Risk, Time Preferences and Tenure Reform: Impact on Forest Management

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Abstract: We examine the role of risk and time preferences in how forest owners respond to strengthened forest property rights. We test hypotheses from a two-period harvest model in the context of Fujian, China, where a property right reform began in 2003. Using survey and field experiment data, we find that risk and time preferences affect households' forest management responses to forest plot certification. The reform resulted in less labor for harvesting and more labor for applying forest inputs among more risk averse households, while more loss averse households used more labor for harvesting. Households with higher discount rates used less labor for applying inputs and spent less on forest inputs in response to forest plot certification. These findings underscore the importance of recognizing that the impact of reforms may be heterogeneous across households, and those diverse individual preferences—which are usually unobservable to policymakers—may be one source of heterogeneity.

Key words: tenure reform, property rights, forests, risk preference, time preference, China, field experiment, poverty

1 Introduction

Forest degradation persists throughout much of the world (FAO 2010). The cause of this continued degradation is complex and multifaceted but over the last decade insecure rights to ownership and use of forest resources, especially in developing countries, has been recognized as a key cause (White and Martin 2002; Sunderlin et al. 2005). Rights to ownership and use of forest resources are often undefined, contested, overlapping or unenforced. Without secure rights forest holders have few incentives to invest in managing and protecting their forest resources. This realization has stimulated the current trend in forest policy toward strengthening property rights for forest resources by transferring rights from the state to communities and individuals, giving them defined rights to manage and extract forest resources (Ellsworth and White 2004; FAO 2011). However, reforms on property rights have not consistently led to the intended sustainable resource use and management, particularly in developing countries. On one hand, studies such as Besley (1995) and Holden et al. (2009) find empirical evidence that more secure land rights facilitated investment in trees in Ghana and Ethiopia, respectively. At the same time, other studies have found that tenure reforms have not led to their intended consequence of sustainable resource management, for example, in Indonesia (Barr 2001), Russia (White and Martin. 2002), newly independent states of Eastern Europe (INDUFOR OY/ECO for The World Bank and World Wildlife Fund Alliance 2001) and others (Ostrom 1990; Bromley 1991; Alston et al. 1999; Bohn and Deacon 2000).

The purpose of this study is to examine the role of individual preferences in how resource owners respond to property rights reforms. Households making forest management decisions face many uncertainties through prices, growth and quality of retained stands, outbreaks of disease, pest infestations, forest fire, extreme weather events, and importantly in the context of this study, through redistribution of forest land. Furthermore, decisions about forest management often involve a long time horizon. As such, households' risk and time preferences play an important role in their forest management decisions (Newman 2002; Tahvonen and Kallio 2006; Couture and Reynaud 2008). For example, a more patient or less risk averse individual may invest more labor and inputs into their forest. Changes in property rights can affect forest management directly (Johansson and Lofgren 1985) but the reform effects can interact with individual time and risk preferences, affecting the net effect of how households change their forest management practices. For example, even if households are given secure property rights, those with a strong preference for current benefits may have the incentive to harvest forest resources faster. Failure to recognize the impacts of households' risk and time preferences may result in outcomes that 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 (Pender 1996; Holden et al. 1998; Nielsen 2001; Yesuf and Bluffstone 2008, 2009). Yet to our knowledge, no previous study has directly examined how risk and time preferences affect household responses to property right reforms.

This paper begins by constructing a simple intertemporal model of optimal forest management under uncertainty based on prospect theory, taking account of risk preference, time preference, and risk over property rights of forests. The model explains the direct effects of the reform and individual preferences on tree harvest and investments on forest land. We then test empirically which effects dominate by using original survey and field experiment data from Fujian Province, China, where a large-scale reform of forest land tenure began in 2003. Under this reform, the responsibilities of forest planting and management were transferred from collective management (by townships and villages) to households. This transfer of responsibility was accompanied by a forest certificate, a legal document establishing a household's rights to a specific forest area.

Empirically, we combine the risk and time preference field experiment data collected from 103 households in Fujian Province with a panel survey data 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 examine three sets of outcome variables related to household forest management: 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.[1] To identify the effect of forest tenure reform on household forest management and how risk and time preference augment the effect, we use matching techniques to preprocess the data (Ho et al. 2007a) and then use the preprocessed matched data in a difference-in-differences framework.

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.

This study contributes to the literature in three ways. First, we employ prospect theory to examine the impact of property rights and time and risk preferences on forest management. This departs from the models often used in resource economics. In modeling the effect of tenure security, the standard approach in the classical natural resource economics literature is to differentiate full property right (sole ownership) vs. no property rights (open access) in a resource harvesting decision (e.g., Gordon 1954; Hardin 1968). We take a different approach, which is to view the degree of property rights as having a spectrum between complete property rights and open access. We model strengthened property rights as reducing risks in benefits from future harvests. This modeling approach has been taken, for example, in agricultural and development economics to model investment decisions when future returns from investment is risky because there is a positive expropriation risk from insecure property rights (e.g., Jacoby et al. (2002); Goldstein and Udry (2008)). Second, in contrast to previous studies which used proxies for tenure security (such as conflicts with abutters and duration of residence in a village (Godoy et al. 1998, 2001)), this study uses actual changes in forest property rights indicated by whether or not a household has a forest certificate for a plot. Third, this study uses experiments with real monetary rewards to capture time and risk preferences (Tanaka et al. 2010). Offering real monetary rewards reduces the hypothetical bias that may exist in previous related studies, which use hypothetical questions to elicit risk and time preferences (Godoy et al. 1998; Godoy et al. 2001; Hagos and Holden 2006).[2] Finally, our study is unique because we link time and risk preferences elicited using experiments with real monetary rewards to actual natural resource management behavior, which few studies have previously done (Godoy et al. 2001; Liu 2013).

2 China's Forest Tenure Reform

China has two main categories of forest land ownership—state-owned and collectively owned forest. Over the last 60 years, forest tenure and management policies in China have undergone a series of changes.[3] Collectivization of non-state owned forests began in 1956 (Xu and Jiang 2009). Under collectivization, administrative villages functioned as the legal owners of collective forests and households had little active participation in management and no links among their use rights, responsibility for forest management, and benefits from forests (Dachang 2001). Collectivization remained dominant until the 1980s when the first major wave of tenure reform began in China's collective forest under the "Three Fixes" policy. This reform 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 collectively owned forest land in China had been transferred to rural household management (Xu and Jiang 2009). In the late 1980s, however, due the occurrence of unsustainable logging the government returned a large portion of forest land under household management back to collective management (Hyde et al. 2003). In the early 2000s, constrained forest tenure rights became increasingly recognized as a cause of a political crisis in the forestry sector and a key impediment to sustainable forest management, increased timber production, and poverty alleviation. As a result, the State Forestry Administration encouraged provinces to implement forest tenure reforms, and by mid-2003 the central government devised the “Resolution on the Development of Forestry” (the “No. 9 Policy”) (Xu et al. 2010).

