\sigma$ for $x>0$ and $v(x)=-\lambda(-x)^\sigma$. For ease of comparison with respect to the conventional form of expected utility under constant relative risk aversion, where $u(x)=x^{1-\sigma}/(1-\sigma)$, Liu (2008) rewrites the value function as $v(x)=x^{1-\sigma}$. We follow Liu's choice of value function for ease of understanding.

¹⁰ Three examples were given in the instructions to help ensure that the subjects did not feel that they must make a switch within the series. In one example, the subject never switches to option B. In another example, the subject switches to option B at question 7. And in a third example, the subject switches to option B at question 1.

¹¹ Inconsistent choices within series of questions (in both risk and time preference experiments of the type reported on in this paper) are problematic for identifying parameters when structures are imposed on the subject's responses but the theory underlying those structures does not justify the subject's responses. In risk and time preference experiments, where subjects have been allowed to switch back and forth between A and B, often only a small percentage of individuals do so. Using experiments where in some rounds subjects are given an added option of indicating indifference between option A and B, researchers have found that subjects who switch back and forth between option A and B are not actually making inconsistent choices but rather the subjects are expressing their indifference over a range of choices (Holt and Laury 2002; Andersen et al. 2006). In our experiments, we follow the methods of Tanaka et al. (2010) and Liu (2008), both of whom enforce mono-tonic switching.

¹² Note that in the risk experiment is possible for the subject to lose up to 10 yuan. However, it would be unethical to ask rural households who participate in the

experiment to pay us if they incur the loss. To address this issue at the beginning of the game we announce that there will be participation compensation of 10 yuan (which is equivalent to the highest possible loss in the risk experiment). Liu et al. (2008) follows a similar strategy to ensure the subjects are treated ethically. While Camerer (2000) suggests that losses that are in fact net gains may be treated differently from real losses, we believe that because the 10 yuan participation fee was pointed out at the very beginning of the experiment, 30-45 minutes later when the subject got to Series 3 the individual would not consider the 10 yuan as a windfall but rather earning they had made for participating, and therefore treat the possible losses in the experiment as true losses.

¹³ The risk preference parameter estimation methods are detailed in appendix 2.

¹⁴ For a critical review of time discounting and time preference see Frederick, Loewenstein, and O'Donoghue (2002).

¹⁵ Benhabib et al.'s (2007) model is detailed in appendix 2, as well as the time preference parameter estimation procedure.

¹⁶ Our design differs from the time preference experiments of Coller and Williams (1999) and Harrison et al. (2002) in that we do not frame the choices with a front-end delay. An example of using a front-end delay, is a choice between money one month from today and more money seven months from now, rather than asking participants to choose between money today and more money six months from now, as we did. A front-end delay is used in time preference experiments to control (at least partially) for the credibility problem. The credibility problem is that participants may not believe that they will receive future payments, and therefore; will be biased toward choosing

the immediate payoff. However, in much of the behavior economics literature, a significant proportion of the action seems to revolve around payoffs that are truly immediate versus payoffs that are not immediate (Frederick, Loewenstein, and O'Donoghue 2002). By using a front-end delay, we would lose information about how individuals treat choices between payoffs that are truly immediate versus payoffs that are not immediate. Ideally, to address the credibility problem, while still having a way to capture the information about choices between immediate payoffs and future payoffs, an experimental design would include both questions with and without front-end delays. Due to time constraints, in that participants may become exhausted with too many questions, we choose to only use questions without a front-end delay.

¹⁷ The entire set of payoff-time combinations that were used in the experiment are displayed in appendix table 2.4.

¹⁸ The 15 combinations of future payoff and time as described in the text were used in 9 of the 10 villages. In the first village, we used the same payoffs but shorter timeframes. Specifically, in the first village we used payoffs of 15, 60 and 150 yuan with delays of 1 week, 1 month, and 3 months and 30 and 120 yuan with delays of 1 week, 2 weeks and 2 months. In the first village, 5 out of 10 households always choose the future payoff. We thought that this high degree of preference for the future amongst the households might be due to the timeframes being too short, and so in the remaining villages we increased the timeframes.

¹⁹ We use the Durbin-Wu-Hausmann (DWH) test as detailed in Cameron and Trivedi (2009) to test the exogeneity of net worth per capita. To do so, we estimated a regression with net worth per capita as the dependent variable. The explanatory

variables included households' net worth rank per capita in the village (the instrumental variable) and all of the other control variables as in table 2.5, column 1 and 3 (for risk aversion and loss aversion) and table 2.6, column 1 (for the hyperbolic discounting parameter). From each of those regressions, we obtain the predicted residual, and use them to run the regression as reported for risk aversion and loss aversion (table 2.5, column 1) and for the hyperbolic discounting parameter (table 2.6, column 1) but add the residual as an additional explanatory variable. In all three cases, we cannot reject the null hypothesis that household net worth per capita is exogenous (the robustified DWH test statistic is 1.32, 1.24 and 0.67 when the dependent variable is risk aversion, loss aversion and the hyperbolic discounting parameter, respectively).

²⁰ This is a result of the 1989 Village Self-Governance Law, under which decisions on village affairs should be made by farmers through voting. Furthermore, provincial decrees stated that decisions regarding forest land reallocation should be made by village representative committees or by village assemblies required a 2/3 vote majority.

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Table 2.1 Descriptive statistics (2008)

Variable	Mean
Risk aversion	0.42 (0.35)
Loss aversion	6.02 (6.67)
Probability weighting parameter	0.73 (0.29)
Hyperbolic discounting parameter	0.13 (0.24)
Male	0.86 (0.34)
Education (years)	5.36 (3.54)
Age (years)	51.47 (12.12)
Had off farm work (1=yes; 0=no)	0.46 (0.50)
Household size	4.53 (1.88)
Dependency Ratio: Number of children/number of adults	0.15 (0.26)
Number in household who work	3.19 (1.51)
Farm land per capita (hectares)	0.07 (.084)
Forest land per capita (hectares)	0.59 (1.14)
Distance to post office (km)	7.58 (7.22)
Distance to county seat (km)	37.36 (22.97)

Note: Standard deviations in parentheses. For all variables except farm land per capita n=103. For farm land per capita n=102 because one subject did not know the area of the household's farm land.

Table 2.2 Household wealth composition (2008)

Variable	Obs.	Mean	Std. Dev.	Min	Max
<i>Assets</i>					
House value	94	23146	45239	200	250833
Consumptive assets	103	946	1171	7	8240
Livestock	71	876	4979	4	42033
Productive assets	82	1487	6773	4	50002
Savings in the bank	18	6881	8802	37	30000
Loans provided to others	9	3572	2698	150	6667
Other investments/deposits	2	1500	707	1000	2000
<i>Liabilities</i>					
Productive loans	9	4531	4322	500	12500
Non-productive loans	21	4899	5433	333	20000
Net worth = Assets - Liabilities	96	25936	47029	-9785	251808

Note: This table displays conditional means. All values are measured in yuan per capita. For net worth per capita, n=96 because seven subjects did not know the value of their household's house. 1 USD = 6.94 yuan (Average for the year 2008.)

Table 2.3 Payoff matrix for risk experiment

Series 1	Option A		Option B		Expected payoff difference (A-B)
<i>Probability</i>	30%	70%	90%	10%	
20	5	2.5	34.0	3.85	
20	5	2.5	37.5	3.50	
20	5	2.5	41.5	3.10	
20	5	2.5	46.5	2.60	
20	5	2.5	53.0	1.95	
20	5	2.5	62.5	1.00	
20	5	2.5	75.0	-0.25	
20	5	2.5	92.5	-2.00	
20	5	2.5	110.0	-3.75	
20	5	2.5	150.0	-7.75	
20	5	2.5	200.0	-12.75	
20	5	2.5	300.0	-22.75	
20	5	2.5	500.0	-42.75	
20	5	2.5	850.0	-77.75	

Series 2					
<i>Probability</i>	90%	10%	30%	70%	
20	15	2.5	27	-0.15	
20	15	2.5	28.0	-0.85	
20	15	2.5	29.0	-1.55	
20	15	2.5	30.0	-2.25	
20	15	2.5	31.0	-2.95	
20	15	2.5	32.5	-4.00	
20	15	2.5	34.0	-5.05	
20	15	2.5	36.0	-6.45	
20	15	2.5	38.5	-8.20	
20	15	2.5	41.5	-10.30	
20	15	2.5	45.0	-12.75	
20	15	2.5	50.0	-16.25	
20	15	2.5	55.0	-19.75	
20	15	2.5	65.0	-26.75	

Table continued on the next page.

Table 2.3 [continued] Payoff matrix for risk experiment

Series 3	Option A		Option B		Expected payoff difference (A-B)
<i>Probability</i>	50%	50%	50%	50%	
	12.5	-5	15	-10	1.25
	2.0	-2	15	-10	-2.50
	0.5	-2	15	-10	-3.25
	0.5	-2	15	-8	-4.25
	0.5	-4	15	-8	-5.25
	0.5	-4	15	-7	-5.75
	0.5	-4	15	-5	-6.75

Note: All payoffs listed under option A and B are in yuan.

Table 2.4 Correlations between risk preferences and characteristics

Dependent variable:	Risk aversion		Loss aversion	
Net worth per capita (1000s of yuan)	-0.001 (0.84)	-0.001 (0.93)	-0.31 (2.95)***	-0.033 (2.69)***
Male	-0.060 (0.53)	0.043 (0.42)	3.152 (1.20)	3.234 (1.24)
Years of education	-0.016 (1.18)	-0.013 (0.89)	-0.245 (0.95)	-0.206 (0.74)
Age	-0.001 (0.40)	-0.001 (0.32)	0.056 (1.23)	0.063 (1.12)
Has off farm employment	0.044 (0.61)	0.026 (0.32)	1.900 (1.23)	1.857 (1.12)
Household size	-0.034 (1.10)	-0.029 (0.92)	0.378 (0.67)	0.568 (0.91)
Number of children/number of adults	0.121 (1.05)	0.071 (0.55)	-3.975 (1.80)*	4.867 (2.01)**
Number in household who work	0.060 (1.38)	0.061 (1.44)	-0.089 (0.11)	-0.333 (0.38)
Distance to post office (km)	0.001 (0.17)	0.008 (1.48)	-0.039 (0.40)	0.002 (0.02)
Distance to county seat (km)	0.002 (1.12)	-0.005 (1.01)	0.050 (1.56)	-0.050 (0.44)
Constant	0.476 (1.97)*	0.551 (2.34)**	-0.694 (0.13)	-0.800 (0.14)
Township fixed effects:	No	Yes	No	Yes
N	96	96	96	96
R ²	0.09	0.13	0.15	0.18

Note: Ordinary least squares estimations. Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level.

Table 2.5 Correlations between time preference and characteristics

Dependent Variable:	Hyperbolic discounting parameter	
Net worth per capita (1000s of yuan)	-0.001 (2.58)**	-0.001 (2.78)***
Male	0.089 (1.76)*	0.064 (1.15)
Years of education	0.014 (1.62)	0.016 (1.75)*
Age	0.007 (2.55)**	0.007 (2.39)**
Has off farm employment	0.123 (2.29)**	0.109 (2.11)**
Household size	0.014 (0.75)	0.011 (0.63)
Number of children/number of adults	-0.111 (1.51)	-0.082 (1.05)
Number in household who work	-0.04 (1.68)*	-0.044 (1.78)*
Distance to post office (km)	-0.003 (0.77)	-0.005 (1.39)
Distance to county seat (km)	-0.001 (1.11)	-0.002 (0.64)
Risk aversion	0.13 (1.61)	0.153 (1.91)*
Risk experiment earnings	0.000 (0.82)	0.000 (0.48)
Constant	-0.304 (1.78)*	-0.266 (1.42)
Township fixed effects:	No	Yes
N	96	96
R ²	0.23	0.29

Note: Ordinary least squares estimation. Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level.

Table 2.6 IV-2SLS for risk preferences

Dependent variable:	Risk aversion		Loss aversion	
Net worth per capita (1000s of yuan)	-0.002	-0.002	-0.013	-0.016
	(1.38)	(1.48)	(0.55)	(0.68)
Male	-0.047	-0.035	2.927	3.062
	(0.41)	(0.33)	(1.12)	(1.19)
Years of education	-0.016	-0.013	-0.239	-0.213
	(1.20)	(0.87)	(0.93)	(0.76)
Age	-0.001	-0.001	0.054	0.061
	(0.35)	(0.30)	(0.72)	(0.80)
Has off farm employment	0.064	0.038	1.544	1.62
	(0.91)	(0.48)	(0.97)	(0.95)
Household size	-0.032	-0.027	0.358	0.546
	(1.07)	(0.90)	(0.61)	(0.85)
Number of children/number of adults	0.098	0.048	-3.57	-4.415
	(0.86)	(0.38)	(1.53)	(1.76)*
Number in household who work	0.054	0.055	0.022	-0.219
	(1.24)	(1.33)	(0.03)	(0.24)
Distance to post office (km)	0.002	0.009	-0.054	-0.022
	(0.33)	(1.60)	(0.54)	(0.17)
Distance to county seat (km)	0.002	-0.006	0.045	-0.038
	(1.25)	(1.10)	(1.34)	(0.33)
Constant	0.477	0.572	-0.725	-1.214
	(1.94)*	(2.36)**	(0.14)	(0.22)
Township fixed effects:	No	Yes	No	Yes
N	96	96	96	96
R ²	0.07	0.12	0.14	0.16

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level. The instrumental variable for net worth per capita in the IV-2SLS regressions is the households wealth rank in the village according to their net worth per capita. The first stage results of the IV-2SLS regressions are presented in appendix D, table 1.

Table 2.7 IV-2SLS for time preference

Dependent Variable:	Hyperbolic Discounting parameter	
Net worth per capita (1000s of yuan)	-0.001 (1.77)*	-0.001 (1.60)
Male	0.095 (1.83)*	0.066 (1.16)
Years of education	0.013 (1.58)	0.016 (1.74)*
Age	0.007 (2.58)**	0.007 (2.40)**
Has off farm employment	0.133 (2.47)**	0.111 (2.17)**
Household size	0.014 (0.78)	0.012 (0.65)
Number of children/number of adults	-0.122 (1.50)	-0.086 (1.02)
Number in household who work	-0.043 (1.75)*	-0.045 (1.81)*
Distance to post office (km)	-0.002 (0.60)	-0.004 (1.16)
Distance to county seat (km)	-0.001 (0.96)	-0.002 (0.68)
Risk aversion	0.124 (1.61)	0.15 (1.90)*
Risk experiment earnings	0.000 (0.96)	0.000 (0.53)
Constant	-0.295 (1.76)*	-0.258 (1.41)
Township fixed effects:	No	Yes
N	96	96
R ²	0.23	0.29

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level. The instrumental variable for net worth per capita in the IV-2SLS regression is the households wealth rank in the village according to their net worth per capita. The first stage results of the IV-2SLS regressions are presented in appendix D, table 2.

Table 2.8 Effect of alternative wealth proxy variables on risk aversion

Dependent Variable:		Risk aversion			
Estimation method:		OLS	OLS	IV-2SLS	IV-2SLS
Township fixed effects:		No	Yes	No	Yes
Wealth variable	IV				
Forest land area per capita (hectares)	Rank in village by forest land per capita	-0.001 (0.02)	-0.007 (0.27)	0.020 (0.43)	0.013 (0.33)
House value per capita	Rank in village by net worth per capita	-0.001 (0.87)	-0.001 (0.90)	-0.002 (1.38)	-0.002 (1.47)
Assets per capita (savings, consumptive, and productive assets)	Rank in village by assets per capita	0.000 (0.05)	-0.001 (0.53)	-0.002 (0.37)	-0.003 (0.55)
Liabilities per capita	Rank in village by debt per capita	-0.010 (0.72)	-0.009 (0.56)	-0.003 (0.18)	0.000 (0.02)

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level. n=103 for the regressions where the dependent variables is forest land per capita. n=96 for all other regressions. House value, assets and liabilities per capita are measured in 1000's of yuan. This table summarizes the results for our wealth variable of interest for 32 separate regressions. All regressions include the following controls: male, years education, age, has off farm work, household size, number of children/number of adults, number of household members who work, distance to post office, and distance to county seat.

Table 2.9 Effect of alternative wealth proxy variables on loss aversion

Dependent Variable:		Loss aversion			
Estimation method:		OLS	OLS	IV-2SLS	IV-2SLS
Township fixed effects:		No	Yes	No	Yes
Wealth variable	IV				
Forest land area per capita (hectares)	Rank in village by forest land per capita	-1.046 (3.02)***	-1.11 (3.14)***	-1.467 (1.81)***	-1.45 (2.06)**
House value per capita	Rank in village by net worth per capita	-0.032 (2.98)***	-0.035 (2.79)***	-0.015 (0.56)	-0.018 (0.68)
Assets per capita (savings, consumptive, and productive assets)	Rank in village by assets per capita	-0.001 (0.01)	-0.004 (0.06)	0.101 (0.88)	0.085 (0.82)
Liabilities per capita	Rank in village by debt per capita	0.352 (1.59)	0.405 (1.74)*	0.472 (1.54)	0.500 (1.57)

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level. n=103 for the regressions where the dependent variables is forest land per capita. n=96 for all other regressions. House value, assets and liabilities per capita are measured in 1000's of yuan. This table summarizes the results for our wealth variable of interest for 32 separate regressions. All regressions include the following controls: male, years education, age, has off farm work, household size, number of children/number of adults, number of household members who work, distance to post office, and distance to county seat.

Table 2.10 Effect of alternative wealth proxy variables on time preference

Dependent Variable:		Hyperbolic discounting parameter			
Estimation method:		OLS	OLS	IV-2SLS	IV-2SLS
Township fixed effects:		No	Yes	No	Yes
Wealth variable	IV				
Forest land area per capita (hectares)	Rank in village by forest land per capita	-0.045 (3.20)***	-0.043 (2.92)***	-0.032 (0.99)	-0.017 (0.53)
House value per capita	Rank in village by net worth per capita	-0.001 (2.11)**	-0.001 (2.43)**	-0.002 (1.69)*	-0.001 (1.57)
Assets per capita (savings, consumptive, and productive assets)	Rank in village by assets per capita	-0.003 (2.36)**	-0.002 (1.98)*	-0.004 (1.18)	-0.003 (0.86)
Liabilities per capita	Rank in village by debt per capita	0.013 (1.54)	0.010 (1.24)	0.009 (1.03)	0.005 (0.56)

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level. n=103 for the regressions where the dependent variables is forest land per capita. n=96 for all other regressions. House value, assets and liabilities per capita are measured in 1000's of yuan. This table summarizes the results for our wealth variable of interest for 16 separate regressions. All regressions include the following controls: male, years education, age, has off farm work, household size, number of children/number of adults, number of household members who work, distance to post office, distance to county seat, risk aversion, and the amount earned in the risk experiment.

Table 2.11 Robustness of time preference results

Dependent Variable:	Hyperbolic discounting parameter			
Estimation Method:	OLS	OLS	IV-2SLS	IV-2SLS
Net worth per capita (1000s of yuan)	-0.003 (3.09)***	-0.003 (2.73)**	-0.004 (1.79)*	-0.003 (1.64)
Male	0.273 (1.65)	0.208 (1.09)	0.272 (1.60)	0.209 (1.09)
Years of education	0.009 (0.53)	0.016 (0.75)	0.009 (0.56)	0.016 (0.76)
Age	0.003 (0.59)	0.007 (1.19)	0.003 (0.52)	0.007 (1.16)
Has off farm employment	0.162 (1.46)	0.223 (1.58)	0.169 (1.60)	0.223 (1.56)
Household size	0.041 (0.97)	0.027 (0.46)	0.039 (0.90)	0.027 (0.46)
Number of children/number of adults	-0.325 (2.16)**	-0.162 (0.59)	-0.342 (2.20)**	-0.169 (0.61)
Number in household who work	-0.115 (1.84)*	-0.071 (0.75)	-0.115 (1.87)*	-0.072 (0.77)
Distance to post office (km)	0.003 (0.35)	-0.004 (0.33)	0.003 (0.38)	-0.004 (0.29)
Distance to county seat (km)	0.001 (0.17)	0.000 (0.01)	0.001 (0.23)	0.000 (0.00)
Risk aversion	0.099 (0.70)	0.148 (0.85)	0.099 (0.71)	0.147 (0.85)
Risk experiment earnings	(0.001) (0.23)	0.001 (0.26)	(0.002) (0.34)	0.001 (0.21)
Constant	-0.033 (0.08)	-0.458 (0.71)	0.008 (0.02)	-0.441 (0.66)
Township fixed effects:	No	Yes	No	Yes
N	41	41	41	41
R ²	0.42	0.46	0.42	0.46

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level. This set of regressions only includes those individuals whose hyperbolic discounting parameter when estimated was statistically significant at the 1%, 5% or 10% level. The instrumental variable for net worth per capita in the IV-2SLS regression is the households wealth rank in the village according to their net worth per capita.