The new forest tenure reforms provide a national-level policy framework that encourages collective forest rights to be reallocated to households. The decisions regarding reallocation during this reform require a 2/3 majority vote by the village representative committees or assemblies. Redistribution is accompanied by legal contract 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, rights under the new forest certificates are expanded to include land transfer, inheritance, and mortgaging (Xu and Jiang 2009). 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). By 2007, 14 provinces had begun implementation of the reform. In June 2008, the State Forestry Administration (SFA) indicated that tenure reform of collective forests is a top priority with the release of "the CPC Central Committee State Council advice on promoting a comprehensive Tenure Reform for Collective Forest" (FAO 2010).

Fujian has been a leader in the recent forest tenure reform even though during the reforms of the 1980s Fujian resisted and did not fully participate. During the 1980s, Fujian had implemented a shareholding system to keep forest under collective management while distributing "paper shares" of collective forests and had only distributed 32% of the collective forest land for household management. Under this system by the late 1990s, two issues became increasingly evident. First, forestry's contribution to rural economy was negligible despite the fact that forest land occupies more than 60% of the total provincial land area. Second, enforcing forest conservation had become increasingly difficult for local forest authorities due to lack of cooperation from farmers. For example, forest fires grew in the 1990s, many of which were said to be caused by farmers (Xu and Jiang 2009). These problems led Fujian to take a leadership role in implementing the recent forest tenure reforms in 2003. Fujian is an ideal setting to test our hypotheses due to the early implementation of the reform and the extent of the reform in the province.

3 Theoretical Framework

In this section, we construct a simple model of optimal forest management under uncertainty, taking account of risk preference, time preference, and risk over property rights of forests. The model motivates our empirical approach because the comparative statics are difficult to sign without further specific assumptions.

Consider a forest owner with reference dependent preferences who maximizes the present value of utility from harvest, with discount factor, ρ. We collapse the inter-temporal problem into a two-period problem, where only the second period is discounted. In the first period, the forest has size, *C*, and the owner can harvest, $c_1 \in [0, C]$. The forest owner can also make a risky investment, *I*, that enhances the returns of the forest in the second period, but only in some states of nature. Namely, if the second period is a high state, she receives $c_2^H = C - c_1 + b \cdot I$, where $b > 0$ is a constant marginal return on investment, and she receives no return in a low state, so $c_2^L = C - c_1$. The high state occurs with probability, p^H, and the low state occurs with probability p^L, where $p^H + p^L = 1$. However, the forest owner faces risk of expropriation, where ownership rights would be taken away with probability p^0 and she loses both the residual harvest and the proceeds of her investment, receiving a payoff of zero.

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 loss are large or small (Kahneman and Tversky 1979). Under prospect theory, an individual's risk preferences are described by three measures: the degree of risk aversion, σ, the degree of loss aversion, λ, and a nonlinear probability weighting function, π. We use these three measures to represent each household's risk preferences in the empirical analysis that follows.

Following theory, we assume the forest owner's expected prospect value of a random payoff, *X*, is given by:

$$U(X) = \sum_{x_i} \pi(p_i) \cdot v(x_i)$$

where $p_i = p(x_i)$ are the state probabilities, *v* is a standard, power value function, and π is the nonlinear probability weighting function. These functions are given by:

$$v(x) = \begin{cases} (x-r)^{(1-\sigma)} & x \geq r \\ -\lambda(r-x)^{(1-\sigma)} & x < r \end{cases}$$

$$\pi(p) = \exp\left(-(-\ln p)^{\alpha}\right).$$

The standard features of this specification are the kink in the value function at the reference point, *r*, where the forest owner switches from risk averse to risk loving, and the loss aversion parameter, λ. The parameter σ describes the curvature of an individual's value function: for values above the reference point, $\sigma \in (0,1)$ implies risk aversion, $\sigma = 0$ implies risk neutrality, and $\sigma < 0$ implies risk loving. The parameter α induces a non-linear weighting measure on the state probabilities, which is extended from Prelec (1998). When $\alpha > 0$, $\pi(p)$ has an inverted S-shape, indicating that an individual tends to overweight low probabilities and underweight high probabilities as in Tversky and Kahneman (1992).

Choosing the reference point, *r*, can be easy or challenging depending on the setting. In our first stage estimation of household preferences, the reference point is clearly $r = 0$, with losses below zero and gains above. However, in any inter-temporal model, the reference point for future periods will be based on expectations, and these expectations will be a function both of the owner's own actions and of the distorted probability weights. For internal consistency in our model, we model the reference point as $r = E_{\pi}[X]$, which is shorthand for the weighted sum over pseudo-probabilities, π_i; $E_{\pi}[X]$ is not a true expectation because $\pi(p)$ is not a probability measure – the state weights do not sum to one. The interest reader may consult Koszegi and Rabin (2009) for an overview of dynamic considerations with reference dependent preferences, though their paper focuses much more closely on how and when information arrives than the present article.

Returning to the forest management problem, the owner's objective is to maximize the value of consumption in period 1, and the expectation of discounted value in period 2, subject to her preferences. The objective function is given by:

$$\max_{c_1, I} U = v^{+}\left(c_1 - I\right) + \rho \cdot \left(\pi^{0} \cdot v^{-}\left(-r\right) + \pi^{L} \cdot v\left(c_2^{L} - r\right) + \pi^{H} \cdot v^{+}\left(c_2^{H} - r\right)\right)$$

where $v^{+}(\ )$ and $v^{-}(\ )$ denote the value function for arguments above and below the reference point, respectively, and the low state's value function has no superscript because it may be a gain or loss. We use the shorthand, $\pi^{0} = \pi\left(p^{0}\right)$, $\pi^{L} = \pi\left(\left(1 - p^{0}\right) \cdot p^{L}\right)$, and $\pi^{H} = \pi\left(\left(1 - p^{0}\right) \cdot p^{H}\right)$, where we assume the realization of a high or low state in period 2 is independent of the probability of expropriation. The reference point is $r = \pi^{L} \cdot c_2^{L} + \pi^{H} \cdot c_2^{H}$. We assume zero non-forest wealth in the initial period, and assume the investment, *I*, is constrained to $I \leq c_1$.