Figure 2.1 Box plot of risk aversion estimated from experiment data relative to self-rated hypothetical risk aversion level

Note: For each self-rated level of risk aversion, the bottom bar corresponds to the minimum value of the risk aversion parameter, while the top bar corresponds to the maximum value. The box corresponds to the 25th to the 75th percentile values, with the median value represented by the line that bisects the box. Outliers are represented by a dot.

Figure 2.2 Box plot of hyperbolic discounting parameter estimated from experiment data relative to the hypothetical investment question

Note: For each investment level, the bottom bar corresponds to the minimum value of the hyperbolic discounting parameter, while the top bar corresponds to the maximum value. The box corresponds to the 25th to the 75th percentile values, with the median value represented by the line that bisects the box. Outliers are represented by a dot.

Appendix 2

Risk preference parameter estimation

Table 2.3 shows the entire payoff matrix for the experiment. The payoffs ranged from a loss of 10 yuan to a gain of 850 yuan. Since our intent is to relate the risk experiment results to the subject's household's forest management activities, we use a relatively high maximum payoff of 850 yuan, which is roughly half a months pay in rural China and corresponds more closely to the magnitude of monetary payoffs faced by individuals in forest management decisions (CSY 2009). The average payoff in the risk experiment was 27 yuan (inclusive of the 10 yuan participation compensation), which is roughly half a single days wage in rural Fujian, China in 2008 (CSY 2009).

Note that in the risk experiment is possible for the subject to lose up to 10 yuan. However, it would be unethical to ask rural households who participate in the experiment to pay us if they incur the loss. To address this issue at the beginning of the game we announce that there will be participation compensation of 10 yuan (which is equivalent to the highest possible loss in the risk experiment). Liu et al. (2008) follows a similar strategy to ensure the subjects are treated ethically. While Camerer (2000) suggests that losses that are in fact net gains may be treated differently from real losses, we believe that because the 10 yuan participation fee was pointed out at the very beginning of the experiment, 30-45 minutes later when the subject got to Series 3 the individual would not consider the 10 yuan as a windfall but rather earning they had made for participating, and therefore treat the possible losses in the experiment as true losses.

In the payoff matrix (table 2.3) note that at first, the first column (Option A) dominates the second column (Option B) in terms of expected payoff and variance in the payoffs, but eventually, as the value of the high outcome in the second column increases, the expected value of the second column starts to dominate (table 2.3). The more risk averse individual would choose Option A longer before switching to Option B. The point at which participants switch from Option A to Option B in Series 1 and 2 allows for the classification of an individual's risk preferences as risk adverse, risk neutral or risk seeking (the curvature of the value function) and to identify if the subject tends to overweight low probabilities and underweight high probabilities (the non-linear probability weighting parameter). The points at which participants switch from Option A to Option B in Series 1, 2 and 3, jointly allow for the identification of the loss aversion parameter.

Suppose an individual switched from Option A to Option B at question 7 in Series 1, question 7 in Series 2 and question 5 in Series 3. When a subject switches from Option A to B at the seventh question in both Series 1 and Series 2, the following inequalities should hold:

$$\begin{aligned}
20^{(1-\sigma)} + \exp[-(-\ln .3)^\alpha] (20^{(1-\sigma)} - 5^{(1-\sigma)}) &> 2.5^{(1-\sigma)} + \exp[-(-\ln .1)^\alpha] (62.5^{(1-\sigma)} - 2.5^{(1-\sigma)}) \\
5^{(1-\sigma)} + \exp[-(-\ln .3)^\alpha] (20^{(1-\sigma)} - 5^{(1-\sigma)}) &> 2.5^{(1-\sigma)} + \exp[-(-\ln .1)^\alpha] (75^{(1-\sigma)} - 2.5^{(1-\sigma)}) \\
15^{(1-\sigma)} + \exp[-(-\ln .9)^\alpha] (20^{(1-\sigma)} - 15^{(1-\sigma)}) &> 2.5^{(1-\sigma)} + \exp[-(-\ln .7)^\alpha] (32.5^{(1-\sigma)} - 2.5^{(1-\sigma)}) \\
15^{(1-\sigma)} + \exp[-(-\ln .9)^\alpha] (20^{(1-\sigma)} - 15^{(1-\sigma)}) &> 2.5^{(1-\sigma)} + \exp[-(-\ln .7)^\alpha] (34^{(1-\sigma)} - 2.5^{(1-\sigma)})
\end{aligned}$$

The ranges of σ and α that satisfy the above inequalities are $0.26 < \sigma < 0.35$ and $0.66 < \alpha < 0.74$. The approximate mid-points (σ, α) of these intervals are $(0.30, 0.70)$. Mid-points are taken for the later purpose of using the parameters as explanatory variables in the regression models. When subjects do not switch, the appropriate

boundaries are used to solve for the σ and α . Then with the values of σ and α , a set of inequalities can be constructed for the switch point in series 3, and solved for upper and lower bound on λ . We follow the same convention and take the mid-point as the estimate of λ for use in regression models.

Appendix tables 2.1, 2.2, and 2.3 illustrate the combinations of approximate values of σ (the curvature of an individual's value function), λ (the probability sensitivity parameter), and α (the loss aversion parameter), respectively. Looking at the corresponding columns and rows in appendix tables 2.1, 2.2, and 2.3, you will find that for this individual who switched at the seventh question the values for (σ, α) are (0.30, 0.70) and for λ the lower bound is 2.26 and the upper bound 4.11, taking the midpoint the value for λ is 3.2.

Time preference parameter estimation

For our time preference experiment, we use a general model proposed by Benhabib et al. (2007), which allows us to test exponential, hyperbolic, quasi-hyperbolic, and a more general form. Benhabib et al.'s (2007) model assigns a value of reward y at time t according to $yD(y,t)$ where:

$$yD(y,t) = \begin{cases} y & \text{if } t = 0 \\ \beta(1 - (1 - \theta)rt)^{\frac{1}{1-\theta}} & \text{if } t > 0 \end{cases} \quad (1)$$

The conventional time discounting parameter is r . The present-bias parameter is β , and hyperbolicity of the discount function is described by θ . The model reduces to exponential discounting when $\beta=1$ and $\theta=1$. When $\beta=1$ and $\theta=2$, the model reduces to hyperbolic discounting. When $\theta=1$ and β is free the model reduces to quasi-hyperbolic discounting. When $\theta > 2$ and β is free, the model is “hyper-hyperbolic”, meaning that, for example, the weight on future rewards drops even more steeply than in the hyperbolic model. By using this specification, we can compare the three models at once.

The probability of choosing immediate reward x over the delayed reward y in t days is denoted by $P(x > (y,t))$. We use a logistic function to describe this probabilistic relation as follows:

$$P(x > (y,t)) = \frac{1}{1 + \exp(-\mu(x - y\beta(1 - (1 - \theta)rt)^{\frac{1}{1-\theta}}))} \quad (2)$$

The variable μ is a response sensitivity or noise parameter. We estimate the parameters r , β , θ , and μ in the above logistic function. For each subject, there are thirty observations, one observation for just before the switching point and one observation for just after the switching point for each of the fifteen series of questions.

For example if a subject choose to receive 150 yuan in 6 months over 75 yuan today (Plan A) and switched to Plan B when the payoff today increased to 100 yuan, then the dependent variable for the first response is 1 and the dependent variable for the second response is 0. The complete set of discounting choices is presented in table 1.

We estimated the above logistic function using non-linear least squares. In addition, to estimating the full model above, we estimated the model with restrictions for exponential discounting, hyperbolic discounting, and quasi-hyperbolic discounting.

Appendix Table 2.1 Switching point (question) in Series 1 and 2 and the approximation of σ (parameter for the curvature of the power value function)

σ	Switching question in Series 1														
Series															
2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Never
1	-0.40	-0.35	-0.30	-0.25	-0.15	-0.10	0	0.05	0.10	0.15	0.20	0.25	0.35	0.40	0.45
2	-0.35	-0.30	-0.20	-0.15	-0.10	0	0.05	0.10	0.15	0.20	0.25	0.30	0.40	0.45	0.50
3	-0.30	-0.20	-0.15	-0.10	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.45	0.50	0.55
4	-0.20	-0.15	-0.10	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.50	0.55	0.60
5	-0.15	-0.10	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.60	0.65
6	-0.10	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
7	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70
8	0.10	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
9	0.15	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80
10	0.20	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
11	0.25	0.30	0.35	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.80	0.85
12	0.35	0.35	0.40	0.45	0.50	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.80	0.85	0.90
13	0.40	0.40	0.45	0.50	0.55	0.60	0.60	0.65	0.70	0.75	0.80	0.80	0.85	0.90	0.95
14	0.45	0.45	0.50	0.55	0.60	0.65	0.65	0.70	0.75	0.80	0.80	0.85	0.90	0.90	0.95
Never	0.50	0.50	0.55	0.60	0.65	0.70	0.70	0.75	0.80	0.85	0.85	0.90	0.95	0.95	0.95

Appendix Table 2.2 Switching point (question) in Series 1 and 2 and the approximation of α (probability sensitivity parameter in Prelec's weighting function)

α	Switching question in Series 1														
Series 2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Never
1	0.65	0.70	0.75	0.80	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40
2	0.60	0.65	0.70	0.75	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35
3	0.55	0.60	0.65	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30
4	0.50	0.55	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20	1.25
5	0.45	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15	1.20
6	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10	1.15
7	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05	1.10
8	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.05
9	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
10	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
11	0.20	0.25	0.30	0.40	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90
12	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85
13	0.10	0.15	0.25	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80
14	0.05	0.15	0.20	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
Never	0.05	0.10	0.15	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70

Appendix Table 2.3 Switching point (question) in Series 3 and the approximation of λ (loss aversion parameter)

λ	$\sigma=0.55$		$\sigma=0.60$		$\sigma=0.65$		$\sigma=0.70$		$\sigma=0.75$	
	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound
1	$-\infty$	0.36	$-\infty$	0.35	$-\infty$	0.34	$-\infty$	0.33	$-\infty$	0.32
2	0.36	1.38	0.35	1.37	0.34	1.35	0.33	1.33	0.32	1.32
3	1.38	1.82	1.37	1.84	1.35	1.86	1.33	1.88	1.32	1.91
4	1.82	2.24	1.84	2.24	1.86	2.25	1.88	2.26	1.91	2.28
5	2.24	3.88	2.24	3.94	2.25	4.02	2.26	4.11	2.28	4.21
6	3.88	4.95	3.94	5.02	4.02	5.1	4.11	5.2	4.21	5.3
7	4.95	13.44	5.02	13.51	5.1	13.6	5.2	13.73	5.3	13.89
8	13.44	∞	13.51	∞	13.6	∞	13.73	∞	13.89	∞

Note: To find the mid-points for estimation, a value of 0 was used in place of $-\infty$ and a value of 18 was used in place of $+\infty$.

Appendix Table 2.4 Discounting choices

Question	Option A		Option B	
	Payoff	Time	Payoff	Time
1-1	60	2 weeks	10	today
1-2	60	2 weeks	20	today
1-3	60	2 weeks	30	today
1-4	60	2 weeks	40	today
1-5	60	2 weeks	50	today
2-1	60	3 months	10	today
2-2	60	3 months	20	today
2-3	60	3 months	30	today
2-4	60	3 months	40	today
2-5	60	3 months	50	today
3-1	60	6 months	10	today
3-2	60	6 months	20	today
3-3	60	6 months	30	today
3-4	60	6 months	40	today
3-5	60	6 months	50	today
4-1	150	2 weeks	25	today
4-2	150	2 weeks	50	today
4-3	150	2 weeks	75	today
4-4	150	2 weeks	100	today
4-5	150	2 weeks	125	today
5-1	150	3 months	25	today
5-2	150	3 months	50	today
5-3	150	3 months	75	today
5-4	150	3 months	100	today
5-5	150	3 months	125	today
6-1	150	6 months	25	today
6-2	150	6 months	50	today
6-3	150	6 months	75	today
6-4	150	6 months	100	today
6-5	150	6 months	125	today
7-1	15	2 weeks	2.5	today
7-2	15	2 weeks	5	today
7-3	15	2 weeks	7.5	today
7-4	15	2 weeks	10	today
7-5	15	2 weeks	12.5	today
8-1	15	3 months	2.5	today
8-2	15	3 months	5	today

*Table continued on
the next page.*

Appendix Table 2.4 [continued] Discounting choices

Question	Option A		Option B	
	Payoff	Time	Payoff	Time
8-3	15	3 months	7.5	today
8-4	15	3 months	10	today
8-5	15	3 months	12.5	today
9-1	15	6 months	2.5	today
9-2	15	6 months	5	today
9-3	15	6 months	7.5	today
9-4	15	6 months	10	today
9-5	15	6 months	12.5	today
10-1	120	1 week	20	today
10-2	120	1 week	40	today
10-3	120	1 week	60	today
10-4	120	1 week	80	today
10-5	120	1 week	100	today
11-1	120	2 months	20	today
11-2	120	2 months	40	today
11-3	120	2 months	60	today
11-4	120	2 months	80	today
11-5	120	2 months	100	today
12-1	120	4 months	20	today
12-2	120	4 months	40	today
12-3	120	4 months	60	today
12-4	120	4 months	80	today
12-5	120	4 months	100	today
13-1	30	1 week	5	today
13-2	30	1 week	10	today
13-3	30	1 week	15	today
13-4	30	1 week	20	today
13-5	30	1 week	25	today
14-1	30	2 months	5	today
14-2	30	2 months	10	today
14-3	30	2 months	15	today
14-4	30	2 months	20	today
14-5	30	2 months	25	today
15-1	30	4 months	5	today
15-2	30	4 months	10	today
15-3	30	4 months	15	today
15-4	30	4 months	20	today
15-5	30	4 months	25	today

Appendix Table 2.5 First stage from IV-2SLS regressions for risk aversion and loss aversion

Dependent variable:	Net worth per capita (1000s of yuan)	
Rank in village by net worth per capita	94.651 (8.74)***	102.175 (9.92)***
Male	-1.363 (0.12)	-4.958 (0.48)
Years of education	0.279 (0.23)	0.686 (0.57)
Age	0.035 (0.09)	-0.176 (0.50)
Has off farm employment	1.934 (0.24)	-5.566 (0.70)
Household size	4.390 (1.32)	4.546 (1.43)
Number of children/number of adults	-12.816 (15.30)	-12.139 (0.83)
Number in household who work	-5.357 (1.29)	-4.401 (1.11)
Distance to post office (km)	0.552 (1.11)	0.939 (1.63)
Distance to county seat (km)	0.419 (2.54)	-0.416 (0.81)
Constant	-23.33 (0.89)	-1.631 (0.06)
Township fixed effects:	No	Yes
N	96	96
R ²	0.54	0.63
F-statistic	10.20	9.15

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level.

Table 2.6 First stage from IV-2SLS regressions for hyperbolic discounting parameter

Dependent variable:	Net worth per capita (1000s of yuan)	
Rank in village by net worth per capita	94.144 (8.43)***	101.876 (9.48)***
Male	-0.821 (0.07)	-4.651 (0.44)
Years of education	0.177 (0.14)	0.647 (0.52)
Age	-0.004 (0.01)	-0.192 (0.52)
Has off farm employment	1.978 (0.24)	-5.575 (0.69)
Household size	4.512 (1.33)	4.613 (1.42)
Number of children/number of adults	-13.904 (0.89)	-12.696 (0.85)
Number in household who work	-5.651 (1.32)	-4.539 (1.11)
Distance to post office (km)	0.609 (1.18)	0.986 (1.57)
Distance to county seat (km)	0.420 (2.50)**	-0.437 (0.82)
Risk aversion	0.944 (0.09)	0.517 (0.05)
Risk experiment earnings	-0.048 (0.49)	-0.023 (0.23)
Constant	-20.608 (0.74)	-0.215 (0.01)
Township fixed effects:	No	Yes
N	96	96
R ²	0.55	0.63
F-statistic	8.35	7.88

Note: Absolute value of robust t-statistic in parentheses. ***=significant at 1% level, **=significant at 5% level, and *=significant at 10% level.

Appendix Table 2.7 Risk preference elicitation in developing countries

Source	Study Sample	Experiment Methodology	Findings
Binswanger (1980)	-India -Tropical area, characterized by high climatic risk for agriculture -240 participants	-Given list of 8 choices; each with 50% probability (coin toss) but low payoff decreased and high payoff increased as moved down the list -Included one safe option where heads or tails resulted in Rs. 50 -There was a sequence of games over time and higher levels of payoffs -Photographs of sums of money to be received indicated by coins placed in each field were given several weeks prior to the experiment to help illiterate people understand	-Objective was to determine whether differences in behavior between farmers of different wealth levels are the consequence of different attitudes toward risk or of different constraint sets such as limitations on credit or on access to modern inputs -Experimental measures of risk aversion indicate that at higher payoffs virtually all individuals are moderately risk averse with little variation according to personal characteristics -Wealth tends to reduce risk aversion slightly, but its effect is not statistically significant
Nielsen (2001)	-Toliara province of Madagascar -70 households across 6 villages	-Follow design of Binswanger (1980) -Each participated in 4 experiments; 2 time preferences experiments (both hypothetical payments); 2 risk preference experiments (1 hypothetical and 1 with real payoffs) -Presented with series of 6 binary choices between two payoffs with 0.5 probability -One experiment involved only gains, the other involved gains and losses	-Finds a linkage between asset poverty, time discounting and environmental degradation in the form of deforestation (and slash-and-burn agriculture) -Finds empirical linkage between willingness to take risks and willingness to delay
Barr (2003)	-Zimbabwe -678 subjects across 23 villages	-Follow design of Binswanger (1980) -Presented with six gambles; each yields high or low payoff determined by guessing which researcher's hand contained a blue rather than yellow ball -Risk-pooling introduced by giving subjects the next days choice list and allowing them to form groups in which all winning would be shared equally between group members	-Finds that more extrinsic commitment is associated with more risk pooling but that more information is associated with less risk pooling -In 4 of 5 villages networks of risk pooling contracts during the experiment and the networks existing in real life were significantly correlated
Mette Wik et al. (2004)	-Northern Zambia -110 participants across 6 villages	-Follow design of Binswanger (1980) -Given choice between set of 6 games each with 50% probability of winning -Played 7 games during the first visit and 6 more during a second visit two weeks later (varied payoff levels between games) -Paid randomly on several games	-Wealth indicator variables are found to be significant, and partial relative risk aversion decreases as wealth increases -Females are found to be more risk averse than males
Humphrey (2004)	-Uganda -Two regions: Sironko township in Sironko District and Bufumbo sub-county in Mbale District	-Presented 12 pair-wise decisions between risky lotteries -One question was randomly chosen for payment -Also asked two hypothetical valuation tasks in terms of disease control decisions	-Find that risk preferences of east Ugandan farmers exhibit systematic and predictable deviations from expected utility maximization; including: violations of the independence and transitivity axioms of expected utility theory, and reference-dependent preferences

Table continued on the next page.