The first order necessary conditions for an interior solution are given by:

$$\frac{\partial U}{\partial c_1} \approx \frac{\partial v^{+}\left(c_1 - I\right)}{\partial x} + \rho \pi^{0} \cdot \left(\left(1 - \pi^{0}\right) \cdot \frac{\partial v^{-}\left(-r\right)}{\partial x} - \pi^{L} \cdot \frac{\partial v\left(c_2^{L} - r\right)}{\partial x} - \pi^{H} \cdot \frac{\partial v^{+}\left(c_2^{H} - r\right)}{\partial x} \right) = 0$$

$$\frac{\partial U}{\partial I} = -\frac{\partial v^{+}\left(c_1 - I\right)}{\partial x} + \rho b \pi^{H} \cdot \left(\left(1 - \pi^{H}\right) \frac{\partial v^{+}\left(c_2^{H} - r\right)}{\partial x} - \pi^{0} \cdot \frac{\partial v^{-}\left(-r\right)}{\partial x} - \pi^{L} \cdot \frac{\partial v\left(c_2^{L} - r\right)}{\partial x} \right) = 0$$

where the first partial with respect to c_1 is approximated using $\pi^{L} + \pi^{H} \approx 1 - \pi^{0}$, and we omit the constraints on c_1 and I for brevity. The first order conditions show direct tradeoffs between certain consumption early versus risky consumption later, while making explicit the role of choices in adjusting expectations (with partial effects on –*r* throughout). The effects on expectations cushion the loss of later harvest due to early consumption in the first period, and investment activities must overcome the increased expectations that they cause. *Thus, relative to risk averse harvesters under expected utility, we expect loss averse harvesters to harvest more early and invest less in the future.*

The first order necessary conditions are not sufficient for an optimum, as the objective function is not concave in the initial harvest choice, c_1 , without many further assumptions. Even under our relatively simple specification, the second order conditions cannot be signed without loss of generality. However, we are able to make testable predictions in terms of the *direct effects* (the marginal effects of parameters on the first order conditions), in the sense that empirically observing result with the same sign means these direct effects dominate indirect effects from the other chice variable.

For example, $\partial U / \partial c_1$ is decreasing in the discount factor, ρ, so we expect more initial consumption by harvesters with higher discount rates (that is, $\partial^2 U / \partial c_1 \partial \rho < 0$). The converse holds for the marginal investment: $\partial^2 U / \partial I \partial \rho > 0$. Forest certification and reforms serve to *decrease* π^0, the perceived probability of expropriation in the second period. Ignoring spillover effects on the other state probabilities, we observe that $\partial^2 U / \partial c_1 \partial \pi^0 < 0$ and the same for *I*, so the direct effect of these programs should be to encourage early harvest and investment simultaneously. While these effects do not constitute comparative statics predictions, we can nonetheless test empirically to see if they dominate. We do exactly that in the coming sections.

4 Data, Definitions, and Descriptive Statistics

Our study area includes two counties in Fujian, China—Datian County in central Fujian and Sanming City in the west. Forest land covers more than 60% of the provincial land area, and is a growing source of income for households living in rural forested areas. Based on a larger survey of 600 households in Fujian, forestry accounted for 8.98% of household income in 2006, a 3.71% share increase since prior to the reform in 2000 (Xu et al. 2010). Other income sources include agriculture (1.28%), livestock (9.21%), off-farm (65.14%), and other (6.36%). In our study area and in rural China in general, credit markets are missing or incomplete at best, and most households have limited access to formal loans (Ong 2012).

Household survey

The household panel data set includes 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). Data for the years 2000 and 2005 were collected in 2006 by a research team from Peking University, Gothenburg University, and Forest Trends, and data for year 2008 was collected in 2009 by researchers from Peking University and the University of Rhode Island. Table I provides a description of the survey instruments implemented and the sample in each year of data collection. During the 2009 data collection, 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 to complete the survey plus their earning in the decision-making tasks.[2]

For 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. The resulting sample includes 197 plots, owned by 69 households.

Table II provides sample means of the household and plot characteristics. In 2000, an average household had 4.9 household members; a head of household, who was 46 years old and 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. 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 197 plots in our balanced panel data set had forest certificates. By the year 2005, 36 of these plots had received forest certificates and 69 plots by the year 2008.

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. 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 the total annual value of family, exchanged, and hired labor used for each activity. The annual expenditure on hired labor is calculated from the survey data on the number of working days and the wage paid per working day for hired labor. For the annual value of family and exchanged labor, we take the total number of working days of family and exchanged labor for each forest management activity and multiply the total by the average county wage paid to hired forest labor based on our survey data. We 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 III). Likewise, the expenditure on forest inputs increased from 466 to 1,010 yuan per hectare from 2000 to 2008. From 2000 to 2005, labor used for harvesting forest products increased from 148 to 525 yuan per hectare, and then decreased slightly 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 their 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 IV). 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.

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 (2013), both of whom expand the classic Accept/Reject lottery experiments of Holt and Laury (2002) to incorporate prospect 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 loss are large or small (Kahneman and Tversky 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 weight measure. We use these three parameters to represent each household's risk preferences in our empirical analysis.

We use cumulative prospect theory and a non-linear probability weighting measure extended from the one-parameter form of Prelec's (1998) axiomatically-derived weighting function (Kahneman and Tversky 1979). Following Liu (2013), we assume a utility function of the following form:

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

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

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

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. 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 curvature of an individual's value function above zero relative to the curvature of the value function below zero is described by the parameter λ. The higher the value of λ, the more loss averse an 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 *π(p).* When α <1, π(p) has an inverted S-shape, indicating that an individual tends to overweight low probabilities and underweight high probabilities (Tversky and Kahneman 1992). This model reduces to expected utility theory when α = 1 and λ=1.

In the experiment, participants were asked to choose between sets of lottery options. For example, Appendix figure 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 month's pay in rural China (CSY 2009). Monotonic switching was enforced, meaning that once the subject switched to option B they were not allowed to switch back to option A. 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. 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, implying 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 households in the sample exhibit risk aversion.[4] The average payoff in the risk experiment was 27 yuan, which is roughly half a single days wage in rural Fujian in 2008 (CSY 2009).

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.

Time Preference Data

Our time preference experiment design follows methods originally developed by Coller and Williams (1999) and Harrison et al. (2002), and allows for the estimation of 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. 2010; 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 related 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.

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 People's 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 (see appendix table 2 for complete payoff matrix). A single series of questions is depicted in appendix figure 2. 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 plan, Plan B, increased as the subject moved down the column from 25 yuan to 125 yuan, at 1/6 increments of the future payoff. Monotonic switching within each series was 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.