Source	Study Sample	Experiment Methodology	Findings
Mosley and Verschoor (2005)	-Uganda(205 participants) -Ethiopia(100 participants) -India(227 participants)	-Participants presented with various pairs of lotteries; one 'risky' with a higher expected value but riskier than the other -Paid randomly on 1 choice -Additionally, asked two hypothetical questions to elicit certainty equivalents	-Examines all of the linkages in the 'vicious circle of poverty' -Finds that there is very little relationship between risk aversion and the income measure of poverty but there are strong and significant linkages from low return on assets, to asset levels, to ability to diversify and manage risk, to income poverty -It may be forward-looking perceptions of vulnerability to risk on behalf of themselves and their families best explain their attitudes of risk aversion, and thus help determine their investment and diversification decisions, capacity to manage risk, and ultimately whether they remain in poverty
Hamoudi and Thomas (2006)	-Mexico -1,253 participants in 11 rural communities in the states of Guanajuato and Michoacan	-Use modified design of Binswanger (1980) -Use 6 questions with 50/50 probability including one safe choice -With riskiest choice could win 540 pesos or lose 20 pesos (if lose, loss taken from show-up fee) -Choice presented in a circle, increasing risk as moved clockwise, high payoff would increase while low payoff would decrease -Paid randomly on 1 out of 5 preference tasks	-Examine the relationship between inter-generational transfers and attitudes towards risk -Finds that inter-generational transfers are associated with attitudes toward risk (although associations are mostly weak or insignificant) - Risk attitudes measured were correlated with actual behaviors
Liu (2008)	-Four provinces in China: Henan, Shandong, Hebei and Anhui -320 participants	-Use design of Tanaka et al. (2010) -Payoffs ranged from lose 10 yuan to win 850 yuan	-Examines role of risk attitudes in the decision to adopt a new form of agricultural biotechnology -Expands measure of risk preferences beyond expected utility theory to incorporate prospect theory parameters such as loss aversion and nonlinear probability weighting -Farmers who are more risk averse or more loss averse adopt the agricultural biotechnology (Bt cotton) later -Farmers with small probability weighting parameters adopt Bt cotton earlier
Carlsson et al. (2009)	-Guizhou province, China -117 couples	-Use procedure of Holt and Laury (2002) -10 pair-wise choices -Payoffs ranged from 1 to 38.5 yuan -One question chosen randomly for payoff -Have couples make decisions separately and then also together	-On average individuals are risk averse -Find spouses in richer households have more similar individual risk attitudes -Length of marriage has no impact on similarity -A couples joint decision is typically closer to the husband's individual decision -Women with higher income, more years of education, and communist party membership have a significantly stronger influence on joint decisions

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Source	Study Sample	Experiment Methodology	Findings
Yesuf and Bluffstone (2009)	-State of Amhara in the highlands of Ethiopia -262 farmers in seven local areas, in five counties and two zones	-Use design of Binswagner (1980) but frame choice sets to reflect real farming decisions -Use six farming systems, all having similar costs but different output levels depending on 50% probability of good or bad harvest (based on coin toss) -Use 5 experiment sets with 6 choices each; sets 2 to 5 derived by scaling up amounts of set 1 by 5, 10, 20 and 30 ETB; set 5 was hypothetical -After experiment with only gain-gain choices those who had made enough earnings were asked to participate in experiment with gain-loss choices	-Examine 4 research questions: (a) How does the buildup of wealth at very low income levels affect risk behavior? (b) In very low-income rural settings, how does the possibility of loss affect aversion to risk? (c) Do past successes within risky environments affect subsequent risk responses? (d) Do levels of potential gains and losses affect responses to risk? -Find high risk aversion and evidence that constraints have important impacts on risk-averting behavior with perhaps implication for long-term poverty
Bauer, Chytilová, and Morduch (2010)	-Rural population of Karnataka in southern India -573 subjects, 9 villages, 2 taluks (Honavar and Haliyal) -35 people selected in each village by random walk (90% of invited participated)	-Follow design of Binswagner (1980) -Asked to select 1 out of 6 different gambles, each with a high and a low payoff with a probability 0.5 -In each subsequent gamble expected value increased jointly with the variance -Expected value of least risky gamble was Rs. 250, and higher payoff in most risky gamble was Rs. 1000	-Used risk aversion to control for the curvature of utility function, when examining determinants of savings and borrowing behavior -More risk averse females save a lower proportion of savings at home and more outside of home -More risk averse males borrow more
Gong et al. (2010)	-Yunnan Province in southwestern China -300 households across 30 villages	-Follow design of Holt and Laury (2002) -Series of 10 lottery-choices (Option A and Option B), where probability of higher payoff increased as participant moved down the list and Option B was more “risky” than Option A since its payoffs (CNY 35 and CNY 5) are more variable than the payoffs for Option A (CNY 20 and CNY 16) -One question chosen randomly for payoff	-Participants exhibit substantial risk aversion -Risk aversion affects input intensity differently for market-oriented versus subsistence farmers -Risk aversion related with increasing use of pesticides by market-oriented producers but a reduction of pesticide use by subsistence farmers -Market producers are more concerned with stabilizing income, while subsistence producers are more concerned with stabilizing production
Tanaka, Camerer, and Nguyen (2010)	- Vietnam -180 participants across 4 villages in the south and 4 in the north	-Use modified design of Holt and Laury (2002) -Use 3 series of paired lotteries, 35 choices in total -Choice between lotteries (A and B) -Probabilities stay the same in each series but payoffs increase as move down rows in the lottery B column -Monotonic switching is enforced -One question chosen randomly for payoff	- Results indicate that mean village income is related to risk and time preferences -See Appendix B, Table 1 and 2 for ,more details

Appendix Table 2.8 Relationship between risk preferences and poverty

Source	Location and Sample Size	Wealth Definition	Income Definition	Empirical Methods	Findings
Binswanger (1980)	India	-Use gross sales value of physical assets		-OLS with village fixed effects	-At higher payoffs (approximately monthly labor income) wealth does not appear to influence risk aversion significantly, although at low game levels such an effect appears to exist
Nielsen (2001)	-Toliara province of Madagascar -70 households across 6 villages	-Increase in cattle holdings; Reduction in cattle holding	-Income	-Estimated mean of discount rate by sub-groups -Ordered probit model	-Respondents with a reduction in cattle holdings were more risk averse -Income positively related to risk aversion (opposite of what you would expect from expected utility theory) -Cattle assets did not have a significant influence on risk aversion
Wik et al. (2004)	-Northern Zambia -110 participants across 6 villages		-Log of income per capita -Cash liquidity per capita	-Random effects interval regression and pooled interval regression model -Use lower and upper boundaries of the interval for risk aversion	-Found evidence of decreasing absolute risk aversion when income per capita increases
Mosley and Verschoor (2005)	-Uganda(205 participants) -Ethiopia(100 participants) -India(227 participants)	-Wealth (does not explain how wealth is defined) <i>Note:</i> Also creates an index of perceived vulnerability as a better measure of poverty	-Income per capita	-OLS -Binary logistic regression (when risk aversion is a RA1-6, where $RA_i = 1$ for participants who state a preference for a risky lottery less than i times)	-Only in Ethiopia are any of the risk aversion measures correlated with income, and only RA2 at the 10% level -In Uganda per capita wealth is correlated with three RA measures but not with any Arrow-Pratt measures -The vulnerability index (when substituted for wealth and income in the regressions) is significantly correlated for all RA risk aversion measures, so it may be subjective rather than objective factors that drive attitudes towards risk (more vulnerable, more risk averse in Uganda; more vulnerable, less risk averse in India)
Liu (2008)	-Four provinces in China: Henan, Shandong, Hebei and Anhui -320 participants	-Use wealth per capita, where wealth is defined as the value of durable goods per capita		-OLS	-Wealthier respondents were less risk averse (significant at 10% level) -Wealth did not have a statistically significant impact on loss aversion or the probability weighting parameter

Table continued on the next page.

Source	Location and Sample Size	Wealth Definition	Income Definition	Empirical Methods	Findings
Yesuf and Bluffstone (2009)	Ethiopia	-Several indicators of wealth: value of domestic animals, number of oxen, current cash availability (annual cash income – cash expenditure), household land area, and number of cultivated plots -Livestock is major form of wealth		-Random effects model of risk aversion -Ordered probit marginal effects by risk category	- All wealth indicators are negative and significant, indicating that wealth is correlated with lower risk aversion - Wealth accumulation tends to reduce severe and extreme risk aversion and moves respondents into less risk-averse categories
Tanaka, Camerer, and Nguyen (2010)	- Vietnam -180 participants across 4 villages in the south and 4 in the north		-Total income -Relative income within the village (subtracting the mean and dividing by the within-village standard deviation) -Village mean income	-Non-linear estimations of the logistic function, allowing the discount rate and present bias parameter to depend on demographic variables -Use instrumental variables (rainfall and head of household cannot work as instruments) because results of Hausman and Davidson-MacKinnon tests suggest OLS is an inconsistent estimator	-Household income is not significantly correlated with risk aversion or loss aversion -Mean village income is highly correlated with loss aversion but not risk aversion (people in poor villages are not necessarily afraid of uncertainty, in the sense of income variation; instead, they are averse to loss)

Appendix Table 2.9 Time preference elicitation in developing countries

Source	Location and Sample Size	Experiment Methodology	Findings
Pender (1996)	-Andhra Pradesh, India -96 participants, 2 villages (1989) -72 participants in follow-up (1991)	-Each participated in 3 experiments (6 variations of experiments used) - Presented with a series of 8 to 10 binary choices between a specified amount of rice to be received at a particular date and alternative amount to be received at some other date -Each choice presented on a separate card -One card randomly selected for payment -Time frames ranged from 7, 12, 19 and 24 months; reference point was 1 month, 13 months or 25 months -Follow-up experiments conducted in 1991	-Find that minimum discount rates in all experiments were higher than the maximum interest rates paid by most respondents -Use experiment data and credit market data to test three models of credit markets : (1) the permanent income model, (2) upward sloping credit supply to individual borrowers, and (3) constrained credit due to imperfect enforcement -Rejects the permanent income model -Discount rate data are consistent with (2) and (3), while the credit market data are consistent with a combination of (2) and (3)
Godoy et al. (1998)	-Chimane Amerindian households in 18 villages in the Bolivian rainforest -209 participants	-Twenty minutes into an interview asked participants “We realize you may be getting tired from answering questions. We would like to give you a rest. Would you like to have one candy now or two candies at the end of the interview?” -If participant said no, then asked “One now or three at the end?” -Then delivered candy at the appropriate time	-The average impatience of the household heads was associated with less deforestation
Holden, Shiferaw, and Wik (1998)	-Indonesia(41 participants) -Zambia (86 participants) -Ethiopia (120 participants)	-Each participant asked “If you were told you have the choice between an amount of money today (PV) and the amount (FV) in one year, how large would the amount PV have to be for you to prefer it instead of FV in one year?” -Question was repeatedly asked lowering the PV until a cut-off point was identified -In Indonesia and Ethiopia used cash value and in Zambia used both cash and maize; however, questions were hypothetical	-Discount rates found to be very high -Market imperfections (credit and insurance markets) led to variation in discount rate -Poverty in assets, or cash liquidity constraints, was leading to or correlated with higher rates of time preference -In Zambia estimates of risk preferences were also estimated; more risk averse people tended to have lower discount rates
Godoy, Kirby, and Wilkie (2001)	-Bolivian lowlands -443 participants across 42 villages	-Each asked 9 questions about a small reward today or larger reward at a specified delay (7 to 162 days) -Carried out experiment half way through field work to ensure delivery of future reward at specified time	-Rates of time preference had a small economic and statistical effect on the use of natural resources (old-growth forest, fallow forests, fish, and game)
Nielsen (2001)	-Toliara province of Madagascar -70 households across 6 villages	-Each participated in 4 experiments; 2 time preferences experiments (both hypothetical payments); 2 risk preference experiments (1 hypothetical and 1 with real payoffs) -Presented with series of 6 binary choices between payoff today and 1 year from now -One experiment involved only gains, the other involved gains and losses	-Finds a linkage between asset poverty, time discounting and environmental degradation in the form of deforestation (and slash-and-burn agriculture) -Finds empirical linkage between willingness to take risks and willingness to delay

Table continued on the next page.

Source	Location and Sample Size	Experiment Methodology	Findings
Pendleton and Howe (2002)	-Bolivian lowlands -Sub-sample from Godoy et al.'s (2001) data -209 participants across 18 villages included in data set	-Data collected by Godoy et al. (2001)	-Patient farmers clear more forest than impatient farmers -Similar coefficients on impatience for clearance of old-growth and secondary-growth areas but only significant for secondary growth
Kirby et al. (2002)	-Beni, Bolivia -154 Tsimane' Amerindians from 53 households across 2 villages along the River Maniqui in the tropical rainforest	-Participants given a list of 8 choices between X today and X+Y in the future -Future time frames ranged from 7 to 157 days -Participant were also given a list of 8 choices between a smaller number of candy today and a larger numbers of candy in the future -Conducted the experiments quarterly over the course of 1 year	-Discount rates increased with age, decreased with educational levels and literacy, and tended to decrease as recent income rose -Discount rates were not associated with wealth, nutritional status, or moderate drug use -Low but reliable correlations between discount rates across quarters, suggesting that a person's discount rate is a somewhat stable characteristic
Anderson et al. (2004)	-Vietnam -Two villages in the region of Hanoi city, one considered a rural commune (Thach Ban) and the other considered a urban commune (Quynh Mai)	-Asked respondents to imagine that they had the opportunity to receive a loan from a local NGO and that they had the choice of paying back the loan immediately or postponing the payment to a later date, at which time they would have to pay a larger amount -9 questions -Future times included: 1 day, 3 months or 1 year -Hypothetical question	-Trade-offs between today and tomorrow are different from trade-offs between any other 24-hour period -Examines correlations between discount rate and household characteristics -Find no relationship between income or gender and discount rate, an inverse correlation between age and discount rate -Find that those living in rural area have significantly higher discount rates
Casse et al. (2005)	-Toliara province of Madagascar -74 participants across 6 villages (part of larger sample of 240 households across 20 villages)	-Each participant asked to choose among six hypothetical options -Options were between for example "X payment now or X+Y payment for one year later?"	-High rates of time preference found
Hamoudi and Thomas (2006)	-Mexico -1,253 participants in 11 rural communities in the states of Guanajuato and Michoacan	-Use 10 questions; "Receive X today or X+Y in the future (1 and 2 months; 3 years?" -Those subjects who opted for future payoff were given contact information, a postcard to tell them if they moved and a written pledge that the surveyor would return on the specified date with the specified amount	-Examine the relationship between intergenerational transfers and time preference -Male adults who are more patient are more likely to support parents -Both mothers and fathers who are more patient appear to invest more in their children -Time preference measures collected were correlated with actual behaviors

Table continued on the next page.

Source	Location and Sample Size	Experiment Methodology	Findings
Gunatilake, Wickramasinghe, and Abeygunawardena (2007)	-Sinharaja Man and Biosphere Reserve in Sri Lanka -180 participants	-First conducted a survey to calculate the value of non-timber forest products (NTFP) collected by the household in the previous year -Then asked hypothetical stated preference survey question -If the Forest Department (FD) told them that they could not collect any NTFP for 1 year and that they would be compensated for the NTFP they did not harvest but that the payment would be delayed X months due to administrative problems. How much would the FD have to pay you if payment was made exactly X months from the due date?	-Investigate impact of time preference on NTFP harvesting, using a simultaneous question model -Villagers discount future consumption at an average rate of 24%, which is above existing market rate of interest for bank loans (18.5%) -Individuals with a higher rate of time preference harvest more forest resources
Yesuf and Bluffstone (2008)	-State of Amhara in the highlands of Ethiopia -262 farmers in seven local areas, in five counties and two zones	-Four experiment sets; each with choice between X amount today or Y amount in the future (3,6, and 12 months); amounts were either ETB 15 or 40 (\$1.76 and \$4.70) -Each choice set presented on a card and recorded on the card, after 28 cards completed one was chosen at random for payment	-Find that median discount rate for each set of experiments is high (more than double the average interest rate on outstanding debt) -Discount rate varied systematically with wealth (physical asset) and risk preferences
Bauer and Chytilová (2008)	-Rural population in Mukono district, southern Uganda -910 participants, 10 villages	-Asked "Would you prefer Ush 200,000 today or Ush 250,000 in one year?" -Asked 5 questions, each time increasing the future payment -Hypothetical survey questions	-Examine causal impact of education on subject discount rates using instrumental variables (varying school frequency in different villages and number of school-age years that overlap with the era of Idi Amin) - Find that for men education has significant impact on discount rate
Bauer, Chytilová, and Morduch (2010)	-Rural population of Karnataka in south India -573 participants, 9 villages, 2 taluks (Honavar and Haliyal) -35 people selected in each village by random walk (90% of invited participated)	- Asked "Would you rather consume Rs. 250 tomorrow or X+Y in t months?" -Asked 2 sets of 5 questions each -In one set t=3 and in the other t=15 months -Shifted future question exactly 1 year to avoid any seasonality -In current question included 1 day time delay to lower credibility and higher transaction costs associated with future payments -Real monetary rewards with stakes as large as a week's wage (min Rs. 250, max Rs. 375)	-Integrate experimental measures of time discounting and risk aversion with survey data on financial activity to identify time inconsistencies between current and future questions -Identify 1/3 of population exhibits choices consistent with hyperbolic discounting (discount future more heavily when asked a series of questions about consumption now vs. in 3 months, relative to discounting in similar questions about consumption in 12 vs. 15 months) -Women with hyperbolic preferences save less at home, save less in total levels and are more likely to borrow generally but to do so through microcredit institutions specifically
Tanaka, Camerer, and Nguyen (2010)	- Vietnam -180 participants across 4 villages in the south and 4 in the north	-Subjects are asked to make 75 choices between smaller rewards delivered today and larger rewards delivered at a specified time in the future -Future times include: 3 days, 1 week, 2 weeks, 1, 2 and 3 months -Payment varied between 30,000 to 300,000 dong (15 days wage in rural north) - Enforced monotonic switching within question sets -A single question was selected at random for payment -Before experiment selected trusted agent to deliver the future payments	-Results indicate that mean village income is related to risk and time preferences -See appendix table 2.10

Appendix Table 2.10 Relationship between time preference and poverty

Source	Location and Sample Size	Wealth Definition	Income Definition	Empirical Methods	Findings
Pender (1996)	-Andhra Pradesh, India -96 participants, 2 villages (1989) -72 participants in follow-up (1991)	-Use household's net wealth per capita defined as total value of assets minus debts -Assets include: land, buildings, livestock, farm implements, stocks of agricultural products, inputs, household items and consumer durables, and financial assets		-Maximum likelihood estimations -Uses Hausman's procedure (Hausman, 1978) to test the assumption that wealth is an exogenous variable and cannot reject exogeneity of net wealth at the 5% level in any of the regressions	-Wealthier respondents had lower discount rates in all experiments, although only statistically significant in 3 experiments -Size of wealth effect is substantial, implying an increase of Rs 10,000 net wealth per capita results in as much as a 22 percentage point reduction in the discount rate
Holden, Shiferaw, and Wik (1998)	-Indonesia(41 participants) -Zambia (86 participants) -Ethiopia (120 participants)	-Labor force per capita -Savings last year per capita (Indonesia) -Number of oxen (Ethiopia) -Former land ownership in Indonesia before transferred to Sumatra (past wealth)	-Total income per capita -Net cash liquidity per capita (income minus expenditure)	-OLS	-Indonesia: current liquidity had a significant positive correlation with the discount rate; income per capita had a negative (but insignificant) relationship with the discount rate; savings last year had a significant positive correlation with the discount rate -Zambia: Total income and labor force per capita had no significant correlation with discount rates; cash liquidity significant positive relationship -Ethiopia: Oxen wealth had a significant correlation with discount rate; total income per consumer unit had a significant negative relationship with discount rate
Nielsen (2001)	-Toliara province of Madagascar -70 households across 6 villages	-Increase in cattle holdings; reduction in cattle holding	-Income	-Estimated mean of discount rate by sub-groups -Ordered probit model	-Respondents with increases in cattle stock demonstrate significantly lower discount rates
Kirby et al. (2002)	-Beni, Bolivia -154 Tsimane' Amerindians from 53 households across 2 villages along the River Maniqui in the tropical rainforest	-Log of the value of physical assets	-Log of cash received during previous month	-OLS -Discount rates were regressed on each explanatory variable, both separately and in multivariate analyses that included together the explanatory variable, gender and age -Focus on simple regressions	-Found an inverse relationship between discount rates and income, but no relationship with wealth

Table continued on the next page.

Source	Location and Sample Size	Wealth Definition	Income Definition	Empirical Methods	Findings
Anderson et al. (2004)	-Vietnam -Two villages in the region of Hanoi city, one considered a rural commune (Thach Ban) and the other considered a urban commune (Quynh Mai)		-Household monthly income	-Correlation analysis -Categorical comparison	-No relationship between income and discount rates
Gunatilake, Wickramasinghe, and Abeygunawardena (2007)	-Sinharaja Man and Biosphere Reserve in Sri Lanka -180 participants		-Total income	-OLS	-Individual rate of time preference declines when total income increases
Yesuf and Bluffstone (2008)	Ethiopia	-Use wealth indicators such as value of capital stock, number of oxen and land size	-Use cash liquidity (difference between all sources of cash revenue and cash expenditure)	-Interval regression model (due to right- censored, left-censored and interval discount rates)	-Farm households with relatively better stock of capital, bigger farm sizes, and a larger number of oxen are likely to have relatively low discount rate -Insignificant effect of cash liquidity
Bauer and Chytilová (2008)	Mukono district, southern Uganda		-Use profession as a proxy of income -Self-employed farmers and non-farm workers (drivers, shopkeepers vs. employed individuals (teachers, employees of public bodies or NGOs) and students	-Examines average discount rates across profession groups -OLS, clustering at village level	-Individuals facing less income pressures discount less when looking at average discount rates across profession groups -From OLS, some evidence that employed females discount more, however no other significant impact of profession on time preference
Bauer, Chytilová, and Morduch (2010)	Karnataka in southern India	-Wealth index calculated by principal component analyses from questions on type of house, electricity connection, land ownership and dummies for possession of 14 types of household equipment		OLS, clustering at village level	Wealth is not correlated with the discount rate

Table continued on the next page.