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. 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 the amount of the payoff 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 V compares the aggregate results of the discount rate estimates. Estimating the full model with unrestricted θ gives a relatively high value of θ=5.16, which is similar to Tanaka et al.'s (2010) estimate of θ=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 use the parameter estimates from the hyperbolic model to represent the time preference of each household in our empirical 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.

5 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. A simple comparison of changes in forest management between plots that received and did not receive certification demonstrates that there is a correlation between certification and forest management (table IV). However, it would clearly be a mistake to jump from this association to the conclusion that certification impacts forest management because certification plots were not selected randomly. This nonrandom placement of certification could bias the results.

There are some indications that the bias may not be large in our context. As with other forest policies in China in which participation is often exogenous to the household's decision (e.g., Li et al. (2011)), the decision to be part of the property rights reform and the start date was decided at the village level and implemented through the traditional small groups (xiaozu). In addition, comparison of plot and household characteristics between the two groups of plots demonstrates that they are similar in many respects, including plot area, distance from plot to home or the closest road, and the slope of the plot (table II).

However, there could be some self selection bias. A larger proportion of the noncertified plots grow bamboo compared to certified plots, and this difference is statistically significant (table II). If we do not account for these and other potentially systematic differences between certified and noncertified plots, 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 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).

There is also a concern for inconsistency of the coefficients on the risk and time preference variables due to measurement error. These variables are predicted for each household using the data from the field experiments as described in the previous section. It is possible that factors such as the individual player's ability to play the field experiments could lead to a discrepancy—measurement error—between the observed measures and true values of time and risk preference variables. An implication of this problem is attenuation bias of the estimated coefficients of these variables in OLS. Moreover, the more collinear the observed measurements are with other explanatory variables, the worse is the attenuation bias (Wooldridge 2010). We will address the measurement error issue in our identification strategy.

Identification Strategy

We employ a two-step strategy to account for the non-random placement of certification and the bias due to measurement error in the time and risk preference variables. 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.) The purpose of this preprocessing is to reduce estimator bias caused by potential self-selection of households into forest plot certification based on observed characteristics (Ho et al. 2007a; 2007b). 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 use 1-to-1 nearest neighbor matching with a logistic regression based propensity score (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"). The propensity score is the true probability of forest plot *i* receiving a forest certificate, given the covariates X_i, $e(X_i) = p(T_i=1 | X_i)$. The propensity score is estimated via a logistic regression of Ti on a constant term and X_i (without regard to Y_i), where T_i is equal to 1 if a household has received a forest certificate for the plot. We match based on 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). Control observations that are not matched are discarded. This reduced our sample to 197 to 134 plots. Following Ho et al. (2007a; 2007b), we selected the matching method that produced the best balance. Balance refers to how close the covariate distributions are between the treated and control plots. Balance statistics are summarized in appendix table 8. We find that matching improved the balance for each covariate except distance from plot to home. The overall distance in the mean propensity score between the treated and control was reduced. 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, we use the preprocessed matched data in a difference-in-differences (DD) model. Using DDs allows us to compare the before-after changes in forest management activities on those plots for which households received a forest certificate to the before-after changes in forest management activities on those plots that households did not receive a forest certificate. Specifically we apply the pre-processed data to a general DD framework for more than two periods:

$$y_{ijgt} = \lambda_t + \alpha_g + X_{gt}\varphi + (X_{gt} * RT_j)\delta + RT_j\omega + Z_{ijt}\gamma + u_{ijgt} \quad (1)$$

where y_{ijgt} refers to the three forest management variables: (i) the value of labor used for applying inputs (*input labor*$_{ijgt}$); (ii) expenditure on forest inputs (*inputs*$_{ijgt}$); and (iii) the value of labor used for harvesting (*harvest labor*$_{ijgt}$) on forest plot *i* managed by household *j* in treatment group *g* at time *t.* All forest management variables are measured in yuan per hectare at the plot level. λ_t is a set of time effects for 2005 and 2008, α_g is the forest certificate effect which is a dummy variable that is equal to one if household *j* had a forest certificate for forest plot *i* in any year, $X_{gt}*RT_j$ is a set of interaction terms between the tenure reform treatment and the risk and time preferences for household *j*, Z_{ijt} are plot-specific covariates, and u_{ijgt} is plot-specific error term. In some models we also control for household-specific covariates, village fixed effects and the interaction between time and village fixed effects. We are interested in the forest certification effect (φ), the coefficients on the interaction term between the forest certificate and the time and risk preferences (δ) and the coefficients on time and risk preferences (ω). Table II provides the sample means of the household and plot characteristics controlled for in the regression models.[5] For a better fit, we estimate a log transformation of equation (1).

The main advantage of the DD model is that it allows us to control for unobservable heterogeneity in plot and household characteristics that may lead to selection bias. Moreover, it addresses the potential inconsistency caused by the measurement errors in the time and risk preference variables. The DD accounts for measurement error to the extent that the unobserved heterogeneity that explains the measurement error is time invariant. This assumption is reasonable since we are measuring time and risk preferences at one point in time.

6 Empirical Results

Overall the DD estimates indicate that although the total implied certification effect is insignificant, risk and time preferences do impact the certification effects on households' forest management (tables VI, VII and VIII).[6] Our first finding is that the impact of forest certification on forest management is insignificant. Having an insignificant coefficient does not mean zero impact; it means that the variation is large, and hence the treatment effect on the treated on average is negligible. If the effect is truly zero impact, we would have an estimate close to zero with statistical significance. When we allow for interaction of the preference parameters with the forest certification treatment variable we do see variation in behavior according to risk and time preferences. These findings are consistent across alternative specifications.[7] In this section, we examine the empirical results for each of the three dependent variables. We focus our interpretation on the heterogeneous certification effects attributable to households' degree of risk and loss aversion and time preference estimated in the full DD model, which includes the full set of plot and household covariates, village fixed effects, time fixed effects and the interaction between time and village fixed effects (column 5).

Impact on labor used for harvesting forest products

The estimates indicate that the more risk averse a household is, the more value of labor used for harvesting forest products (table VI, column 5, row 2). To interpret the coefficient, recall that risk aversion ranges from -1 to 1, and both the risk aversion and the value of labor used for forest harvesting variables are logged in the model. Hence, the coefficient of 0.95 indicates that a one percent increase in risk aversion, holding other control variables constant, corresponds to an increase in value of labor by approximately 0.95%. The degree of loss aversion, tendency to place excessive weight on small probabilities or time preference do not affect the amount of labor for harvesting forest products (rows 3, 4 and 5).

Interestingly, when we allow the certification effect to vary with households' risk and time preferences, we find that the effect of certification on the value of labor allocated to harvest is negative for households that are more risk averse and positive for those households that are more loss averse (rows 6 and 7). Specifically, the interaction term between *ln(risk)* and *Reform* is -1.53%, 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 15% less. And the coefficient on the interaction term between *ln(loss aversion)* and *Reform* is 1.59%, 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 16% 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.

Finally, the implied certification effect on value of labor used for harvesting forest products is negative but statistically insignificant (row 11). When we evaluate the certification effect at the median values of the time and risk preferences parameters as well as other variables in the model, the implied total certification effect on labor for harvesting is -2.91% but is only statistically significant only at 14% .[10]

Impact on expenditure and value of labor used for applying forest inputs

The DD estimates indicate that the more risk averse the household is, the lower the value of labor used for applying forest inputs (table VII, column 5, row 2). More precisely, a 10 percent increase in the risk aversion parameter corresponds to a decrease in the value of labor for applying inputs of 6.5%. Likewise, we find evidence that more risk averse households also spend less expenditure on forest inputs (table VII, column 5, row 2). When we allow the certification effect to vary with households' risk and time preferences, we find that the certification effect did not vary with households' degree of risk or loss aversion.

The certification effects on both value of labor and expenditure for inputs are negative for households who indicated higher discount rates (tables VII and VIII, row 9). Specifically, we a household with a time preference parameter that is 10% higher (stronger preference for income today) has a forest certification effect on labor for applying inputs and expenditure on forest inputs that is 7.6% and 9.9% lower but in the full DD model is statistically significant only at 16% and 13%, respectively. Finally, the implied certification effect on both the value of labor used for applying inputs and the expenditure on forest inputs were statistically insignificant (tables VII and VIII, row 11).

Implied certification effect

We next investigate the question of whether or not the implied certification effect was heterogeneous depending on the degrees of risk aversion and time preference. This question brings us back to the primary motivating question of this paper, i.e., whether or not strengthening property rights have different impacts on households' forest management behavior depending on their preferences. We test the impact heterogeneity by evaluating the implied certification for the 10th percentile and the 90th percentile of the sample distribution of the estimated time and risk preference variables, changing one variable at a time.

We find weak evidence that the implied certification effect differs depending on household's risk preferences (table IX). When evaluating the effect at the median of all variables, we found that certification led to a decrease in labor for harvesting (-2.91) but this coefficient was not statistically significant at the 10% level (t-statistic = 1.45). However, when we evaluate the effect for a household who is more risk averse (at the 90th percentile of the sample distribution), the certification effect was negative and even larger (-3.59), and statistically significant at the 10% level (t column 1, row 1). In contrast, the effect for a household at the 10th percentile of the risk aversion variable was smaller in magnitude and insignificant (row 2). When evaluating the effect for a household with a high degree of loss aversion (90th percentile), the certification effect is negligible (row 3); however, when evaluated at the 10th percentile, the effect is negative (-6.70) and statistically significant (row 4). In contrast, the implied certification effect is insignificant for the other preference parameter, percentile, and forest management variable combinations. We therefore conclude that we have only found weak evidence that impact heterogeneity exists.

Robustness Checks

To check the robustness of our results, we run three additional variations of the DD equation (1). 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 10 and 11). Second, we estimate the model using the exponential time discounting parameter instead of the hyperbolic time discounting parameter (appendix tables 12, 13 and 14). 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, $Reform_{ijt}$, that takes the value one when household i has a forest certificate for plot j in a post-reform year (appendix tables 15, 16 and 17). We find that the results are robust to these alternative specifications with two exceptions. The first exception is that when we estimate the model for the expenditure on forest inputs using the exponential time discounting parameter instead of the hyperbolic time discounting parameter, 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 significant at the 10% level rather than at the 13% level (appendix table 14, column 5, row 9). The second expectation is that when we estimate the model for the value of labor used for harvesting using the number of years since the household received a forest certificate for a plot rather than the dummy variable, the coefficient on the tendency of a household to place excessive weight on small probabilities becomes significant at the 10% level rather than at the 15% level (appendix table 16, column 5, row 8).

7 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 forest 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 using risk and time preference data from a field experiment and a panel household survey data set from Fujian, China.We first constructed a simple model of optimal forest management under uncertainty, taking account of risk preferences as described in prospect theory, time preference, and risk over property rights of forests. While the effects derived in the model did not constitute comparative statics predictions, we tested empirically to see if they dominate. To empirically identify how risk and time preferences augment the effect of forest plot certification on forest management activities, we used a two-step approach. In the first step, we preprocessed the data using matching methods. We then used that preprocessed data in a DD framework in order to obtain more robust estimates of the 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 or 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 harvests.

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. 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.

Additionally, we used preference parameters that are derived from field experiments that occur after the households' forest management experience and those households' preferences may have been shaped by certification and other experiences. Unfortunately, we have no way of testing this with our current data. At best we can look to the existing literature to see what evidence there is for the intertemporal stability of time and risk preferences. Frederick et al. (2002) wrote a critical review of the existing time preference literature in which they note that "no longitudinal studies have been conducted to permit any conclusions about the temporal stability of time preferences". Since that time to our knowledge there have been two studies that begin to address this gap. Andersen et al. (2008) find stable risk preferences in a sample of 97

Danes over a period of 17 months, while Meier and Sprenger's (2010) study of 250 individuals in Massachusetts find that although some subjects show variation in their time preference in one year's time, individual level correlations over time were strongly significant and the mean change in the individual discount factor and present-bias parameter was small. Furthermore, Meier and Sprenger (2010) investigate potential sources of variation and find that changes in income, unemployment, family composition or future liquidity cannot be used to predict the differences in time preferences, nor was there correlation between demographics and preference instability. Several studies have explored the intertemporal stability of risk preferences and found that there is no tendency for risk preferences to systematically increase or decrease over time and those measures taken at two different periods of time show acceptable correlations (Harrison et al. 2005; Sahm 2007; Andersen et al. 2008; Baucells and Villasis 2009; Reynaud and Couture 2012). We therefore, believe that our use of these parameters in both time periods is justified, however we caution the reader of this potential bias.

Overall 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.