Source	Location and Sample Size	Wealth Definition	Income Definition	Empirical Methods	Findings
Tanaka, Camerer, and Nguyen (2010)	- Vietnam -180 participants across 4 villages in the south and 4 in the north		-Total income -Relative income within the village -Village mean income	-Non-linear estimations of the logistic function, allowing the discount rate and present bias parameter to depend on demographic variables -Use instrumental variables (rainfall and head of household cannot work) because results of Davidson-MacKinnon test suggest OLS is an inconsistent estimator	-Mean village income is related to time preferences -Mean village income is correlated with lower discount rates (people living in wealthy villages are more patient) -Household income is correlated with patience -People are present biased regardless of their income levels and economic environments

MANUSCRIPT 3

Forest Tenure Reform and Household Wealth: Insights from China

Prepared for submission to Environment and Development Economics

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Forest Tenure Reform and Household Wealth: Insights from China

3.1 Abstract

This paper examines the effect of forest tenure reform on household wealth in Fujian Province, China, where a large-scale reform of property rights began in 2003. We use a balanced panel survey data set that contains data for three years: 2000 (before the reform), 2005 and 2008 (after the reform) in a fixed effect model to identify the impact of the reform on wealth. We find weak evidence that the forest tenure reforms had a positive effect on household wealth. Specifically, increased tenure security in the form of a forest certificate increased net worth per capita by 42% between 2000 and 2008. To further examine the source of increased wealth, we also examine the effect of the reform on household forest use. Results suggest that forest certification increased bamboo revenue, while obtaining a new plot (without a forest certificate) increased non-timber forest product revenue, although these results are statistically weak. Overall this paper provides weak evidence that forest tenure reform garners potential for improving poor rural households' livelihoods in China.

3.2 Introduction

Many people living in or near forests in developing countries are poor (Sunderlin et al. 2007). For example, in China, Zhou and Veeck (1999) observed that many

counties with abundant forest also were categorized as being severely poor. In India, approximately 275 million people live in or near forests and depend on them for their income. These people are disproportionately 'tribal' ethnic minorities, who are among the poorest and most vulnerable people in India (Mehta & Shah 2003; World Bank 2006). Similar observations have also been made in Cambodia (Dasgupta et al 2005), Vietnam (Muller et al. 2006) and Brazil (Sunderlin et al. 2007). Overall there are hundreds of millions of people who depend on forests for their livelihood (Byron & Arnold 1999; Calibre Consultants and Statistical Services Centre 2000).¹

The correlation between people living in poverty and their dependence on forest resources, combined with the continued deforestation in the world, has stimulated a call from international institutions, NGOs, and community organizations, for pro-poor forestry policies in the last decade (Wunder 2001; FAO 2003; Sunderlin et al. 2005; Hobley 2007; FAO 2009). Amongst the various pro-poor forestry policies that have been recommended, one that has received notable attention and gained momentum in implementation is forest tenure reform. Property rights to ownership and use of forest resources are often contested, overlapping or unenforced, leaving households with insecure ownership and use rights to forest resources. This insecurity undermines sound forest management, for without secure rights forest holders have few incentives to invest in managing and protecting their forest resources. These realizations have stimulated the recent trend in forest policy toward strengthening property rights for forest resources by transferring property rights from the state to communities and individuals, giving them defined rights to manage and use forest resources (Edmonds 2002; FAO 2003; Ellsworth and White 2004).

In this paper, we assess the impact of forest tenure reforms on household wealth in Fujian, China, where an extensive forest tenure reform, aimed at transferring the responsibility of forest planting and management from the collective (by townships and villages) to households began in 2003. China implemented the reform with the objectives of increasing forest coverage, increasing farmers' enthusiasm for forest management and investment, and improving farmers' livelihoods (Liu and Lixia 2009). China's collectively owned forests total approximately 100 million hectares and are home to more than 400 million people, which arguably makes these reforms the largest one undertaken in modern times both in terms of forest area and people affected (Xu et al. 2010). By 2006, about 70% of collective forests had been allocated to households (Xu et al. 2010). Recent guidelines issued by the CPC Central Committee and State Council suggest that China is going to continue further with the privatization of forest land (Shen et al. 2009). As such, it is important that we examine the effect of China's forest tenure reform on rural households, many of whom despite China's recent rapid economic growth remain in poverty. Lessons learned will be of significant value to China and to other developing countries as they too design policy to address the interrelated problems of deforestation, insecure forest tenure, and poverty in their countries.

To assess the tenure reform's progress towards meeting its objective of improving farmers' livelihoods, we use a panel survey data set collected among 103 households in 2006 and 2009, which contains pre- and post-reform, quantitative and qualitative data for three years: 2000 (before the reform), 2005 and 2008 (after the reform). To identify the effect of the reform on wealth, we use a fixed effects model.

Results provide statistically weak evidence that the forest tenure reforms have had a positive effect on household wealth in our study area. Specifically, increased tenure security in the form of a forest certificate increased net worth per capita. This positive forest certification effect on wealth was larger in magnitude when the forest certificate was on a plot that a household had already been managing than when the forest certificate accompanied a new plot that a household received as a result of the reform.

To gain insight into the mechanism through which tenure reform leads to increased wealth, we also examine the effect of the tenure reform on households' forest use. Specifically, we examine changes in household revenue per capita from the sale of non-timber forest product (NTFP) and total revenue from the sale of bamboo, as households were relatively more engaged in these two forest income generating activities than in the sale of timber. The results suggest that forest certification had a positive effect on total bamboo revenue, while it did not have a significant effect on NTFP revenue. Obtaining a new plot (without a forest certificate) resulted in an increase in NTFP revenue per capita, while it did not have a significant effect on bamboo revenue.

This paper proceeds as follows. The first section gives an overview of the forest tenure reform history in China, with an emphasis on the recent tenure reforms in Fujian, China. The next section explains the data collection procedures, gives a description of the data and reports a preliminary examination of the impact of the forest tenure reform on households' livelihoods using descriptive statistics. Then the empirical framework is outlined, followed by the results and a concluding section.

3.3 China's Forest Tenure Reform

This paper examines the impact of tenure reforms on wealth in the context of China, specifically in Fujian Province. China's forest area accounts for 4.5 percent of the world's total. China has two main categories of forest landownership.

Approximately 42 percent of forest land in China is owned by the state and the rest is owned by the collective (Liu and Lixia 2009). Since the early 1950s, forest tenure and management policies of China's collective forests have undergone fundamental changes. Collectivization of non-state owned forests began in 1956, and remained dominant until the reforms of the 1980s (Xu and Jiang 2009). Under collectivization, administrative villages, usually comprised of a number of natural villages or clusters of families, functioned as the legal owners of collective forests, and households had little active participation in management. For households there were no links between or among their rights to forests, their responsibility for forest establishment and management, and their benefits from forests (Dachang 2001).

The first major wave of reforms in China's collective forests began in 1981, and was aimed at transferring the responsibility of forest planting and management from the collective to households (Miao and West 2004). By 1986, nearly 70% of the collectively owned forest land had been transferred to rural household management (Xu and Jiang 2009). In 1987, however, due to unsustainable logging the government reverted a large portion of forest land under household management back to collective management (Hyde et al. 2003).

By 1986, while 70% of the collectively owned forest land in China had been transferred to rural household management, in Fujian only 32% of the collective forest

land had been distributed for household management (CFYB 1987). This low percentage of forest land under household management was due to the fact that Fujian had not fully participated in the first round of the tenure reforms in the 1980s. Instead, the provincial government in Fujian had implemented a shareholding system to keep forests under collective management while distributing “paper shares” of collective forests based on family population. In Fujian, forest land was not actually physically distributed, rather only dividends from the forest were distributed to households.

At first, Fujian’s shareholding system was highly regarded by forest administrators for its ability to maintain forests under collective management but fifteen years after establishment of the system, two issues became increasingly evident (Xu and Jiang 2009). First, forestry’s contribution to rural incomes was negligible in spite of the fact that forest land occupies more than 60% of the total provincial land area and 80% of rural land area (Qin 2008). Second, enforcing forest conservation had become increasingly difficult for local forest authorities due to lack of cooperation from farmers. For example, the severity of forest fire incidents grew over the course of the 1990s, and there is anecdotal evidence that many of the fires were caused by farmers (Xu and Jiang 2009).

Under these circumstances, in 2003 the second wave of reforms was officially approved by the provincial government in Fujian province.² In this second wave of reforms, Fujian, the largest but once resistant collective forest province, adopted forest tenure reforms aimed at individualization of forest land. The decisions regarding forest land reallocation during this reform required a 2/3 majority vote by the village representative committees or by village assemblies. Redistribution of plots was

accompanied by legal contracts and forest certificates with extended contract periods of 30 to 70 years, whereas previously contract periods had only been 5 to 15 years (Liu and Lixia 2009). Furthermore, adoption of the Rural Land Contract Law allowed for the expansion of rights under the new forest certificates to include those of land transfer, inheritance and mortgaging (Xu and Jiang 2009).

In mid-2003, the central government announced the “Resolution of Development of Forestry.” This forest policy aimed to reduce the growing rural-urban economic disparities in China and to increase domestic forest production by distributing stronger forest use and management rights to households (Xu et al. 2010). Since 2003, fourteen other provinces have initiated reforms aimed at both delegating collective-owned forest land to direct household management and strengthening property rights with forest certificates for both households already managing forest plots individually and for new forest plots distributed to households.

About 70% of collective forests had been allocated to households by 2006 (Xu et al. 2010). Recent guidelines issued by the CPC Central Committee and State Council suggest that China is going to further privatize forest land (Shen et al. 2009). As such, it is important that to examine the effect of China’s forest tenure reform on rural households, many of whom despite China’s recent rapid economic growth remain in poverty. Xu and Jiang (2009) report that household net income as a whole has increased from 2000 (before the reform) to 2006 (after the reform) based on a household survey of 3,180 households across 8 provinces, where the reform had been implemented in China. Furthermore, in provinces that had a shift in rights towards households (Fujian, Jiangxi, Zhejiang, Hunan, Liaoning, Shandong and Yunnan

Province), Xu and Jiang (2009) report that there was an increase in the share of household income generated from forestry, and where rights were shifted back towards the collective (Anhui), the share of household income from forestry diminished. In Fujian, the site of our study, forestry's share in household income increased 3.71% between 2000 and 2006 in Fujian (Xu, White, and Lee 2010). While this suggests that forestry income has become more important to households as a result of the reform, further analysis is needed to identify a causal effect between the forest tenure reform and changes in household income. From these statistics, we are unable to determine if the changes in forest income are a result of households receiving forest certificates for plots they were already managing, new plots with forest certificates or new plots without forest certificates. In this study, we aim to disentangle the causality between the forest tenure reform (stronger rights from forest certificates and increased forest area from new plots distributed during the reform) and changes in household wealth, as well as changes in revenue from the sale of NTFP and bamboo.

3.4 Data, Definitions, and Descriptive Statistics

The household panel data set contains pre- and post-reform, quantitative and qualitative data for 104 households spanning two counties, Sanming City and Datian County, and 10 villages in Fujian Province for three years: 2000 (before the reform), 2005 and 2008 (after the reform). Survey data for the years 2000 and 2005 were collected in 2006 by a research team from Peking University, Gothenburg University and Forest Trends. The 2006 survey team conducted interviews in three townships, each with two villages and ten households in each village—for a total of 600

households. In 2009, two of the twelve counties were randomly chosen and efforts were made to conduct a follow-up survey with the 120 households in those counties that had been included in the previous survey.

During the 2009 follow-up survey, 104 of the 120 households included in the previous survey were located. The 104 located households were asked to complete the survey. All households completed the survey. Each household was paid 15 yuan compensation for completing the survey.³

We construct a balanced panel data set by using only those households that were included in both survey years, so that we have pre- and post- reform data for every household in the analysis. Ten households, that had no forest land area, as well as no forest income, in any of the survey years are excluded from the analysis. Seven households for which there was missing data that was essential to this analysis are also discarded. This results in a sample size of 87 households.

In 2000, average household size in the sample was 4.9 people (table 3.1). Only two of the 87 households had a female head of household. On average the head of household was 46.43 years old and had 5.09 years of education. The typical household managed 0.59 hectares of forest land per capita and had a crop production area (area of production multiplied by the number of times harvested) of 0.08 hectares per capita.

Changes in forest tenure

Prior to the recent forest tenure reform, 96.6% of the households in our balanced panel data set had already been managing forest plots. We will refer to each of these plots as *pre-FTR plots*. The reform impacted household forest plot structure in a

variety of ways. First, a household may have gotten a forest certificate for a pre-FTR plot (23% of households by 2008). Second, a new forest plot (*new plot*) may have been distributed to the household (24% of households by 2008). Third, the household may have been distributed a new plot, along with a forest certificate for the new plot (7% of households by 2008). Lastly, in some cases households may have experienced one or more of these changes to their forest plot tenure structure (51% of households by 2008). To summarize, households' forest plots can be categorized into four categories: 1) pre-FTR plots without a forest certificate; 2) pre-FTR plots with a forest certificate; 3) new plots without a forest certificate; and 4) new plots with a forest certificate. In each year, a given household's total forest area will be distributed amongst one or more of these four categories.

Figure 3.1 depicts changes the forest plot tenure structure of households in our sample. In 2000, the total forest land area managed by the households in our sample was 216.1 hectares. By 2008, the total forest land area managed by the households in our sample had risen only slightly to 219.3 hectares, of which 66.7 hectares was managed by a household with a forest certificate for that forest land and 42.4 hectares that had been distributed to households as a new forest plot area during the reform.

Wealth

Our primary interest is to assess the impact of the forest tenure reform on household wealth. To measure household wealth we use net worth per capita, which is equal to total assets minus total liabilities. Household assets include: the value of consumer durables, productive assets, and livestock; savings held in bank accounts; loans provided to others; and other investments and deposits. Liabilities include loans

for both productive and non-productive purposes. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Between 2000 (before the reform) and 2008 (after the reform), net worth per capita more than doubled, increasing from 1,360 to 3,349 yuan (table 3.2).

As a preview to more rigorous estimates of the effect of the forest tenure reform on wealth, we examine the mean net worth per capita for three discrete measures of household forest tenure reform status: 1.) whether or not a household received a forest certificate for at least one plot, 2.) whether or not a household received at least one new plot, and 3.) whether or not a household experienced at least one of these two events. Interestingly, we see that those households that got a forest certificate for at least one plot between 2000 and 2008 had a lower average net worth per capita in 2000 and experienced a proportionally larger increase in net worth per capita than those households that did not get a forest certificate (figure 3.2, panel a). On average, those households that received a forest certificate for at least one plot experienced a 233% increase in net worth per capita, whereas those that did not receive a forest certificate for any plots experienced only a 128% increase. A similar pattern holds when we examine the other two discrete measures of household forest tenure reform status (figure 3.2, panel b and c). While these differences are noticeable, there is no statistically significant difference in the means (in any year) nor in the change in the means (between 2000 and 2008) when households are grouped by these discrete measures of household forest tenure status. The mean comparison suggests that the forest tenure reform has not had an effect on the growth in net worth per capita.

Forest Use

As an extension to the analysis of the affect of the forest tenure reform on household wealth, we also examine the affect of the reform on household forest use. Households use their forest resources as both an income source (sale of bamboo, timber and non-timber forest products (NTFP)) and to meet their personal needs for forest products (table 3.3). On average 25% of households engaged in the harvesting and sale of bamboo each year. Between 2000 (pre-reform) and 2008 (post-reform), the mean bamboo revenue increased by 141.8 yuan per capita (table 3.3). The percentage of households selling NTFP (e.g., bamboo shoots, tea, nuts, mushrooms, products for medicinal use, etc.) increased from 23% in 2000 to 71% in 2008 and the mean NTFP revenue increased by 627.9 yuan per capita. Similarly, there has been an increase in revenue from timber. However, only a very small percentage of households (0-3%) reported revenue from timber in any of the survey years.

Households also harvest forest products for their own use. The primary forest product harvested for own use is firewood (51% of households in 2000), followed by bamboo (29%) and timber (3%).⁴ Interestingly, there was an increase in the percentage of households that collected firewood but there was a decrease in the average kilograms per capita collected by each household between 2000 and 2008. Also, there was a decrease in the percentage of households harvesting bamboo for own use from 29% in 2000 to 14% in 2008.

Next, we examine changes in revenue from the sale of bamboo and NTFP. These two revenue sources are worth examining because a larger proportion of households derive income from these two activities relative to the sale of timber. Furthermore,

while most information on forest activities in the data set is limited to the years 2000, 2005 and 2008, data for bamboo revenue are available for each year from 2000 to 2008. The nine years of observations for bamboo revenue will allow us to exploit the variation in the length of time between planting and harvesting. Bamboo can be harvested yearly or biennially. However, bamboo culms attain their maximum quality (in terms of strength and flexibility) and economic value after about seven years (Coggins 2000).

We examine the mean NTFP revenue per capita and the total bamboo revenue for the same three discrete measures of household forest tenure reform status, as we examined for wealth above. Interestingly, when we examine the change in bamboo revenue per capita based on whether or not the household received at least one forest certificate, those households that got a forest certificate for at least one plot between 2000 and 2008 experienced a 209% increase in their NTFP revenue, while those that did not experienced a much higher increase of 426% in their NTFP revenue (figure 3.3, panel a). A similar pattern holds when we examine the other two discrete measures of forest tenure reform household status (figure 3.3, panel b and c).

Figure 3.4 displays the trend in mean total bamboo revenue by each of the three discrete measures of household forest tenure reform status. Interestingly, we see that the trends for each forest tenure reform category are more divergent from each other after 2003 (the official start year of the reform). Specifically, after 2003 those that get a forest certificate for at least one plot tend to have a higher average total bamboo revenue than those that do not get a forest certificate (figure 3.4, panel a). However, those that got at least one new plot have a lower average total bamboo revenue in each

year between 2005 and 2008 than those that did not get a new plot (figure 3.4, panel b). When we examine the trend for those that got at least one new plot or one forest certificate, we see that those households that did also have a lower average total bamboo revenue in each year between 2005 and 2008 than those that did not (figure 3.4, panel c).

While these differences in both NTFP and bamboo revenue are noticeable, there is no statistically significant difference in the change (from 2000 and 2008) in the means between households grouped according to these discrete measures of household forest tenure status. This suggests that the forest tenure reform has had no effect on household revenue from NTFP and bamboo.

Measuring household forest tenure reform status

Although our descriptive analysis suggests that the forest tenure reform has not had an impact on wealth, NTFP revenue per capita, or total bamboo revenue, it may be that the discrete measures used to capture household forest tenure status do not fully capture the magnitude of changes in a household's forest plot tenure structure. For instance, with a discrete measure of whether or not a household received a new plot, a household that received a new plot with an area of 5 hectares would be categorized in the same way as a household that received a new plot with an area of 0.01 hectares. However, it is likely that acquiring a new plot with an area of 5 hectares would have a greater impact on a household's wealth and forest product revenue than a plot with an area of only 0.01 hectares. Therefore, in our empirical analysis each plot in each year is identified as belonging to one of the following four categories: 1) pre-FTR plots without a forest certificate; 2) pre-FTR plots with a forest certificate; 3) new plots

without a forest certificate; and 4) new plots with a forest certificate. In each year, a given household's total forest area will be distributed amongst one or more of these four categories (table 3.4).

3.5 Empirical Strategy

Our main objective is to identify how the forest tenure reform affected household wealth. In order to do so, we must address the concern that changes in household wealth could be due to factors other than the changes in household forest plot tenure structure. For example, changes in household wealth between 2000 and 2008 could be due to unobservable time-invariant variables (e.g., household's entrepreneurial drive or location factors that affect forest productivity) or unobservable variables that change over time (e.g., increased forest productivity due to favorable weather conditions). Furthermore, changes in a household's wealth that had an increase in plot area with a forest certificate and/or a new plot relative to those that did not could be due to initial differences in observed (e.g., education of the head of household) and unobserved characteristics (e.g., entrepreneurial ability) between the two. Without controlling for this we risk incorrectly attributing differences in wealth between those households that experienced a change in their forest plot tenure structure to those that did not experience a change in its forest plot tenure structure, when in fact they are due to initial differences between the two groups.

To address these concerns, we use three years of balanced household panel data in a fixed effect model, which allows us to control for time-invariant observable and unobservable variables. The limitation of approach is that it does not allow us to

control for time-variant unobservable variables or for possible self-selection of households into acquiring a forest certificate or a new plot during the reform.

As an extension to the analysis, we also examine the effect of the reform on households' bamboo and NTFP revenue. To do so, we must again address the concern that changes could be due to factors other than the changes in household forest plot tenure structure, and additionally we must address possible selection bias (i.e., factors that are inherently different about those households that engage in NTFP or bamboo sales and those that do not). For example, on average only 26% of households engaged in the sale of bamboo. Therefore, our dependent variable (bamboo revenue) is censored (i.e. a positive outcome is not observed for many households) and ordinary least squares estimation will produce biased parameter estimates. To address this issue, we use Heckman's two-stage estimation procedure for panel data that uses the Inverse Mill's Ratio to take into account selection bias (Wooldridge 1995). In the first stage, we use a probit model to estimate the likelihood of a household engaging in sales of each forest product. The estimated parameters are then used to calculate an Inverse Mill's Ratio for each forest product and year. We then include the Inverse Mill's Ratio as an explanatory variable in the fixed effects estimations to capture the selection effect.