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Table I. Survey Description

Year of Data Collection	Survey Instruments Implemented	Sample Description
2006	• Household survey for the years 2000 (recall) and 2005	• 10 counties in Fujian, China • Three townships per county, two villages per township, 10 households per village • A total of 600 households were interviewed
2009	• Household survey for the year 2008 • Time preference experiment • Risk preference experiment	• Targeted 120 households who were part of the 2006 sample in two counties • 104 of the 120 households were located and completed the household survey • 103 households completed the time and risk preference experiments

Table II. Cross-sectional, pre-reform comparison of the sample means (2000)

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	
Household Characteristics				
Age of head of household (years)	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 (hectares)	2.30	2.07	2.74	1.121
Plot Characteristics				
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 degrees)	0.71	0.73	0.67	0.877

Source: Authors' data.

Table III. Forest management variables descriptive statistics by year

Variable	Year	Mean (yuan/ha)	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

Note: 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). 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 a household having a certificate on forest management with the changes in forest management on plots with the earlier type of "forest certificate."

Source: Authors' data.

Table IV. 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 (yuan/ha)	166	116	0.295	
Value of labor for applying inputs (yuan/ha)	447	560	0.720	
Expenditure on forest inputs (yuan/ha)	283	807	1.520	
Between 2000 and 2008:				
Δ Value of labor for harvesting forest (yuan/ha)	558	-61	1.686	***
Δ Value of labor for applying inputs (yuan/ha)	4605	2599	3.111	*
Δ Expenditure on forest inputs (yuan/ha)	425	762	1.018	

Notes: t-statistic 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 V. Comparison of exponential, hyperbolic, quasi-hyperbolic and full discounting models

Parameter	Description	Exponential		Hyperbolic		Quasi-hyperbolic		Full model	
μ	Noise parameter	0.010	***	0.012	***	0.015	***	0.015	***
		(0.001)		(0.001)		(0.001)		(0.001)	
r	Time discounting parameter	0.009	***	0.018	***	0.002	***	0.006	
		(0.001)		(0.002)		(0.000)		(0.005)	
β	Present-bias	β=1		β=1		0.573	***	0.601	***
						(0.032)		(0.039)	
θ	Hyperbolicity of the discount function	θ=1		θ=2		θ=1		5.162	
								(3.514)	
Observations		3090		3090		3090		3090	
Adjusted R^2		0.510		0.512		0.517		0.517	

Note: *, ** and *** denote significant at the 10%, 5% and 1% level, respectively. See appendix for specification of the full model. Robust standard errors are in parentheses.

Source: Authors' data.

Table VI. 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)	(5)
Reform	-2.091	-2.255	-0.682	-2.175	-2.67
	(1.03)	(1.28)	(0.24)	(1.04)	(1.03)
ln(risk aversion)		0.729	0.445	0.969	0.95
		(2.92)***	(4.94)***	(4.07)***	(4.15)***
ln(loss aversion)		-0.062	-0.96	-0.449	-0.492
		(0.12)	(2.31)**	(0.86)	(0.94)
probability weighting dummy		2.36	4.482	2.649	2.382
		(2.03)**	(2.63)**	(1.76)*	(1.46)
ln(time preference)		0.101	-0.058	0.112	0.133
		(0.54)	(0.18)	(0.55)	(0.61)
*ln(risk aversion)*Reform*			-1.126	-1.374	-1.530
			(3.90)***	(11.70)***	(7.72)***
*ln(loss aversion)*Reform*			1.119	1.336	1.597
			(1.99)*	(3.67)***	(3.43)***
*probability weighting dummy*Reform*			-2.638	-2.031	-1.688
			(1.02)	(1.11)	(0.83)
*ln(time preference)*Reform*			-0.05	0.025	0.111
			(0.11)	(0.08)	(0.26)
Constant	-9.624		-11.991	-5.304	-7.573
	(8.07)***		(6.22)***	(0.56)	(0.90)
Implied certification effect	-2.091	-2.255	-1.712	-2.643	-2.905
	(1.03)	(1.28)	(0.90)	(1.50)	(1.45)
N	414	414	414	414	414
R^2	0.03	0.37	0.09	0.40	0.43
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

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

Source: Authors' data.

Table VII. 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)	(5)
Reform	0.117	0.369	-7.809	-7.773	-8.085
	(0.06)	(0.20)	(2.29)**	(2.51)**	(2.94)***
ln(risk aversion)		-0.685	-0.673	-0.719	-0.647
		(3.78)***	(10.38)***	(4.41)***	(3.72)***
ln(loss aversion)		0.013	0.150	0.001	-0.113
		(0.03)	(0.39)	(0.00)	(0.24)
probability weighting dummy		0.589	-1.300	-1.147	-1.372
		(0.26)	(0.69)	(0.59)	(0.71)
ln(time preference)		-0.266	-0.046	-0.086	-0.166
		(1.37)	(0.28)	(0.34)	(0.63)
*ln(risk aversion)*Reform*			0.571	0.555	0.327
			(2.72)***	(2.19)**	(1.12)
*ln(loss aversion)*Reform*			-0.431	-0.356	0.223
			(0.57)	(0.44)	(0.31)
*probability weighting dummy*Reform*			6.015	6.915	6.816
			(1.57)	(1.92)*	(2.03)**
*ln(time preference)*Reform*			-1.206	-0.943	-0.757
			(2.68)***	(1.68)*	(1.43)
Constant	-11.417	-5.36	-11.359	0.944	-1.69
	(15.49)***	-0.48	(5.97)***	(0.10)	(0.17)
Implied certification effect	0.117	0.369	2.900	2.741	2.047
	(0.06)	(0.20)	(1.42)	(1.14)	(0.95)
N	414	414	414	414	414
R^2	0.32	0.40	0.38	0.42	0.48
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Note: Same notes as table VI.

Source: Authors' data.

Table VIII. 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)	(5)
Reform	-1.380	0.661	-7.651	-6.708	-6.053
	(0.50)	(0.23)	(1.85)*	(1.78)*	(1.23)
ln(risk aversion)		-1.045	-0.430	-0.999	-0.92
		(5.09)***	(3.44)***	(5.13)***	(5.08)***
ln(loss aversion)		-0.830	-0.313	-0.735	-0.856
		(1.92)*	(0.46)	(1.23)	(1.45)
probability weighting dummy		2.266	0.208	1.390	1.19
		(1.63)	(0.09)	(0.85)	(0.67)
ln(time preference)		0.026	0.262	0.287	0.183
		(0.11)	(0.89)	(0.84)	(0.54)
*ln(risk aversion)*Reform*			-0.122	-0.010	-0.31
			(0.42)	(0.03)	(1.09)
*ln(loss aversion)*Reform*			-0.878	-0.887	0.003
			(0.77)	(0.79)	(0.00)
*probability weighting dummy*Reform*			2.575	3.925	4.123
			(0.54)	(0.90)	(0.77)
*ln(time preference)*Reform*			-1.468	-1.376	-0.989
			(2.46)**	(2.06)**	(1.54)
Constant	-9.783	-37.127	-8.794	-29.73	-28.024
	(8.15)***	(2.15)**	(3.26)**	(1.73)*	(1.61)
Implied certification effect	-1.38	0.661	0.812	2.635	2.578
	(0.50)	(0.23)	(0.25)	(0.80)	(0.82)
N	414	414	414	414	414
R^2	0.05	0.24	0.11	0.26	0.31
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Note: Same notes as table VI.