Empirical Model

The base estimate (model 1) of the forest tenure reform effect is obtained from the ordinary least squares estimation:

$$\begin{aligned} net\ worth_{it} = & \beta_0 + \beta_1(preFTRplot_FC_{it}) + \beta_2(newplot_FC_{it}) \\ & + \beta_3(newplot_noFC_{it}) + \beta_4(year2005_t) + \beta_5(year2008_t) \end{aligned}$$

$$+ \beta_6(FC_i) + \beta_7(newplot_i) + e_{it} \quad (1)$$

where $net\ worth_{it}$ is the net worth per capita (yuan) of household i in year t . $preFTRplot_FC_{it}$ is the total area per capita of household i 's pre-FTR plots that have a forest certificate in year t . $newplot_FC_{it}$ is the total area per capita of household i 's new plots that have a forest certificate in year t . $newplot_noFC_{it}$ is the total area per capita of household i 's new plots that do not have a forest certificate in year t . The coefficients on $preFTRplot_FC_{it}$, $newplot_FC_{it}$, and $newplot_noFC_{it}$ are the estimated forest tenure reform effects, which provide a measure of the conditional average difference in household wealth for changes in households' per capita area of plots with a forest certificate, new plots with a forest certificate and new plots without a forest certificate, respectively. The coefficients on $year2005_t$ and $year2008_t$ control for any systematic differences for years 2005 and 2008, respectively. FC_i is a dummy variable that is equal to one if household i had a forest certificate for any plot in any year. The coefficient on FC_i controls for characteristics that may differ between households that received a forest certificate for at least one plot during the recent tenure reform and those that did not. $newplot_i$ is a dummy variable that is equal to one if household i had a new plot in any year. The coefficient on $newplot_i$ controls for characteristics that may be different between those households that received a new plot during the recent tenure reform and those that did not.

In addition to the base model (1), we estimate the model controlling for the value of the dependent variable, household net worth per capita, in the base year, 2000 (model 2). And in model (3) we add other base year demographic controls, including: household size; head of household's education level and age; and the number of

household members who work, as well as household total area of pre-FTR plots without forest certificates and total area of crop production (area of production multiplied by the number of harvests) in each year.⁵ In models (4), (5) and (6), we add township, village and household fixed effects, respectively.

As an extension to the analysis of the effect of the forest tenure reform on household wealth, we also estimate the effect of the reform on household NTFP and bamboo revenue. To estimate the effect of the forest tenure reform on household NTFP and bamboo revenue, we use Heckman's two-stage estimation procedure for panel data, which uses the Inverse Mill's Ratio to take into account selection bias (Wooldridge 1995). In the first stage, we use a probit model to estimate the likelihood of a household engaging in sales of each forest product.⁶ As explanatory variables in the probit model, we include the number of households that sold each forest product in each year in the village and households' total forest area per capita. We use the number of households that sold each forest product in each year in the village as the exclusion restriction (i.e., the variable that is included in the first stage probit model but omitted from the second stage outcome estimation). This variable is likely to impact the decision of a household to sell (or not sell) a forest product but is unlikely to impact the household's decision of what quantity to sell. The estimated parameters from the probit are used to calculate an Inverse Mill's Ratio (i.e., the error from the Probit equation explaining selection) for each forest product and year. We then include the Inverse Mill's Ratio as an explanatory variable in the fixed effects estimations to capture the selection effect.

To estimate the effect of the forest tenure reform on bamboo revenue, we also include a dummy variable for each year from 2001 to 2008 to control for systematic differences in each year because we have bamboo revenue data for all year from 2000 to 2008. Lastly, in models (3) thru (5) above for the effect of the forest tenure reform on wealth and NTFP revenue we control for the total area of crop production in each year. However, we do not have the total area of crop production data for each year from 2000 to 2008, and so instead here we control for the total area of crop production in the base year (2000).

3.6 Empirical Results

Overall we find statistically weak evidence that the forest tenure reform has increased household wealth (table 3.5).⁷ Specifically, forest certification of a plot that a household had already been managing prior to the reform had the most consistent and largest positive effect on household net worth per capita. In all models the coefficient on *preFTRplot_FC_{it}* is positive (table 3.5, row 1). In models (4) and (5) that included township and village fixed effects, respectively, the coefficients on *preFTRplot_FC_{it}* are statistically significant at the 10% level, while in the remaining models, (1) to (3) and (6), they are statistically significant at the 15% level. The coefficient on *preFTRplot_FC_{it}* in model (6), which includes household fixed effects, suggests that for a one hectare per capita of pre-FTR land area that receives a forest certificate the effect is an increase in net worth per capita of 5,650 yuan. Households on average received forest certificates for 0.14 hectares of their forest land, his implies

that stronger property rights in the form of a forest certificate have increased household wealth on average by 42% (i.e., on average 5.2% per year).

Receiving a new plot with a forest certificate also had a positive effect, however the evidence is weaker. In all models the coefficients on *newplot_FC_{it}* is positive (table 3.5, row 2) but has a lower magnitude (328 to 820 yuan) than the coefficients on *preFTRplot_FC_{it}* (2923 to 5650 yuan). In models (3) thru (5) the coefficients on *newplot_FC_{it}* are statistically significant at the 10% level or above, while the remaining models are insignificant. This suggests that there is also a positive effect on wealth when households receive a new plot with a forest certificate, however, the effect is not as large as the effect of forest certification of pre-FTR plots.

Finally, although the coefficient on *newplot_noFC_{it}* was positive in each model, receiving a new plot without a forest certificate did not have a statistically significant effect on household net worth per capita (table 3.5, row 3).

Impact on non-timber forest product sales

The results suggest that forest certification of a forest plot had no effect on household NTFP revenue per capita, as the coefficients on *preFTRplot_FC_{it}* or *newplot_FC_{it}* in each model (except for the coefficient on *newplot_FC_{it}* in model 1) are not statistically significant (table 3.6, rows 1 and 2).⁸ However, receiving a new plot without a forest certificate as a result of the reform had a positive effect on households' bamboo revenue per capita (table 3.6, row 3). The coefficient in each model on *newplot_noFC_{it}* is positive, and it is significant at least at the 10% level in models (1) and (5) and at least at the 20% level in models (4) and (6). The coefficient on *newplot_noFC_{it}* in model (6), which includes household fixed effects, suggests that

for a one hectare area per capita increase in forest land (without a forest certificate) the effect is an increase in household NTFP revenue per capita of 1,474 yuan.

Impact on bamboo sales

The results suggest that forest certification of a plot that a household had already been managing prior to the reform has a positive effect on total bamboo revenue, while receiving a new plot with a forest certificate has a negative effect on total bamboo revenue (table 3.7). However, the evidence in both cases is statistically weak. In all models the coefficient on $preFTRplot_FC_{it}$ is positive, however it is only statistically significant in model (3) and (6) at the 5% and 20% level (table 3.7, row 1). And in all models the coefficient on $newplot_FC_{it}$ is negative but it is only statistically significant in model (3) at the 5% level (table 3.7, row 2). There is no evidence of an effect of receiving a new plot without a forest certificate on bamboo sales (tables 3.7, row 3).

Additionally, the coefficients on each year dummy from 2005 to 2008 capture an interesting effect, as they are positive and statistically significant at the 1% level in all models. This suggests that there is something different about those years with regards to bamboo sales revenue. This may be a result of the enthusiasm of farmers, forest farms and forestry authorities that have been engaging in the expansion of both fruit and nut trees and bamboo plantations over the last two decades, as they are considered more profitable than conventional timber plantations and have a less burdensome more transparent taxation system (Perez et al. 2004).

3.7 Conclusion

Over the last decade there has been a call from international institutions, NGO's, and community organizations, for pro-poor forestry policies (Wunder 2001; FAO 2003; Sunderlin et al. 2005; Hobley 2007; FAO 2009). Amongst the various pro-poor forestry policies that have been recommended one that has received notable attention and gained momentum in implementation is forest tenure reform (Edmonds 2002; FAO 2003; Ellsworth and White 2004). The hope is that when communities and individuals receive stronger rights to ownership and use of forest resources, those rights will give them an incentive to invest in managing and protecting those resources, and in doing so will also allow poor, rural households to improve their livelihoods.

In this paper, we examined the impact of forest tenure reform on household wealth in Fujian Province, where a large-scale reform of forest land tenure began in 2003. Empirically, we used a balanced household panel data set among 87 households. We examined the effect of the reform on net worth per capita as a measure of wealth. Then as an extension we also examined the effect of the reform on total bamboo sales. Changes in household forest tenure structure were captured by three variables: the total area of pre-FTR plots with a forest certificate; the total area of new plots with a forest certificate, and the total area of new plots without a forest certificate. To identify the effect of the reform on net worth per capita, NTFP revenue per capita, and total bamboo revenue, we used a fixed effects model. Additionally, to identify the effect of the reform on total bamboo sales, we used a two-step Heckman selection approach for panel data to take into account the effect of selection into engaging in the

sale of NTFP or bamboo.

Results suggest that more secure tenure, resulting from the distribution of forest certificates, increased household wealth, although the evidence is statistically weak. This positive forest certification effect was stronger on plots that households had been managing prior to the recent reform than it was on new plots households received during the reform. After identifying a positive effect of the forest tenure reform on wealth, we examined its effect on households' revenue from the sale of forest products. Households were relatively more engaged in the sale of NTFP and bamboo than in the sale of timber. Therefore, we examined changes in household revenue per capita from the sale of NTFP and in total revenue from the sale of bamboo. The results suggest that forest certification of a plot that a household had already been managing prior to the reform had a positive effect on total bamboo revenue but no significant effect on NTFP revenue. Conversely, receiving a new plot without a forest certificate had no significant effect on bamboo revenue, while it had a positive effect on NTFP revenue.

While the reason behind the differing effects of receiving a forest certificate or a new plot is a question for future analysis, a potential hypothesis is that the differing effects may be due to differences in forest stock quantity, quality or type on new plots relative to plots that households had already been managing. Testing this hypothesis would require an analysis at the plot level; however, we do not have bamboo revenue data at the plot level to support such an extension of this analysis.

This paper provides statistically weak evidence that the forest tenure reform has had a positive effect on household wealth in our study area. While the sample is very

small, relative to the number of households affected by the forest tenure reform in China and China is a large diverse country, this paper does suggest that the forest tenure reform garners potential for improving poor rural households' livelihoods. In particular, since only 30% of all forest plots had forest certificates, expanding such certification could potentially increase household wealth. It is likely that with forest plot certification, tenure security will be enhanced. And increased tenure security will stimulate households' investment in their forest plots, improving their livelihoods.

Endnotes

¹ It is difficult to be specific about the number of people dependent on forests because it depends on the definition of dependent. See Byron and Arnold (1999) and Calibre Consultants and Statistical Services Centre (2000) for summaries of existing estimates in the literature.

² While the Fujian provincial government formally approved the reform in 2003, precedents had already been established in 1998 in Hongtian Village, Yongan County of Fujian Province when a rural village suffering from severe deforestation due to ineffective collective management, decided to reform forest tenure. Another village, in 2002 individualized user rights to villagers (those that accepted the forest user rights were required to pay a land rental fee to the villages) and sold some of the forest to people outside the village to help eliminate village debt (Xu and Jiang 2009).

³ 1 USD $\approx$ 6.83 yuan (August 1, 2009).

⁴ Households also collected NTFP for their own use but due to the diversity of products and units, we have not summarized them here.

⁵ In the year 2000, household total area of pre-FTR plots is equal to the household total forest plot area. In year 2005 and 2008, a household's total area of pre-FTR plots changes depending on if it received a forest certificate for a pre-FTR plot or if it received a new plot with or without a forest certificate.

⁶ Results from the probit models are presented in appendix table 3.1 and 3.2.

⁷ Table 3.5 summarizes results for the variables of interest. Appendix table 3.3 show results with coefficients for all household level control variables.

⁸ Table 3.6 summarizes results for the variables of interest. Appendix table 3.4 shows results with coefficients for all household level control variables.

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Table 3.1 Descriptive statistics for the year 2000

Variable	Mean	Std. Dev.	Min	Max
Net worth per capita (yuan)	1,359.56	6,300.70	-5,000.00	5,0680.98
Household size	4.90	1.58	2	9
Number in household who work	2.79	1.26	1	6
Head of household age (years)	46.43	12.19	26	80
Head of household education level (years)	5.09	3.12	0	11
Total forest area (ha/capita)	0.59	1.28	0	6.88
Total crop production area (ha/capita)	0.08	0.06	0	0.29

Note: n=87 households. 1 USD $\approx$ 6.83 yuan (August 1, 2009).

Source: Authors' data.

Table 3.2 Descriptive statistics for wealth by year

	Year	Mean	Std. Dev.	Min	Max
Net worth per capita (yuan)	2000	1360	6301	-5000	50681
	2005	1574	6625	-6640	54997
	2008	3349	11142	-9744	69728
Δ between 2000 and 2008		+1989	1989	-47186	64853

Note: n=87 households. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). 1 USD $\approx$ 6.83 yuan (August 1, 2009)

Source: Authors' data..

Table 3.3 Forest use and change in use between 2000 (pre-reform) and 2008 (post-reform)

		Percent engaging in activity		Mean (based on those engaging in activity)		Mean of changes between 2000 and 2008
	Unit	2000	2008	2000	2008	
<i>Revenue from sale of:</i>						
Bamboo	yuan/capita	26%	24%	207.25 (166.28)	814.30 (1028.65)	141.76 (562.25)
Timber	yuan/capita	0%	3%	N/A N/A	13835.05 (23269.90)	477.07 (4346.62)
Non-timber forest products	yuan/capita	23%	71%	2483.22 (6801.84)	3654.00 (9767.74)	627.90 (4366.50)
<i>Net income from sale of:</i>						
Bamboo	yuan/capita	26%	24%	176.94 (182.67)	757.31 (897.50)	136.02 (494.24)
Timber	yuan/capita	0%	3%	N/A N/A	11823.70 (19786.18)	407.72 (3702.27)
<i>Harvested for own use:</i>						
Bamboo	sticks/capita	29%	14%	3.34 (2.79)	7.90 (16.36)	0.132 (6.65)
Timber	m3/capita	3%	2%	0.95 (0.60)	0.58 (0.12)	-0.012 (0.22)
Firewood	kilogram/capita	51%	77%	687.14 (1395.56)	400.26 (494.24)	-39.28 (1031.20)

Notes: n=87 households. Values for the year 2008 where the unit is yuan/capita are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Mean of changes between 2000 and 2008 are calculated by subtracting the 2000 value from the 2010 value for each of the 87 households and then taking the mean. Net income is calculated by subtracting total harvesting costs from total revenue. Harvesting costs include hired labor, rental of machines, felling design, transportation, taxes, and fees but do not include family labor. Standard deviations are in parentheses. 1 USD $\approx$ 6.83 yuan (August 1, 2009).

Source: Authors' data.

Table 3.4 Changes in household forest tenure plot structure

Forest plot category	Percent of households with plot area in category	Mean area (ha/capita)	Std. Dev.	Min	Max
2000					
Pre-FTR plot without a FC	96.6%	0.574	1.259	0	6.883
Pre-FTR plot with a FC	0	0	0	0	0
New plot without a FC	0	0	0	0	0
New plot with a FC	0	0	0	0	0
<i>All forest plots</i>	96.6%	0.574	1.259	0	6.883
2005					
Pre-FTR plot	75%	0.475	1.192	0	6.883
Pre-FTR plot with a FC	22%	0.122	0.546	0	4.487
New plot	21%	0.099	0.420	0	3.033
New plot with a FC	5%	0.068	0.557	0	5.167
<i>All forest plots</i>	100%	0.763	1.444	0	6.883
2008					
Pre-FTR plot	68%	0.340	0.898	0	6.883
Pre-FTR plot with a FC	23%	0.145	0.552	0	4.487
New plot	24%	0.115	0.445	0	3.033
New plot with a FC	7%	0.033	0.230	0	2.067
<i>All forest plots</i>	94%	0.633	1.142	0	6.883

Note: Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR.

Source: Authors' data.

Table 3.5 Effects of the forest tenure reform on wealth

Dependent Variable: Net worth (yuan/capita)						
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Total area of pre-FTR plots with a FC (ha/capita)	3,002.62 (1.62)	2,923.49 (1.57)	3,144.39 (1.61)	3,339.07 (1.69)*	3,343.94 (1.68)*	5,650.99 (1.55)
Total area of new plots with a forest FC (ha/capita)	302.01 (1.04)	257.41 (0.96)	587.26 (1.67)*	820.12 (2.04)**	648.10 (1.71)*	328.09 (0.56)
Total area of new plots without a FC (ha/capita)	6,519.32 (1.28)	5,610.59 (1.09)	5,254.51 (1.01)	5,087.67 (0.95)	5,037.21 (0.94)	4,975.39 (0.84)
Dummy = 1 if the year is 2005	-814.87 (0.71)	-712.47 (1.01)	-765.766 (1.08)	-759.16 (1.02)	-777.72 (1.04)	-563.33 (0.68)
Dummy = 1 if the year is 2008	792.95 (0.68)	910.524 (0.86)	955.10 (0.96)	984.85 (0.99)	965.34 (0.98)	1,433.06 (1.42)
Dummy = 1 if household has at least 1 new plot in any year	-1,026.73 (1.12)	-658.96 (0.83)	-629.23 (0.76)	-306.57 (0.43)	133.63 (0.18)	
Dummy = 1 if household has at least 1 plot with a FC in any year	-1,139.13 (1.58)	-700.91 (1.20)	-784.28 (1.33)	-1,310.43 (1.61)	-1,427.50 (1.13)	
Net worth in 2000 (yuan/capita)		0.66 (3.08)***	0.61 (2.92)***	0.58 (2.77)***	0.60 (2.77)***	
Constant	2,039.65 (2.18)**	894.28 (2.25)**	4,051.212 (1.79)*	4,915.49 (1.77)*	4,093.74 (1.80)*	
N	261	261	261	261	261	261
R ²	0.10	0.35	0.37	0.38	0.38	0.52
Household characteristics:	No	No	Yes	Yes	Yes	Yes
Fixed effects:	No	No	No	Yes	Yes	Yes
Fixed effect type:	-	-	-	Township	Village	Household

Note: Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Household characteristics control variables in models (3) to (5) include the following variables for the year 2000: household size, head of households' education level and age, and the number of household members who work, as well as the total area of pre-FTR plots without a FC and the total area of crop production in each year. Model (6) includes only the total area of pre-FTR plots without a FC and the total area of crop production in each year as control variables. Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Table 3.6 Effects of the forest tenure reform on non-timber forest product revenue

Dependent Variable: Non-timber forest product revenue (yuan/capita)						
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Total area of pre-FTR plots with a FC (ha/capita)	2,046.42 (0.87)	2,274.99 (0.95)	1,228.47 (0.57)	1,350.06 (0.62)	1,319.21 (0.58)	10,270.98 (0.60)
Total area of new plots with a forest FC (ha/capita)	-4,092.46 (1.93)*	-2,857.37 (1.27)	-2,042.04 (1.01)	-2,221.45 (1.02)	-2,597.95 (1.11)	-69,184.37 (0.69)
Total area of new plots without a FC (ha/capita)	7,414.64 (2.90)***	1,200.47 (1.29)	1,567.79 (1.24)	1,890.45 (1.59)	3,087.09 (1.92)*	1,474.69 (1.44)
Dummy = 1 if the year is 2005	-2,352.53 (1.27)	335.02 (0.32)	28.71 (0.02)	-784.48 (0.49)	-1,002.07 (0.67)	-536.48 (0.46)
Dummy = 1 if the year is 2008	-1,736.00 (0.91)	1,014.04 (0.94)	689.68 (0.50)	776.43 (0.58)	607.73 (0.53)	1,555.88 (0.90)
Dummy = 1 if household has at least 1 new plot in any year	1,189.62 (0.66)	613.45 (0.36)	932.95 (0.55)	2,400.96 (1.11)	2,879.08 (1.24)	
Dummy = 1 if household has at least 1 plot with a FC in any year	-130.08 (0.09)	-932.15 (0.68)	-648.20 (0.48)	488.36 (0.48)	604.35 (0.61)	
Non-timber forest product revenue in 2000 (yuan/capita)		0.96 (9.69)***	0.91 (6.78)***	0.87 (6.36)***	0.76 (3.96)***	
Inverse Mill's ratio	-2,652.86 (1.45)	-1,858.43 (1.22)	-2,242.50 (1.18)	90.25 (0.06)	-103.90 (0.08)	-575.27 (0.20)
Constant	4843.68 (2.17)**	2079.22 (1.34)	2369.69 (0.36)	-4262.89 (0.83)	-4623.87 (1.22)	
N	129	129	129	129	129	129
R ²	0.19	0.36	0.38	0.43	0.44	0.74
Household characteristics:	No	No	Yes	Yes	Yes	Yes
Fixed effects:	No	No	No	Yes	Yes	Yes
Fixed effect type:	-	-	-	Township	Village	Household