Source: Authors' data.

Table IX. Implied certification effect for alternative values for risk and time preference variables

Preference Parameter	Percentile	Percent change in the forest management a household		
		Value of labor for harvesting	Value of labor for applying inputs	Value of expenditure for inputs
Risk aversion	90th	-3.59 (1.78)*	2.19 (1.01)	2.44 (0.76)
	10th	-2.02 (1.02)	1.86 (0.87)	2.75 (0.89)
Loss aversion	90th	0.40 (0.18)	2.51 (1.06)	2.58 (0.80)
	10th	-6.70 (3.01)***	1.52 (0.50)	2.57 (0.58)
Time preference	90th	-2.50 (1.18)	-0.73 (0.44)	-1.05 (0.50)
	10th	-3.07 (1.35)	3.16 (1.15)	4.03 (1.03)
Median		-2.91 (1.45)	2.05 (0.95)	2.58 (0.82)

Note: The implied certification effects for the 10th and 90th percentiles of the risk and time preference variables were evaluated using the median of all variables in model (5) in Tables VII, VIII, and IX. The 90th percentile values for *ln(risk aversion), ln(loss aversion),* and *ln(time preference)* are -0.077, 2.782, and -0.725, respectively. The 10th percentile values are -1.099, -1.661, and 5.861, respectively. Please refer to notes for Table VII for the median values of the variables. The units for each forest management variable is yuan per hectare.

Appendix

Risk preference parameter estimation

Appendix table 2 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 month's 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. (2013) 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 (appendix table 2) note that at first, the first column (Option A) dominates the second column (Option B) in terms of expected payoff and variance in the payoff, but eventually, as the value of the high outcome in the second column increases, the expected value of the second column starts to dominate (appendix table 2). 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 averse, 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:

$$5^{(1-\sigma)} + \exp[-(-\ln .3)^{\alpha}]\,(20^{(1-\sigma)} - 5^{(1-\sigma)}) > 2.5^{(1-\sigma)} + \exp[-(-\ln .1)^{\alpha}]\,(62.5^{(1-\sigma)} - 2.5^{(1-\sigma)})$$

$$5^{(1-\sigma)} + \exp[-(-\ln .3)^{\alpha}]\,(20^{(1-\sigma)} - 5^{(1-\sigma)}) > 2.5^{(1-\sigma)} + \exp[-(-\ln .1)^{\alpha}]\,(75^{(1-\sigma)} - 2.5^{(1-\sigma)})$$

$$15^{(1-\sigma)} + \exp[-(-\ln .9)^{\alpha}]\,(20^{(1-\sigma)} - 15^{(1-\sigma)}) > 2.5^{(1-\sigma)} + \exp[-(-\ln .7)^{\alpha}]\,(32.5^{(1-\sigma)} - 2.5^{(1-\sigma)})$$

$$15^{(1-\sigma)} + \exp[-(-\ln .9)^{\alpha}]\,(20^{(1-\sigma)} - 15^{(1-\sigma)}) > 2.5^{(1-\sigma)} + \exp[-(-\ln .7)^{\alpha}]\,(34^{(1-\sigma)} - 2.5^{(1-\sigma)})$$

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). Midpoints 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 midpoint as the estimate of λ for use in regression models.

Appendix tables 3, 4, and 5 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 3, 4, and 5, 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

Our time preference experiment design follows methods originally developed by Coller and Williams (1999) and Harrison et al. (2002). 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 behavioral 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

For our time preference experiment, we use a general model proposed by Benhabib et al. (20), which allows us to test exponential, hyperbolic, quasi-hyperbolic, and a more general form. Benhabib et al.'s (2010) model assigns a value of reward y at time t according to yD(y,t) where:

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

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 β=1 and θ=1. When β=1 and θ=2, the model reduces to hyperbolic discounting. When θ=1 and β is free the model reduces to quasi-hyperbolic discounting. When θ >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:

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

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 appendix table 6.

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 Figure 1. Example of risk preference experiment choice

	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	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

Appendix Figure 2. 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.

Appendix Table 1. Summary of forest tenure reform events in China and Fujian Province

Year(s)	**China**	**Fujian**
1981	First major wave of tenure reforms aimed at transferring responsibility of forest planting and management from the collective to households as part of the State Councils "Resolution on Issues Concerning Forest Protection and Development", also known as the "Three Fixes".	Instead of fully implementing the first tenure reforms, the provincial government implements a shareholding system to keep forests under collective management. The shareholding system involved distributing "paper shares" of collective forests based on family population.
Mid 1980s	Nearly 70% of collectively owned forest land had been transferred to household management.	Only 32% of collectively owned forest land had been transferred to household management.
1987	The occurrence of unsustainable logging and widespread observed deforestation in some provinces in south China provokes the government to return a large portion of forest land under household management back to collective management.	
Late 1990s		Two issues become apparent: • Forest land occupies more than 60% of the total provincial land area but forestry's contribution to rural economy is negligible • Enforcing forest conservation had become increasingly difficult for local forest authorities due to lack of cooperation of farmers (e.g., the severity of forest fires grew over the 1990s)
Early 2000s	Constrained forest tenure rights are increasingly recognized as a main impediment to sustainable forest management, increased timber production, and poverty alleviation (Xu et al. 2010).	
2003	State Forestry Administration encourages provinces to implement forest tenure reform, and by mid-2003the central government devises the "Resolution on the Development of Forestry" (the "No. 9 Policy"). The new forest tenure reforms provide an explicit national-level policy framework that encourages collective forest rights to be reallocated to households under the following conditions: 1) Decisions regarding forest land reallocation should be made by village representative	Provincial government of Fujian formally approved the tenure reform, and begins delegating collectively owned forest land to direct household management secured with forest certificates.

	committees or by village assemblies requiring a 2/3 vote majority 2) Redistribution of plots will be accompanied by legal contracts and forest certificates 3) Allowable contract period is extended to 30 to 70 years, whereas previously contract periods had only been 5 to 15 years (Liu and Lixia 2009) 4) Adoption of Rural Land Contract Law enabled expanded rights, including land transfer, inheritance and mortgaging	
Mid-2006		Claimed that 99% of the villages completed their reforms towards household forest manage
By end of 2007	14 provinces have initiated forest tenure reforms	
June 2008	The State Forestry Administration (SFA) releases the document of "the CPC Central Committee State Council advice on promoting a comprehensive Tenure Reform for Collective Forest" indicating that tenure reform for collective forests is a top priority for the SFA (FAO 2010)	

Source: Unless otherwise noted, this timeline is a summary of the history of recent forest tenure reform as described in Xu and Jiang (2009).