Note: Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Household characteristics control variables in models (3) to (5) include the following variables for the year 2000: household size, head of household's education level and age, and the number of household members who work, as well as the total area of pre-FTR plots without a FC and the total area of crop production in each year. Model (6) includes only the total area of pre-FTR plots without a FC and the total area of crop production in each year as control variables. Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Table 3.7 Effects of the forest tenure reforms on total bamboo revenue

Dependent variable: Total bamboo revenue (yuan)						
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Total area of pre-FTR plots with a FC (ha/capita)	296.81 (1.09)	289.15 (1.07)	459.50 (2.03)**	286.13 (1.16)	257.90 (1.01)	3823.95 (1.43)
Total area of new plots with a FC (ha/capita)	-5434.02 (1.21)	-5360.35 (1.23)	-8609.17 (2.25)**	-4708.40 (1.05)	-3659.83 (0.81)	-42893.60 (0.80)
Total area of new plots without a FC (ha/capita)	-45.18 (0.23)	-33.34 (0.17)	-149.83 (0.79)	-230.93 (1.26)	-217.62 (1.18)	15.02 (0.10)
Dummy = 1 if household has at least 1 new plot in any year	42.53 (0.09)	20.85 (0.04)	-288.34 (0.71)	-353.66 (0.73)	-490.75 (1.01)	
Dummy = 1 if household has at least 1 plot with a FC in any year	-221.69 (0.54)	-171.80 (0.40)	-135.43 (0.35)	657.44 (1.40)	814.93 (1.82)*	
Total bamboo revenue in 2000		0.24 (1.20)	0.47 (2.30)**	0.266 (0.83)	0.31 (0.96)	
Total area of pre-FTR plots without a FC (ha/capita)			190.06 (4.05)***	148.57 (3.01)***	120.54 (2.19)**	
Dummy =1 if the year is 2001	487.46 (1.26)	533.55 (1.39)	209.71 (0.58)	230.29 (0.63)	113.19 (0.31)	-35.31 (0.08)
Dummy = 1 if the year is 2002	271.98 (1.36)	297.38 (1.63)	240.61 (0.92)	223.96 (0.81)	174.16 (0.59)	40.43 (0.09)
Dummy =1 if the year is 2003	1024.07 (2.22)**	1097.13 (2.42)**	791.73 (1.87)*	851.71 (2.04)**	740.19 (1.72)*	116.17 -0.260
Dummy = 1 if the year is 2004	1380.29 (1.06)	1405.01 (1.08)	1510.18 (1.17)	1520.47 (1.16)	1538.32 (1.17)	1490.95 (1.16)
Dummy = 1 if the year is 2005	1303.33 (3.71)***	1402.60 (4.12)***	1262.39 (3.98)***	1480.79 (4.36)***	1492.19 (4.17)***	1356.95 (3.20)***
Dummy =1 if the year is 2006	1967.08 (3.55)***	2071.97 (3.83)***	2113.13 (3.89)***	2284.96 (4.20)***	2218.46 (4.21)***	2192.33 (4.35)***
Dummy = 1 if the year is 2007	1739.41 (3.58)***	1854.96 (3.78)***	1831.88 (3.97)***	2085.29 (4.30)***	2008.44 (4.23)***	2174.54 (3.94)***

Table continued on the next page.

Table 3.7 [Continued] Effects of the forest tenure reforms on total bamboo revenue

Model:	(1)	(2)	(3)	(4)	(5)	(6)
Dummy = 1 if the year is 2008	2411.15 (5.18)***	2495.18 (5.54)***	2665.31 (7.52)***	2874.32 (7.41)***	2861.10 (6.91)***	2941.85 (5.68)***
Inverse Mills Ratio	-855.64 (2.59)**	-826.32 (2.49)**	-732.90 (2.31)**	-475.30 (1.18)	-83.24 (0.16)	241.15 (0.57)
Constant	1584.61 (5.03)***	1351.46 (3.44)***	3157.85 (3.83)***	2633.68 (2.76)***	1675.37 (1.63)	
N	199	199	199	199	199	199
R ²	0.14	0.15	0.28	0.30	0.31	0.55
Fixed effects:	No	No	No	Yes	Yes	Yes
Fixed effects type:	-	-	-	Township	Village	Household

Note: Model (4) and (5) add township and village fixed effects, respectively, to model (2). Model (6) adds household fixed effects to model (2) and does not include the household characteristic controls from the base year (2000), the dummy indicating if a household had at least one new plot in any year, nor the dummy indicating if a household had at least one plot with a forest certificate in any year. All models also control for the inverse mills ratio for each year from 2000 to 2008. Values for the years 2001 to 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR. Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Figure 3.1 Change in forest tenure plot structure

Note: Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR
Source: Authors' data.

Figure 3.2 Mean net worth per capita by household forest tenure reform status

Panel A. Mean net worth per capita by whether or not a household got a forest certificate

Panel B. Mean net worth per capita by whether or not a household got a new plot

Panel C. Mean net worth per capita by household forest tenure reform participation status

Note: Forest certificate abbreviated to FC. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009).

1 USD $\approx$ 6.83 yuan (August 1, 2009).

Source: Authors' data.

Figure 3.3 Mean non-timber forest product revenue per capita by household forest tenure reform status

Panel A. Mean NTFP revenue per capita by whether or not a household got a forest certificate

Panel B. Mean NTFP revenue per capita by whether or not a household got a new plot

Panel C. Mean NTFP revenue per capita by household forest tenure reform participation status

Note: Forest certificate abbreviated to FC. Non-timber forest product abbreviated to NTFP. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). 1 USD $\approx$ 6.83 yuan (August 1, 2009).

Source: Authors' data.

Figure 3.4 Mean total bamboo revenue by household forest tenure reform status

Panel A. Mean total bamboo revenue by whether or not a household gets a forest certificate for at least one forest plot during the forest tenure reform

Panel B. Mean total bamboo revenue by whether or not a household gets at least one new plot during the forest tenure reform

Panel C. Mean total bamboo revenue by household participation status in the forest tenure reform

Note: Forest certificate abbreviated to FC. Values for the years 2001 to 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). 1 USD $\approx$ 6.83 yuan (August 1, 2009).

Source: Authors' data.

Appendix 3

Appendix Table 3.1 Probit regression results for participation in non-timber forest product sales

Dependent variable: Dummy variable that takes the value 1 if total non-timber forest product revenue (yuan/capita) > 0			
	2000	2005	2008
Number of households in the village that sold NTFPs	0.497 (3.89)***	0.3145 (4.36)***	0.3459 (4.61)***
Total forest area (hectares/capita)	-0.388 (1.10)	0.174 (1.46)	0.219 (0.96)
Constant	-1.641 (4.64)***	-1.08 (3.19)***	-1.303 (3.22)***
N	87	87	87
Pseudo R ²	0.22	0.26	0.32

Note: Non-timber forest products abbreviated as NTFPs Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Appendix Table 3.2 Probit regression results for participation in bamboo revenue

Dependent variable: Dummy variable that takes the value 1 if bamboo revenue > 0									
	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of households in the village that sold bamboo	0.422 (4.89)***	0.459 (4.86)***	0.424 (3.94)***	0.440 (5.13)***	0.484 (4.44)***	0.377 (5.61)***	0.360 (4.58)***	0.344 (4.74)***	0.383 (4.67)***
Total forest area (hectares/capita)	-0.068 (0.65)	-0.054 (0.61)	0.001 (0.02)	-0.027 (0.41)	-0.037 (0.42)	-0.015 (0.35)	-0.067 (0.73)	-0.066 (1.15)	-0.038 (0.57)
Constant	-1.631 (4.96)***	-1.879 (5.08)***	-1.670 (5.14)***	-1.896 (5.08)***	-1.851 (4.84)***	-1.552 (4.95)***	-1.514 (5.17)***	-1.343 (5.14)***	-1.601 (4.99)***
N	87	87	87	87	87	87	87	87	87
Pseudo R ²	0.32	0.38	0.19	0.41	0.31	0.37	0.292	0.28	0.29
Log Likelihood	-34.103	-28.424	-37.907	-28.608	-30.644	-36.462	-32.350	-37.57	-34.32

Note: Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Appendix Table 3.3 Effects of the forest tenure reform on wealth

Dependent variable: Net worth (yuan/capita)			
Model:	(1)	(2)	(3)
Total area of pre-FTR plots with a FC (ha/capita)	3,002.60 (1.62)	2,923.49 (1.57)	3,144.39 (1.61)
Total area of new plots with a forest FC (ha/capita)	302.01 (1.04)	257.41 (0.96)	587.26 (1.67)*
Total area of new plots without a FC (ha/capita)	6,519.32 (1.28)	5,610.59 (1.09)	5,254.51 (1.01)
Dummy = 1 if the year is 2005	-814.87 (0.71)	-712.47 (1.01)	-765.77 (1.08)
Dummy = 1 if the year is 2008	792.95 (0.68)	910.52 (0.86)	955.10 (0.96)
Dummy = 1 if household has at least 1 new plot in any year	-1,026.73 (1.12)	-658.96 (0.83)	-629.23 (0.76)
Dummy = 1 if household has at least 1 plot with a FC in any year	-1,139.13 (1.58)	-700.91 (1.20)	-784.28 (1.33)
Net worth in 2000 (yuan/capita)		0.66 (3.08)***	0.61 (2.92)***
Household size in 2000			-863.08 (2.05)**
Head of household age in 2000 (years)			-12.65 (0.36)
Head of household education level in 2000 (years)			34.10 (0.28)
Number of household members who work in 2000			371.19 (1.09)
Total area of pre-FTR plots without a FC (ha/capita)			406.85 (0.98)
Total area of crop production (ha/capita)			3733.63 (0.59)
Constant	2,039.65 (2.18)**	894.28 (2.25)**	4,051.21 (1.79)*
N	261	261	261
R ²	0.10	0.35	0.37
Fixed effects:	No	No	No
Fixed effect type:	-	-	-

Note: Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Table continued on the next page.

Appendix Table 3.3 [Continued]. Effects of the forest tenure reform on wealth

Dependent variable: Net worth (yuan/capita)			
Model:	(4)	(5)	(6)
Total area of pre-FTR plots with FC (ha/capita)	3,339.07 (1.69)*	3,343.94 (1.68)*	5,650.99 (1.55)
Total area of new plots with FC (ha/capita)	820.12 (2.04)**	649.00 (1.71)*	328.09 (0.56)
Total area of new plots without FC (ha/capita)	5,087.67 (0.95)	5,037.21 (0.94)	4,975.39 (0.84)
Dummy = 1 if the year is 2005	-759.16 (1.02)	-777.72 (1.04)	-563.33 (0.68)
Dummy = 1 if the year is 2008	984.85 (0.99)	965.34 (0.98)	1,433.06 (1.42)
Dummy = 1 if household has at least 1 new plot in any year	-306.57 (0.43)	133.63 (0.18)	
Dummy = 1 if household has at least 1 plot with a FC in any year	-1,310.43 (1.61)	-1,427.50 (1.13)	
Net worth in 2000 (yuan/capita)	0.58 (2.77)***	0.60 (2.77)***	
Household size in 2000	-812.15 (1.74)*	-738.81 (1.68)*	
Head of household age in 2000 (years)	-8.35 -0.23	3.95 -0.11	
Head of household education level in 2000 (years)	86.84 -0.64	126.98 -0.71	
Number of household who work in 2000	239.06 -0.65	88.49 -0.29	
Total area of pre-FTR plots without a FC (ha/capita)	566.25 -1.28	511.81 -1.07	3396.87 -1.06
Total area of crop production (ha/capita)	3082.39 -0.45	4454.53 -0.56	-4140.63 -0.38
Constant	4,915.49 (1.77)*	4,093.74 (1.80)*	
N	261	261	261
R ²	0.38	0.38	0.52
Fixed effects:	Yes	Yes	Yes
Fixed effects type:	Township	Village	Household

Note: Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Appendix Table 3.4. Effect of the forest tenure reform on non-timber forest product revenue

Dependent variable: Non-timber forest product revenue (yuan/capita)			
Model:	(1)	(2)	(3)
Total area of pre-FTR plots with a FC (ha/capita)	2,046.42 (0.87)	2,274.99 (0.95)	1,228.47 (0.57)
Total area of new plots with a forest FC (ha/capita)	-4,092.46 (1.93)*	-2,857.37 (1.27)	-2,042.04 (1.01)
Total area of new plots without a FC (ha/capita)	7,414.64 (2.90)***	1,200.47 (1.29)	1,567.79 (1.24)
Dummy = 1 if the year is 2005	-2,352.53 (1.27)	335.02 (0.32)	28.71 (0.02)
Dummy = 1 if the year is 2008	-1,736.00 (0.91)	1,014.04 (0.94)	689.68 (0.50)
Dummy = 1 if household has at least 1 new plot in any year	1,189.62 (0.66)	613.45 (0.36)	932.95 (0.55)
Dummy = 1 if household has at least 1 plot with a FC in any year	-130.08 (0.09)	-932.15 (0.68)	-648.20 (0.48)
Non-timber forest product revenue in 2000 (yuan/capita)		0.961 (9.69)***	0.91 (6.78)***
Household size in 2000			290.31 (0.75)
Head of household age in 2000 (years)			-9.59 (0.17)
Head of household education level in 2000 (years)			160.22 (0.48)
Number of household who work in 2000			-727.70 (1.05)
Total area of pre-FTR plots without a FC (ha/capita)			-81.13 (0.16)
Total area of crop production (ha/capita)			4200.56 (0.65)
Inverse Mills Ratio	-2,652.864 (1.45)	-1,858.427 (1.22)	-2,242.50 (1.18)
Constant	4843.682 (2.17)**	2079.217 (1.34)	2369.69 (0.36)
N	129	129	129
R ²	0.19	0.36	0.38
Fixed effects:	No	No	No
Fixed effects type:	-	-	-

Notes: All models control for the inverse mills ratio for each year from 2000, 2005 and 2008. Forest certificate abbreviated to FC. Forest tenure reform abbreviated to FTR. Values for the years 2005 and 2008 are adjusted for inflation using the rural consumer price index for Fujian Province, China (China Statistical Yearbook, 2009). Robust t-statistics are in parentheses. * significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

Source: Authors' data.

Table continued on the next page.

Appendix Table 3.4 [Continued]. Effect of the forest tenure reform on non-timber forest product revenue

Dependent variable: Non-timber forest product revenue (yuan/capita)			
Model:	(4)	(5)	(6)
Total area of pre-FTR plots with a FC (ha/capita)	1,350.06 (0.62)	1,319.21 (0.58)	10,270.98 (0.60)
Total area of new plots with a forest FC (ha/capita)	-2,221.45 (1.02)	-2,597.95 (1.11)	-69,184.3 (0.69)
Total area of new plots without a FC (ha/capita)	1,890.45 (1.59)	3,087.09 (1.92)*	1,474.69 (1.44)
Dummy = 1 if the year is 2005	-784.48 (0.49)	-1,002.07 (0.67)	-536.48 (0.46)
Dummy = 1 if the year is 2008	776.43 (0.58)	607.73 (0.53)	1,555.88 (0.90)
Dummy = 1 if household has at least 1 new plot in any year	2,400.96 (1.11)	2,879.08 (1.24)	
Dummy = 1 if household has at least 1 plot with a FC in any year	488.36 (0.48)	604.35 (0.61)	
Non-timber forest product revenue in 2000 (yuan/capita)	0.87 (6.36)***	0.76 (3.96)***	
Household size in 2000	495.85 (1.28)	535.57 (1.20)	
Head of household age in 2000 (years)	67.98 (1.14)	74.38 (1.32)	
Head of household education level in 2000 (years)	442.68 (1.25)	449.80 (1.38)	
Number of household who work in 2000	-983.92 (1.29)	-1029.86 (1.34)	
Total area of pre-FTR plots without a FC (ha/capita)	491.29 (0.95)	436.64 (0.82)	14991.32 (1.68)*
Total area of crop production (ha/capita)	6141.02 (0.87)	7163.93 (1.02)	-13608.05 (1.16)
Inverse Mills Ratio	90.25 (0.06)	-103.90 (0.08)	-575.27 (0.20)
Constant	-4262.89 (0.83)	-4623.87 (1.22)	
N	129	129	129
R ²	0.43	0.44	0.74
Fixed effects:	Yes	Yes	Yes
Fixed effects type:	Township	Village	Household

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The underlying motivation for this dissertation research was to examine if property rights matter for forest management. Economic theory predicts that improved tenure security in the form of strengthened property rights will give households an incentive to invest in their forest resources, which will stimulate income, ultimately increasing households' wealth. However, in the past tenure reforms have not always led to these intended effects. While researchers have empirically examined the impacts of tenure reforms, they have not examined potential heterogeneity in responses due to differences in households' risk and time preferences. Furthermore, these reforms are often implemented in areas where the poverty rate is high. Those living in poverty are assumed to have both high discount rates and high levels of risk aversion, which make them less likely to make investments. Such characteristics may also hinder the intended effects of forest tenure reforms.

In this dissertation, I examined these issues in the context of rural Fujian, China, where a large-scale reform of forest property rights began in 2003 in areas where the poverty rate is still high. To explore these issues, I used panel household survey data and risk and time preference data collected using field experiments with real monetary rewards in empirical models that aimed to alleviate potential biases due to self-selection into receiving a forest certificate for a plot. The four main hypotheses examined included: H1) Forest property right reforms affect how individuals manage their forest resources; H2) Time and risk preferences affect forest management and therefore also augment individual forest management responses to forest property rights reforms; H3) Time and risk preferences differ across individuals and are

correlated with wealth; and H4) Household wealth increases as a result of the forest tenure reforms.

In manuscript 1, I tested H1 and H2. In the base difference-in-differences estimation that does not allow for heterogeneity in time and risk preferences, I found that on average there was no significant forest certification effect on forest management. This suggests that on average that reform is not working as intended. However, it should be noted that this insignificant effect may be due to the possibility that households are still in a transition phase. Since forest management requires long term investments and our data is at most 5 years post-reform, it may be that not enough time has passed since households received their forest certificates to discern the reforms intended effects of increased investment in forest resources. In the future, researchers should collect additional post-reform data to see if the reform has its intended effects over a longer period of time.

Interestingly, when I allowed for heterogeneity in forest certification effect due to households' time and risk preferences, I found that the average overall forest certification effect had been masking a variety of responses that were occurring but which varied depending on households' time and risk preferences. As expected we found that in response to receiving a forest certificate households that were more risk averse used less labor for harvesting and more labor for applying inputs than those that were risk neutral or risk seeking. This supports the hypothesis that households believe that the forest certificate gives them greater assurance that if they invest or delay harvest then they will be able to get their returns in the future. More generally, we found that those households that were risk averse, used less labor for applying inputs,

spent less on forest inputs, and used more labor for harvesting. This suggests that in areas where many households are risk averse, policymakers may want to couple forest tenure reforms with other programs and policy instruments to reduce households' risks (e.g., pest, disease, forest fire). Such coupling may stimulate investment in forest resources generally and also in response to forest tenure reforms. Future research should examine how households perceive the risks specifically associated with forest investment and what the levels of actual risks are in order to inform policymakers. Such information would aid policymakers in identifying which risks need to be dealt with and to design programs or instruments (e.g., programs to reduce threat of pests and fire; insurance programs; encourage the formation of voluntary cooperatives within village as a risk-sharing mechanism) that specifically help to mitigate those risks.

In Manuscript 1, I also found that more loss averse households used more labor for harvesting in response to receiving a forest certificate. This suggests that loss aversion affects harvesting responses to receiving a forest certificate based on the manifestation of loss aversion in an endowment effect of the forest certificate. Receiving a forest certificate may have an endowment effect in that once a household receives a forest certificate for a plot, it becomes more painful for the household to experience a loss of forest stock from that plot than from other forest plots without forest certificates, and therefore loss averse households would harvest more in response to getting a forest certificate for a plot. This suggests that future research should examine households' demand for insurance that hedges against the risk of loss of forest stock from plots with forest certificates.

Lastly, in response to receiving a forest certificate those with higher discount rates used less labor for applying input and spent less on forest inputs than those with lower discount rates. And in Manuscript 2, I found statistically weak evidence that the poorer a household was the higher their discount rate (i.e. more impatient) was. Combined, these findings suggests that forest tenure reforms should be coupled with programs to reduce poverty and to allow for and encourage borrowing. As poverty is alleviated, households' discount rates may fall, making them more likely to be able to invest, whether from their own accumulated savings or by borrowing. While a component of China's forest tenure reform has been the establishment of a loan program that allows households to obtain a loan using their forest certificated plot as collateral, in 2008 only 1 of the 104 surveyed households had used their forest certificate as collateral for a loan. Further research should investigate why households are not taking advantage of this credit opportunity.

This research used risk and time preference field experiments designed in a generic context. The case can be made that preferences measured in a generic context may not translate well to preferences in forest management decisions. I did find that these preferences had some effects on forest management and responses to receiving a forest certificate. While this suggests that these generic risk and time preferences are relevant for forest management decision, it would be valuable in future research to design and implement risk and time preference field experiments that are contextualized in a forest decision-making problem in order to examine if context matters.

In manuscript 3, I found statistically weak evidence that improved tenure security in the form of a forest certificate increased net worth per capita by 42% between 2000 and 2008. Furthermore, I found that there was also statistically weak evidence that forest certification increased bamboo revenue, while obtaining a new plot (without a forest certificate) increased non-timber forest product revenue. This suggests that even in this early post-reform time period, the forest tenure reform in China appears to be improving households' wealth. Given the long-term time horizon of forest investment, it may be that wealth will increase more over the longer term. In the future, researchers should collect additional post-reform data to see if the reform has a more significant impact on households' wealth over a longer period of time.

The overall goal of this research was to understand how heterogeneity in time and risk preferences affected responses to forest tenure reforms. I have found that these preferences matter for forest management and responses to forest tenure reforms. This suggests that policymakers who are going forward with a tenure reform should consider the particular context of the reform and consider coupling the reform with appropriate programs and instruments to alleviate poverty and to help households' to deal with risks and make long-term investments to further stimulate the intended effects of the reform—increased investment in forest resources and improved livelihoods.

Appendix A. Risk Preference Task Instructions

TASK 1 INSTRUCTIONS

During this task, you will be asked to answer 35 questions divided into three sets of questions.

At the end of today's session, 1 of the 35 questions will be randomly selected to determine your earning.

What will each question look like in Task 1?

In each question, you will be offered two options to choose from: Option A and Option B. For each question, you will be asked to choose the option that you prefer. There is no right or wrong answer.

For example, a single question in a set of questions will look something like Question No. 1 below:

Option A		Option B	
Tokens in the bag you will draw from if you choose A:		Tokens in the bag you will draw from if you choose B:

No.	Option A		Option B	
	Option	Description	Option	Description
1	A	If , then receive 20 Yuan	B	If , then receive 34 Yuan
		If , then receive 5 Yuan		If , then receive 2.5 Yuan

This question offers you two options to choose from.

Option A says that:

- If you draw a token from a bag with 3 tokens and 7 tokens in it, then you will receive 20 Yuan.

OR

- If you draw a token from a bag with 3 tokens and 7 tokens in it, then you will receive 5 Yuan.

Option B says that:

- If you draw a token from a bag with 1 token and 9 tokens in it, then you will receive 34 Yuan.

OR

- If you draw a token from a bag with 1 token and 9 tokens in it, then you will receive 2.5 Yuan.

How we will record your choices?

For each question on each record sheet page, you can choose either Option A or B.

There are three different ways in which you can answer the set of questions on each record sheet page:

1. Always choose Option A.
2. Always choose Option B.
3. Choose Option A to start and then switch to Option B at any question in the set.

Please note that you cannot switch from Option B to Option A. This means that:

- you cannot choose Option B to start and then switch to Option A, and
- you cannot switch back to Option A after you have once chosen Option B.

There are no right or wrong answers in this task. Please just choose the option that you prefer.

The next three examples will show you how we will record each of the types of answers discussed above on your record sheets.

Record Sheet Example 1

Suppose you want to choose Option A for all 7 questions.

To record this answer on your record sheet we would do the following, as pictured below:

- Circle Option A for each of the questions from 1 to 7.
- Summarize your answers at the bottom of the Option A column by completing the sentence, "I choose Option A for Line 1 to ____," with the number 7.
- Summarize your answers at the bottom of the Option B column by crossing out the sentence at the bottom of column B, "I choose Option B for Line __ to 7."

Task 1

Record Sheet 1

		Option A		Option B	
		Tokens in the bag you will draw from if you choose A: <div style="display: flex; justify-content: space-around; width: 100px;"> ⊗⊗⊗○○ </div>		Tokens in the bag you will draw from if you choose B: <div style="display: flex; justify-content: space-around; width: 100px;"> ⊗○○○○ </div>	
N o.	Option	Description		Option	Description
1	A	If ⊗, then receive 20 Yuan If ○, then receive 5 Yuan		B	If ⊗, then receive 34 Yuan If ○, then receive 2.5 Yuan
2	A	If ⊗, then receive 20 Yuan If ○, then receive 5 Yuan		B	If ⊗, then receive 37.5 Yuan If ○, then receive 2.5 Yuan
3	A	If ⊗, then receive 20 Yuan If ○, then receive 5 Yuan		B	If ⊗, then receive 41.5 Yuan If ○, then receive 2.5 Yuan
4	A	If ⊗, then receive 20 Yuan If ○, then receive 5 Yuan		B	If ⊗, then receive 46.5 Yuan If ○, then receive 2.5 Yuan
5	A	If ⊗, then receive 20 Yuan If ○, then receive 5 Yuan		B	If ⊗, then receive 53 Yuan If ○, then receive 2.5 Yuan
6	A	If ⊗, then receive 20 Yuan If ○, then receive 5 Yuan		B	If ⊗, then receive 62.5 Yuan If ○, then receive 2.5 Yuan
7	A	If ⊗, then receive 20 Yuan If ○, then receive 5 Yuan		B	If ⊗, then receive 75 Yuan If ○, then receive 2.5 Yuan

I choose Option A for question 1 to 7 .

~~I choose Option B for question to 7.~~

Record Sheet Example 2

Suppose you want to choose Option B for all 7 questions.

To record this answer on your record sheet you would do the following, as pictured below:

- Circle Option B for each of the questions from 1 to 7.
- Summarize your answers at the bottom of the Option A column by crossing out the sentence "I choose Option A for Line 1 to ____".
- Summarize your answers at the bottom of the Option B column by completing the sentence "I choose Option B for Line ____ to 7" with the number 1.

Task 1

Record Sheet 1

		Option A		Option B
		Tokens in the bag you will draw from if you choose A: <div style="display: flex; gap: 5px;"> ☒ ☒ ☒ ☐ ☐ </div>		Tokens in the bag you will draw from if you choose B: <div style="display: flex; gap: 5px;"> ☒ ☐ ☐ ☐ ☐ </div>
No.	Option	Description		
1	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan		<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">B</div> If ☒ , then receive 34 Yuan If ☐ , then receive 2.5 Yuan
2	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan		<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">B</div> If ☒ , then receive 37.5 Yuan If ☐ , then receive 2.5 Yuan
3	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan		<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">B</div> If ☒ , then receive 41.5 Yuan If ☐ , then receive 2.5 Yuan
4	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan		<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">B</div> If ☒ , then receive 46.5 Yuan If ☐ , then receive 2.5 Yuan
5	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan		<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">B</div> If ☒ , then receive 53 Yuan If ☐ , then receive 2.5 Yuan
6	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan		<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">B</div> If ☒ , then receive 62.5 Yuan If ☐ , then receive 2.5 Yuan
7	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan		<div style="border: 1px solid black; border-radius: 50%; width: 30px; height: 30px; display: flex; align-items: center; justify-content: center; margin: 0 auto;">B</div> If ☒ , then receive 75 Yuan If ☐ , then receive 2.5 Yuan

~~I choose Option A for question 1 to .~~

I choose Option B for question to 7.

Record Sheet Example 3

Suppose you want to choose Option A to start and switch to Option B at some question. You can choose to switch from Option A to Option B at any question. For example, you might choose to switch from Option A to Option B at question 4 or question 5. This is your decision to make. Remember that once you switch from Option A to Option B, you cannot switch back to Option A.

For an example of how we will fill in your answer sheet, suppose you want to choose Option A from Question 1 to 5 and Option B from Question 6 to Question 7.

To record this answer on your record sheet you would do the following, as pictured below:

- Circle Option A for each of the questions from 1 to 5.
- Circle Option B for each of the questions from 6 to 7.
- Summarize your answers at the bottom of the Option A column by completing the sentence "I choose Option A for Line 1 to ____" with the number 5.
- Summarize your answers at the bottom of the Option B column by completing the sentence "I choose Option B for Line ____ to 7" with the number 6.

Task 1

Record Sheet 1

Option A			Option B		
Tokens in the bag you will draw from if you choose A: <div style="display: inline-block; text-align: center;"> ☒ ☒ ☒ ☐ ☐ </div>			Tokens in the bag you will draw from if you choose B: <div style="display: inline-block; text-align: center;"> ☒ ☐ ☐ ☐ ☐ </div>		
N o.	Option	Description	Option	Description	
1	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan	B	If ☒ , then receive 34 Yuan If ☐ , then receive 2.5 Yuan	
2	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan	B	If ☒ , then receive 37.5 Yuan If ☐ , then receive 2.5 Yuan	
3	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan	B	If ☒ , then receive 41.5 Yuan If ☐ , then receive 2.5 Yuan	
4	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan	B	If ☒ , then receive 46.5 Yuan If ☐ , then receive 2.5 Yuan	
5	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan	B	If ☒ , then receive 53 Yuan If ☐ , then receive 2.5 Yuan	
6	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan	B	If ☒ , then receive 62.5 Yuan If ☐ , then receive 2.5 Yuan	
7	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan	B	If ☒ , then receive 75 Yuan If ☐ , then receive 2.5 Yuan	

I choose Option A for question 1 to 5 .

I choose Option B for question 6 to 7.

How will your earnings be determined?

You will be asked to answer 35 questions in this task but you will only receive earnings on 1 of the 35 questions. The question that will be used to determine your earning in this task will be randomly selected by the following four steps:

Step 1: You will randomly draw a number between 1 and 35.

I will ask you to randomly draw a number from the numbers 1 to 35. The number you draw will be the question number that will be used to determine your earnings in this task. For example, if you draw a number 23, then your question number 23 will be used to determine your earnings.

Step 2: We will identify your answer to the selected question.

We will identify on your record sheet whether you choose Option A or Option B for the number question that will be used to determine your earnings.

Step 3: I will prepare a bag of 10 tokens.

The bag will contain the number of tokens and the number of tokens as stated at the top of your record sheet for either Option A or Option B, depending on which option you chose.

Step 4: You will randomly draw a token.

I will then ask you to draw a ball from the bag with the appropriate number of and tokens to determine your earnings.

Note that even though you will only receive earnings for one of your questions, **it is very important that you answer each question carefully**. This is because you will not know which question will be used to determine your earnings for Task 1 until the end of today's session.

Let's look at some examples of the steps to determine your earnings!

Earnings Example 1

Step 1: You will randomly draw a number between 1 and 35.

Let's suppose that you draw a number 2. This means that your number 2 question would be used to determine your earnings.

Step 2: We will identify your answer to the selected question.

Since you drew a number 2 in step 1, this means we will look at question 2 on your record sheet. Let's suppose that the following record sheet shows how you answered question 2:

Option A	
Tokens in the bag you will draw from if you choose A:

Option B	
Tokens in the bag you will draw from if you choose B:

No.	Option	Description
1	A	If , then receive 20 Yuan If , then receive 5 Yuan
2	A	If , then receive 20 Yuan If , then receive 5 Yuan
3	A	If , then receive 20 Yuan If , then receive 5 Yuan

Option	Description
B	If , then receive 34 Yuan If , then receive 2.5 Yuan
B	If , then receive 37.5 Yuan If , then receive 2.5 Yuan
D	If , then receive 41.5 Yuan If , then receive 2.5 Yuan

Step 3: I will prepare a bag of 10 tokens.

For question number 2, you choose Option A. This means that I will prepare a bag with 3 tokens and 7 tokens, like this:

If you draw a token from the bag, then you would receive 20 Yuan. But if you draw a token from the bag, then you would receive 5 Yuan.

Step 4: You will randomly draw a token.

Let's suppose that you draw a token from the bag. This means that you would receive 20 Yuan for this task.

Earnings Example 2

Step 1: You will randomly draw a number between 1 and 35.

Let's suppose that you draw a number 3. This means that your number 3 question would be used to determine your earnings.

Step 2: We will identify your answer to the selected question.

Since you drew a number 3 in step 1, this means we will look at question 3 on your record sheet. Let's suppose again that the following record sheet shows how you answered question 3:

Option A			Option B		
Tokens in the bag you will draw from if you choose A:			Tokens in the bag you will draw from if you choose B:

No.	Option	Description	Option	Description	
1	A	If , then receive 20 Yuan If , then receive 5 Yuan	B	If , then receive 34 Yuan If , then receive 2.5 Yuan	
2	A	If , then receive 20 Yuan If , then receive 5 Yuan	B	If , then receive 37.5 Yuan If , then receive 2.5 Yuan	
3	A	If , then receive 20 Yuan If , then receive 5 Yuan	B	If , then receive 41.5 Yuan If , then receive 2.5 Yuan	

Step 3: I will prepare a bag of 10 tokens.

For question number 3, you choose Option B. This means that I will prepare a bag with 1 tokens and 9 tokens, like this:

If you draw a token from the bag, then you would receive 41.5 Yuan. But if you draw a token from the bag, then you would receive 2.5 Yuan.

Step 4: You will randomly draw a token from the bag.

Let's suppose that you draw a token from the bag. This means that you would receive 2.5 Yuan for this task.

Note that on the first and second sets of question you will always receive some money. But on the third set of questions it is possible that you *receive or lose money*.

Whatever money you lose in this task will be deducted from your participation compensation but the amount you lose will never be more than your 10 Yuan participation compensation.

Let's practice on a record sheet where it is possible that you could receive or lose money.

Earnings Example 3

Step 1: You will randomly draw a number between 1 and 35.

Let's suppose that you draw a number 30. This means that your number 30 question would be used to determine your earnings.

Step 2: We will identify your answer to the selected question.

Since you drew a number 30 in step 1, this means we will look at question 30 on your record sheet. Let's suppose again that the following record sheet shows how you answered question 30:

Option A		Option B	
Tokens in the bag you will draw from if you choose A:		Tokens in the bag you will draw from if you choose B:

No.	Option	Description	Option	Description
29	A	If , then receive 12.5 Yuan If , then lose 5 Yuan	B	If , then receive 15 Yuan If , then lose 10 Yuan
30	A	If , then receive 2 Yuan If , then lose 2 Yuan	B	If , then receive 15 Yuan If , then lose 10 Yuan

Step 3: I will prepare a bag of 10 tokens.

For question number 30, you choose Option B. This means that I will prepare a bag with 5 tokens and 5 tokens, like this:

If you draw a token from the bag, then you would receive 41.5 Yuan. But if you draw a token from the bag, then you would receive 2.5 Yuan.

Step 4: You will randomly draw a token. Let's suppose that you draw a token from the bag. This means that you would lose 10 Yuan for this task. This means that the 10 Yuan would be deducted from your 10 Yuan participation compensation.

Practice Example 1

Let's practice how your earnings will be calculated at the end of today's session. Please listen to me as I read you some examples and think about what your earnings would be if this was how you answered your record sheet.

Task 1

Record Sheet 1

		Option A		Option B	
		Tokens in the bag you will draw from if you choose A:	☒ ☒ ☒ ☐ ☐ ☐ ☐ ☐ ☐ ☐	Tokens in the bag you will draw from if you choose B:	☒ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

N o.	Option	Description
1	☒ A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
2	☒ A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
3	☒ A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
4	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
5	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
6	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
7	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
8	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
9	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan
10	A	If ☒ , then receive 20 Yuan If ☐ , then receive 5 Yuan

Option	Description
B	If ☒ , then receive 34 Yuan If ☐ , then receive 2.5 Yuan
B	If ☒ , then receive 37.5 Yuan If ☐ , then receive 2.5 Yuan
B	If ☒ , then receive 41.5 Yuan If ☐ , then receive 2.5 Yuan
☒ B	If ☒ , then receive 46.5 Yuan If ☐ , then receive 2.5 Yuan
☒ B	If ☒ , then receive 53 Yuan If ☐ , then receive 2.5 Yuan
☒ B	If ☒ , then receive 62.5 Yuan If ☐ , then receive 2.5 Yuan
☒ B	If ☒ , then receive 75 Yuan If ☐ , then receive 2.5 Yuan
☒ B	If ☒ , then receive 92.5 Yuan If ☐ , then receive 2.5 Yuan
☒ B	If ☒ , then receive 110 Yuan If ☐ , then receive 2.5 Yuan
☒ B	If ☒ , then receive 150 Yuan If ☐ , then receive 2.5 Yuan

I choose Option A for question 1 to 3 . I choose Option B for question 4 to 10.

Practice Example 2

Let's practice how your earnings will be calculated at the end of today's session. Please listen to me read as I read you some examples and think about what your earnings would be if this was how you answered your record sheet.

Task 1

Record Sheet 3

		Option A		Option B	
		Tokens in the bag you will draw from if you choose A: <div style="display: inline-block; text-align: center;"> ⊗ ⊗ ⊗ ⊗ ⊗ </div>		Tokens in the bag you will draw from if you choose B: <div style="display: inline-block; text-align: center;"> ⊗ ⊗ ⊗ ⊗ ⊗ </div>	
N o.	Option	Description		Option	Description
29	A	If ⊗ , then receive 12.5 Yuan If ○ , then lose 5 Yuan		B	If ⊗ , then receive 15 Yuan If ○ , then lose 10 Yuan
30	A	If ⊗ , then receive 2 Yuan If ○ , then lose 2 Yuan		B	If ⊗ , then receive 15 Yuan If ○ , then lose 10 Yuan
31	A	If ⊗ , then receive 0.5 Yuan If ○ , then lose 2 Yuan		B	If ⊗ , then receive 15 Yuan If ○ , then lose 10 Yuan
32	A	If ⊗ , then receive 0.5 Yuan If ○ , then lose 2 Yuan		B	If ⊗ , then receive 15 Yuan If ○ , then lose 8 Yuan
33	A	If ⊗ , then receive 0.5 Yuan If ○ , then lose 4 Yuan		B	If ⊗ , then receive 15 Yuan If ○ , then lose 8 Yuan
34	A	If ⊗ , then receive 0.5 Yuan If ○ , then lose 4 Yuan		B	If ⊗ , then receive 15 Yuan If ○ , then lose 7 Yuan
35	A	If ⊗ , then receive 0.5 Yuan If ○ , then lose 4 Yuan		B	If ⊗ , then receive 15 Yuan If ○ , then lose 5 Yuan

I choose Option A for question 29 to 32 . I choose Option B for question 33 to 35.

Appendix B. Risk Preference Task Record Sheets

Task 1 Record Sheet 1

Option A	
Tokens in the bag you will draw from if you choose A:

Option B	
Tokens in the bag you will draw from if you choose B:

No.	Option	Description
1	A	If , then receive 20 Yuan If , then receive 5 Yuan
2	A	If , then receive 20 Yuan If , then receive 5 Yuan
3	A	If , then receive 20 Yuan If , then receive 5 Yuan
4	A	If , then receive 20 Yuan If , then receive 5 Yuan
5	A	If , then receive 20 Yuan If , then receive 5 Yuan
6	A	If , then receive 20 Yuan If , then receive 5 Yuan
7	A	If , then receive 20 Yuan If , then receive 5 Yuan
8	A	If , then receive 20 Yuan If , then receive 5 Yuan
9	A	If , then receive 20 Yuan If , then receive 5 Yuan
10	A	If , then receive 20 Yuan If , then receive 5 Yuan
11	A	If , then receive 20 Yuan If , then receive 5 Yuan
12	A	If , then receive 20 Yuan If , then receive 5 Yuan
13	A	If , then receive 20 Yuan If , then receive 5 Yuan
14	A	If , then receive 20 Yuan If , then receive 5 Yuan

Option	Description
B	If , then receive 34 Yuan If , then receive 2.5 Yuan
B	If , then receive 37.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 41.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 46.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 53 Yuan If , then receive 2.5 Yuan
B	If , then receive 62.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 75 Yuan If , then receive 2.5 Yuan
B	If , then receive 92.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 110 Yuan If , then receive 2.5 Yuan
B	If , then receive 150 Yuan If , then receive 2.5 Yuan
B	If , then receive 200 Yuan If , then receive 2.5 Yuan
B	If , then receive 300 Yuan If , then receive 2.5 Yuan
B	If , then receive 500 Yuan If , then receive 2.5 Yuan
B	If , then receive 850 Yuan If , then receive 2.5 Yuan

I choose Option A for question 1 to . I choose Option B for question to 14.

Task 1
Record Sheet 2

Option A	
Tokens in the bag you will draw from if you choose A:

Option B	
Tokens in the bag you will draw from if you choose B:

No.	Option	Description
15	A	If , then receive 20 Yuan If , then receive 15 Yuan
16	A	If , then receive 20 Yuan If , then receive 15 Yuan
17	A	If , then receive 20 Yuan If , then receive 15 Yuan
18	A	If , then receive 20 Yuan If , then receive 15 Yuan
19	A	If , then receive 20 Yuan If , then receive 15 Yuan
20	A	If , then receive 20 Yuan If , then receive 15 Yuan
21	A	If , then receive 20 Yuan If , then receive 15 Yuan
22	A	If , then receive 20 Yuan If , then receive 15 Yuan
23	A	If , then receive 20 Yuan If , then receive 15 Yuan
24	A	If , then receive 20 Yuan If , then receive 15 Yuan
25	A	If , then receive 20 Yuan If , then receive 15 Yuan
26	A	If , then receive 20 Yuan If , then receive 15 Yuan
27	A	If , then receive 20 Yuan If , then receive 15 Yuan
28	A	If , then receive 20 Yuan If , then receive 15 Yuan

Option	Description
B	If , then receive 27 Yuan If , then receive 2.5 Yuan
B	If , then receive 28 Yuan If , then receive 2.5 Yuan
B	If , then receive 29 Yuan If , then receive 2.5 Yuan
B	If , then receive 30 Yuan If , then receive 2.5 Yuan
B	If , then receive 31 Yuan If , then receive 2.5 Yuan
B	If , then receive 32.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 34 Yuan If , then receive 2.5 Yuan
B	If , then receive 36 Yuan If , then receive 2.5 Yuan
B	If , then receive 38.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 41.5 Yuan If , then receive 2.5 Yuan
B	If , then receive 45 Yuan If , then receive 2.5 Yuan
B	If , then receive 50 Yuan If , then receive 2.5 Yuan
B	If , then receive 55 Yuan If , then receive 2.5 Yuan
B	If , then receive 65 Yuan If , then receive 2.5 Yuan

I choose Option A for question 15 to .

I choose Option B for question to 28.

Task 1
Record Sheet 3

No.	Option A		Option B	
	Option	Description	Option	Description
29	A	Tokens in the bag you will draw from if you choose A: If , then receive 12.5 Yuan If , then lose 5 Yuan	B	Tokens in the bag you will draw from if you choose B: If , then receive 15 Yuan If , then lose 10 Yuan
30	A	If , then receive 2 Yuan If , then lose 2 Yuan	B	If , then receive 15 Yuan If , then lose 10 Yuan
31	A	If , then receive 0.5 Yuan If , then lose 2 Yuan	B	If , then receive 15 Yuan If , then lose 10 Yuan
32	A	If , then receive 0.5 Yuan If , then lose 2 Yuan	B	If , then receive 15 Yuan If , then lose 8 Yuan
33	A	If , then receive 0.5 Yuan If , then lose 4 Yuan	B	If , then receive 15 Yuan If , then lose 8 Yuan
34	A	If , then receive 0.5 Yuan If , then lose 4 Yuan	B	If , then receive 15 Yuan If , then lose 7 Yuan
35	A	If , then receive 0.5 Yuan If , then lose 4 Yuan	B	If , then receive 15 Yuan If , then lose 5 Yuan

I choose Option A for question 29 to . I choose Option B for question to 35.

Appendix C. Time Preference Task Instructions

TASK 2 INSTRUCTIONS

During Task 2, you will be asked to answer 75 questions. The 75 questions will be presented to you in sets of 5 questions.

At the end of today's session, 1 of the 75 questions will be randomly selected to determine your earning.

What will each question look like in Task 1?

In each question, you will be offered two plans: Plan A or Plan B.

Please choose the plan that you prefer for each question. There is no right or wrong answer.

For example, a question might look like this:

	Plan A	Plan B
1	Receive 48 Yuan in 1 week	Receive 8 Yuan today

There are two plans, A and B, offered to you.

Under Plan A, you will receive 48 Yuan in 1 week.

Under Plan B, you will receive 8 Yuan today.

Questions will be presented to you in sets of 5 questions, like this:

	Plan A	Plan B
1	Receive 48 Yuan in 1 week	Receive 8 Yuan today
2	Receive 48 Yuan in 1 week	Receive 16 Yuan today
3	Receive 48 Yuan in 1 week	Receive 24 Yuan today
4	Receive 48 Yuan in 1 week	Receive 32 Yuan today
5	Receive 48 Yuan in 1 week	Receive 40 Yuan today

I choose A for questions 1 to .

I choose B for questions to 5.

**How will you obtain your earnings
if you choose the plan with the future payment?**

If your payment for this task will be on a specified date in the future, then you will receive it from China post on the future date. If there is some problem and you do not receive your future payment from China post, then you can contact Jintao Xu of Peking University at 010-62767657.

How will we record your choices?

For each question on each record sheet page, you can choose either Plan A or B.

There are three different ways in which you can answer each set of five questions:

1. Always choose Plan A in the set of 5 questions.
2. Always choose Plan B in the set of 5 questions.
3. Choose Plan A to start and then switch to Plan B at any question in the set of 5 questions.

Please note that you cannot switch from Option B to Option A in each set of 5 questions.

This means that:

- you cannot choose Option B to start and then switch to Option A, and
- you cannot switch back to Option A after you have once chosen Option B.

There are no right or wrong answers in this task. Please just choose the plan that you prefer.

The next three examples will show you how you can record each of the types of answers discussed above on your record sheets.

Record Sheet Example 1

Suppose you want to choose Plan A for all 5 questions in this set.

To record this answer on your record sheet you would do the following, as pictured below:

- Circle Plan A for each of the questions from 1 to 5.
- Summarize your answers at the bottom of the Plan A column by completing the sentence, "I choose Plan A for Line 1 to ____," with the number 5.
- Summarize your answers at the bottom of the Plan B column by crossing out the sentence, "I choose Plan B for Line __ to 5."

	Plan A	Plan B
1	Receive 48 Yuan in 1 week	Receive 8 Yuan today
2	Receive 48 Yuan in 1 week	Receive 16 Yuan today
3	Receive 48 Yuan in 1 week	Receive 24 Yuan today
4	Receive 48 Yuan in 1 week	Receive 32 Yuan today
5	Receive 48 Yuan in 1 week	Receive 40 Yuan today
I choose A for questions 1 to <input type="text" value="5"/> .		I choose B for questions <input type="text" value="1"/> to 5.

Record Sheet Example 2

Suppose you want to choose Plan B for all 5 questions in this set.

To record this answer on your record sheet you would do the following, as pictured below:

- Circle Plan B for each of the questions from 1 to 5.
- Summarize your answers at the bottom of the Plan A column by crossing out the sentence, "I choose Plan A for Line 1 to ____".
- Summarize your answers at the bottom of the Plan B column by completing the sentence "I choose Plan B for Line __ to 5" with the number 1.

	Plan A	Plan B
1	Receive 48 Yuan in 1 week	Receive 8 Yuan today
2	Receive 48 Yuan in 1 week	Receive 16 Yuan today
3	Receive 48 Yuan in 1 week	Receive 24 Yuan today
4	Receive 48 Yuan in 1 week	Receive 32 Yuan today
5	Receive 48 Yuan in 1 week	Receive 40 Yuan today

~~I choose A for questions 1 to .~~

I choose B for questions 1 to 5.

Record Sheet Example 3

Suppose you want to choose Plan A to start and switch to Plan B at some question. You can choose to switch from Plan A to Plan B at any question. For example, you might choose to switch from Plan A to Plan B at question 2 or question 5. This is your decision to make. Remember that once you switch from Plan A to Plan B, you cannot switch back to Plan A.

For an example of how to fill in your answer sheet, suppose you want to choose Plan A from Question 1 to 3 and Plan B from Question 4 to Question 5.

To record this answer on your record sheet you would do the following, as pictured below:

- Circle Plan A for each of the questions from 1 to 3.
- Circle Plan B for each of the questions from 4 to 5.
- Summarize your answers at the bottom of the Plan A column by completing the sentence "I choose Plan A for Line 1 to ___" with the number 3.
- Summarize your answers at the bottom of the Plan B column by completing the sentence "I choose Plan B for Line ___ to 5" with the number 4.

	Plan A	Plan B
1	Receive 48 Yuan in 1 week	Receive 8 Yuan today
2	Receive 48 Yuan in 1 week	Receive 16 Yuan today
3	Receive 48 Yuan in 1 week	Receive 24 Yuan today
4	Receive 48 Yuan in 1 week	Receive 32 Yuan today
5	Receive 48 Yuan in 1 week	Receive 40 Yuan today

I choose A for questions 1 to 3 .

I choose B for questions 4 to 5.

How will your earnings be determined?

You will be asked to answer 75 questions in Task 2 but you will only receive earnings on 1 of the 75 questions.

The question that you will receive earnings on will be randomly selected. To do so, we will ask each of you to draw a number between 1 to 75. The number that you draw will be the number of the question that will be used to determine how much you will be paid and when you will be paid.

Note that even though you will only receive earnings for one of your questions, it is **very important that you answer each question carefully**. This is because you will not know which question will be used to determine your earnings until the end of today's session

Let's look at some examples of the steps to determine the amount and date of delivery of your earnings!

Earnings Example 1

Let's suppose that you draw a number 8. This means that question number 8 will be used to determine the amount of money you will earn in this task.

Suppose that you answered question 8 like this:

Plan A		Plan B	
8	Receive 48 Yuan in 1 month		Receive 24 Yuan today

For question 8 you chose Plan B. This means that you would receive 24 Yuan today.

Earnings Example 2

Let's suppose that you again draw a number 8. Again, this means that your number 8 question will be used to determine the amount of money you will earn.

Now, suppose that instead you had answered question 8 like this:

Plan A		Plan B	
8	Receive 48 Yuan in 1 month		Receive 24 Yuan today

For question 8 you chose Plan A. This means that you would receive 48 Yuan in 1 month.

Earnings Example 3

Suppose that the record sheet below shows how you answered questions 6 thru 10 on your record sheet in this task. It shows that you choose Plan A for questions 6 to 8 and Plan B for questions 9 to 10.

	Plan A	Plan B
6	Receive 48 Yuan in 1 month	Receive 8 Yuan today
7	Receive 48 Yuan in 1 month	Receive 16 Yuan today
8	Receive 48 Yuan in 1 month	Receive 24 Yuan today
9	Receive 48 Yuan in 1 month	Receive 32 Yuan today
10	Receive 48 Yuan in 1 month	Receive 40 Yuan today

I choose A for questions 6 to . I choose B for questions to 10.

Suppose that at the end of today's session, you draw a number 8. You chose Plan A for question 8. This means that you will receive 48 Yuan in 1 month.

Earnings Example 4

Suppose that the record sheet pictured below shows how you answered questions 6 thru 10 on your record sheet in this task. It shows that you chose Plan A for questions 6 to 7 and Plan B for questions 8 to 10.

	Plan A	Plan B
6	Receive 48 Yuan in 1 month	Receive 8 Yuan today
7	Receive 48 Yuan in 1 month	Receive 16 Yuan today
8	Receive 48 Yuan in 1 month	Receive 24 Yuan today
9	Receive 48 Yuan in 1 month	Receive 32 Yuan today
10	Receive 48 Yuan in 1 month	Receive 40 Yuan today

I choose A for questions 6 to . I choose B for questions to 10.

Suppose that at the end of today's session, you draw a number 9. You chose Plan B for question 9. This means that you will receive 32 Yuan today.

Practice Example 1

Let's practice how the amount and date of delivery of your earnings will be determined at the end of today's session. Please listen to me as I explain a few examples and think about what your earnings would be and when you would receive your earnings if this was how you answered your record sheet.

	Plan A	Plan B
16	Receive 150 Yuan in 1 week	Receive 25 Yuan today
17	Receive 150 Yuan in 1 week	Receive 50 Yuan today
18	Receive 150 Yuan in 1 week	Receive 75 Yuan today
19	Receive 150 Yuan in 1 week	Receive 100 Yuan today
20	Receive 150 Yuan in 1 week	Receive 125 Yuan today

I choose A for questions 16 to .

I choose B for questions to 20.

	Plan A	Plan B
21	Receive 150 Yuan in 1 month	Receive 25 Yuan today
22	Receive 150 Yuan in 1 month	Receive 50 Yuan today
23	Receive 150 Yuan in 1 month	Receive 75 Yuan today
24	Receive 150 Yuan in 1 month	Receive 100 Yuan today
25	Receive 150 Yuan in 1 month	Receive 125 Yuan today

I choose A for questions 21 to .

I choose B for questions to 25.

	Plan A	Plan B
26	Receive 150 Yuan in 3 months	Receive 25 Yuan today
27	Receive 150 Yuan in 3 months	Receive 50 Yuan today
28	Receive 150 Yuan in 3 months	Receive 75 Yuan today
29	Receive 150 Yuan in 3 months	Receive 100 Yuan today
30	Receive 150 Yuan in 3 months	Receive 125 Yuan today

I choose A for questions 26 to .

I choose B for questions to 30.

Appendix D. Time Preference Task Record Sheets

Task 2 Record Sheets

Plan A		Plan B	
1	Receive 60 Yuan in 2 weeks	Receive 10 Yuan today	
2	Receive 60 Yuan in 2 weeks	Receive 20 Yuan today	
3	Receive 60 Yuan in 2 weeks	Receive 30 Yuan today	
4	Receive 60 Yuan in 2 weeks	Receive 40 Yuan today	
5	Receive 60 Yuan in 2 weeks	Receive 50 Yuan today	
I choose A for questions 1 to <input type="text"/> .		I choose B for questions <input type="text"/> to 5.	

Plan A		Plan B	
6	Receive 60 Yuan in 3 months	Receive 10 Yuan today	
7	Receive 60 Yuan in 3 months	Receive 20 Yuan today	
8	Receive 60 Yuan in 3 months	Receive 30 Yuan today	
9	Receive 60 Yuan in 3 months	Receive 40 Yuan today	
10	Receive 60 Yuan in 3 months	Receive 50 Yuan today	
I choose A for questions 6 to <input type="text"/> .		I choose B for questions <input type="text"/> to 10.	

Plan A		Plan B	
11	Receive 60 Yuan in 6 months	Receive 10 Yuan today	
12	Receive 60 Yuan in 6 months	Receive 20 Yuan today	
13	Receive 60 Yuan in 6 months	Receive 30 Yuan today	
14	Receive 60 Yuan in 6 months	Receive 40 Yuan today	
15	Receive 60 Yuan in 6 months	Receive 50 Yuan today	
I choose A for questions 11 to <input type="text"/> .		I choose B for questions <input type="text"/> to 15.	

	Plan A	Plan B
16	Receive 150 Yuan in 2 week	Receive 25 Yuan today
17	Receive 150 Yuan in 2 week	Receive 50 Yuan today
18	Receive 150 Yuan in 2 week	Receive 75 Yuan today
19	Receive 150 Yuan in 2 week	Receive 100 Yuan today
20	Receive 150 Yuan in 2 week	Receive 125 Yuan today

I choose A for questions 16 to .

I choose B for questions to 20.

	Plan A	Plan B
21	Receive 150 Yuan in 3 month	Receive 25 Yuan today
22	Receive 150 Yuan in 3 month	Receive 50 Yuan today
23	Receive 150 Yuan in 3 month	Receive 75 Yuan today
24	Receive 150 Yuan in 3 month	Receive 100 Yuan today
25	Receive 150 Yuan in 3 month	Receive 125 Yuan today

I choose A for questions 21 to .

I choose B for questions to 25.

	Plan A	Plan B
26	Receive 150 Yuan in 6 months	Receive 25 Yuan today
27	Receive 150 Yuan in 6 months	Receive 50 Yuan today
28	Receive 150 Yuan in 6 months	Receive 75 Yuan today
29	Receive 150 Yuan in 6 months	Receive 100 Yuan today
30	Receive 150 Yuan in 6 months	Receive 125 Yuan today

I choose A for questions 26 to .

I choose B for questions to 30.

	Plan A	Plan B
31	Receive 15 Yuan in 2 week	Receive 2.5 Yuan today
32	Receive 15 Yuan in 2 week	Receive 5 Yuan today
33	Receive 15 Yuan in 2 week	Receive 7.5 Yuan today
34	Receive 15 Yuan in 2 week	Receive 10 Yuan today
35	Receive 15 Yuan in 2 week	Receive 12.5 Yuan today

I choose A for questions 31 to .

I choose B for questions to 35.

	Plan A	Plan B
36	Receive 15 Yuan in 3 month	Receive 2.5 Yuan today
37	Receive 15 Yuan in 3 month	Receive 5 Yuan today
38	Receive 15 Yuan in 3 month	Receive 7.5 Yuan today
39	Receive 15 Yuan in 3 month	Receive 10 Yuan today
40	Receive 15 Yuan in 3 month	Receive 12.5 Yuan today

I choose A for questions 36 to .

I choose B for questions to 40.

	Plan A	Plan B
41	Receive 15 Yuan in 6 months	Receive 2.5 Yuan today
42	Receive 15 Yuan in 6 months	Receive 5 Yuan today
43	Receive 15 Yuan in 6 months	Receive 7.5 Yuan today
44	Receive 15 Yuan in 6 months	Receive 10 Yuan today
45	Receive 15 Yuan in 6 months	Receive 12.5 Yuan today

I choose A for questions 41 to .

I choose B for questions: to 45.

	Plan A	Plan B
46	Receive 120 Yuan in 1 week	Receive 20 Yuan today
47	Receive 120 Yuan in 1 week	Receive 40 Yuan today
48	Receive 120 Yuan in 1 week	Receive 60 Yuan today
49	Receive 120 Yuan in 1 week	Receive 80 Yuan today
50	Receive 120 Yuan in 1 week	Receive 100 Yuan today

I choose A for questions 46 to .

I choose B for questions to 50.

	Plan A	Plan B
51	Receive 120 Yuan in 2 months	Receive 20 Yuan today
52	Receive 120 Yuan in 2 months	Receive 40 Yuan today
53	Receive 120 Yuan in 2 months	Receive 60 Yuan today
54	Receive 120 Yuan in 2 months	Receive 80 Yuan today
55	Receive 120 Yuan in 2 months	Receive 100 Yuan today

I choose A for questions 51 to .

I choose B for questions to 55.

	Plan A	Plan B
56	Receive 120 Yuan in 4 months	Receive 20 Yuan today
57	Receive 120 Yuan in 4 months	Receive 40 Yuan today
58	Receive 120 Yuan in 4 months	Receive 60 Yuan today
59	Receive 120 Yuan in 4 months	Receive 80 Yuan today
60	Receive 120 Yuan in 4 months	Receive 100 Yuan today

I choose A for questions 56 to .

I choose B for questions to 60.

	Plan A	Plan B
61	Receive 30 Yuan in 1 week	Receive 5 Yuan today
62	Receive 30 Yuan in 1 week	Receive 10 Yuan today
63	Receive 30 Yuan in 1 week	Receive 15 Yuan today
64	Receive 30 Yuan in 1 week	Receive 20 Yuan today
65	Receive 30 Yuan in 1 week	Receive 25 Yuan today

I choose A for questions 61 to .

I choose B for questions to 65.

	Plan A	Plan B
66	Receive 30 Yuan in 2 months	Receive 5 Yuan today
67	Receive 30 Yuan in 2 months	Receive 10 Yuan today
68	Receive 30 Yuan in 2 months	Receive 15 Yuan today
69	Receive 30 Yuan in 2 months	Receive 20 Yuan today
70	Receive 30 Yuan in 2 months	Receive 25 Yuan today

I choose A for questions 66 to .

I choose B for questions to 70.

	Plan A	Plan B
71	Receive 30 Yuan in 4 months	Receive 5 Yuan today
72	Receive 30 Yuan in 4 months	Receive 10 Yuan today
73	Receive 30 Yuan in 4 months	Receive 15 Yuan today
74	Receive 30 Yuan in 4 months	Receive 20 Yuan today
75	Receive 30 Yuan in 4 months	Receive 25 Yuan today

I choose A for questions 71 to .

I choose B for questions to 75.

Appendix E. Earnings Record Sheet

Earnings Record

This sheet will be used to record the number of the balls that you draw and your earnings.

Task 1 Earnings, Participation Compensation and Survey Compensation

Number Drawn between 1 and 35 (Write the number.)	
Option Chosen (Circle A or B.)	A or B
Token Drawn (Circle or .)	or
Earnings or Losses (Circle Receive or Lose and write the amount.)	Receive Yuan Lose
Plus 10 Yuan Participation Compensation	10 Yuan
Plus Survey Compensation	15 Yuan
Total Earnings	Yuan
Date to be Paid	Today

Task 2 Earnings

Number Drawn between 1 and 75 (Write the number.)	
Plan Chosen (Circle A or B.)	A or B
Earnings	Yuan
Date to be Paid	

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