Appendix Table 2. Payoff matrix for risk experiment

Series 1	Option A		Option B		Expected payoff difference (A-B)
Probability	*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					
Probability	*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.

Appendix Table 2 [continued]. Payoff matrix for risk experiment

Series 3	Option A		Option B		Expected payoff difference (A-B)
Probability	*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.

Appendix Table 3. 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 4. 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 5. Switching point (question) in Series 3 and the approximation of λ (loss aversion parameter)

	σ=0.55		σ=0.60		σ=0.65		σ=0.70		σ=0.75	
λ	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound
1	-∞	0.36	-∞	0.35	-∞	0.34	-∞	0.33	-∞	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 midpoints for estimation, a value of 0 was used in place of -∞ and a value of 18 was used in place of + ∞.

Appendix Table 6. Discounting choices

	Option A		Option B	
Question	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 6 [continued]. Discounting choices

	Option A		Option B	
Question	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 7. Variable descriptions

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

Appendix Table 8. Summary of balance statistics

	Before matching (full sample)			After matching		
	Plots for which households receive a forest certificate	Plots for which households do not receive a forest certificate	Mean Difference	Plots for which households receive a forest certificate	Plots for which households do not receive a forest certificate	Mean Difference
Age of head of household	46.91	45.84	1.07	46.91	47.09	-0.17
Household head education (years)	4.94	4.54	0.4	4.94	5.22	-0.28
Total area of households forest land (ha)	2.73	2.07	0.67	2.73	2.92	-0.19
Distance from plot to home (km)	1.43	1.43	0.01	1.43	1.28	0.16
Distance from plot to road (km)	0.83	0.90	-0.07	0.83	0.86	-0.03
Slope of plot (=1 if gradient is > 25')	0.67	0.72	-0.06	0.67	0.71	-0.04
Bamboo (=1 if bamboo)	0.39	0.59	-0.20	0.39	0.43	-0.04
Overall distance in propensity score	0.38	0.33	0.05	0.38	0.37	0.01
N	128	69		69	69	

Source: Authors' data.

Appendix Table 9. The effect of forest plot certification on forest management

Dependent Variable:	*ln(harvest labor)*	*ln(input labor)*	*ln(inputs)*
Fcert	0.135	0.347	-2.925
	(0.11)	(0.23)	(1.30)
year2005	-2.289	-2.837	0.327
	(0.94)	(0.86)	(0.12)
year2008	7.583	18.315	-0.119
	(1.10)	(5.31)***	(0.05)
Reform	-2.67	-8.085	-6.053
	(1.03)	(2.94)***	(1.23)
ln(risk aversion)	0.95	-0.647	-0.92
	(4.15)***	(3.72)***	(5.08)***
ln(loss aversion)	-0.492	-0.113	-0.856
	(0.94)	(0.24)	(1.45)
probability weighting dummy	2.382	-1.372	1.19
	(1.46)	(0.71)	(0.67)
ln(time preference)	0.133	-0.166	0.183
	(0.61)	(0.63)	(0.54)
*ln(risk aversion)*Reform*	-1.53	0.327	-0.31
	(7.72)***	(1.12)	(1.09)
*ln(loss aversion)*Reform*	1.597	0.223	0.003
	(3.43)***	(0.31)	0.00
*probability weighting dummy*Reform*	-1.688	6.816	4.123
	(0.83)	(2.03)**	(0.77)
*ln(time preference)*Reform*	0.111	-0.757	-0.989
	(0.26)	(1.43)	(1.54)
ln(agehead)	-2.174	-2.692	3.922
	(0.89)	(1.13)	(0.93)
ln(yreduchead)	-0.279	-0.155	0.112
	(1.59)	(1.10)	(0.76)
ln(num5and59age)	-0.098	0.026	0.092
	(0.85)	(0.20)	(0.53)
ln(assets)	0.183	0.224	0.018
	(0.91)	(0.85)	(0.08)
ln(hhtotalarea)	-0.323	-0.155	-0.486
	(0.67)	(0.28)	(0.87)
Hhnewplot	0.402	-0.489	-1.05
	(0.34)	(0.24)	(0.60)

Table continued on the next page.

Appendix Table 9 [Continued]. The effect of forest plot certification on forest management

Variable	*ln(harvest labor)*	*ln(input labor)*	*ln(inputs)*
Lnarea	0.96	0.536	0.516
	(2.80)***	(0.95)	(1.10)
lndisthome	-0.031	-0.001	-0.398
	(0.11)	0.00	(0.81)
lndistroad	0.088	0.13	-0.06
	(0.72)	(0.86)	(0.33)
slope25over	1.285	1.126	-0.216
	(1.39)	(1.01)	(0.15)
bamboo	6.818	0.696	0.011
	(5.97)***	(0.59)	(0.01)
Constant	-7.573	-1.69	-28.024
	(0.79)	(0.17)	(1.61)
Implied certification effect	-2.905	2.047	2.578
	(1.45)	(0.95)	(0.82)
N	414	414	414
R^2	0.43	0.48	0.31

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

Source: Authors' data.

Appendix Table 10. 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)	(5)
Reform	-1.598	-1.753	-0.428	-1.702	-2.105
	(0.97)	(1.23)	(0.18)	(1.00)	(1.00)
ln(risk aversion)		0.590	0.361	0.780	0.764
		(2.97)***	(4.89)***	(4.10)***	(4.15)***
ln(loss aversion)		0.056	-0.770	-0.361	-0.393
		(0.13)	(2.29)**	(0.86)	(0.92)
probability weighting dummy		1.913	3.605	2.124	1.912
		(2.02)**	(2.59)**	(1.74)*	(1.44)
ln(time preference)		0.089	-0.050	0.095	0.112
		(0.58)	(0.19)	(0.57)	(0.62)
*ln(risk aversion)*Reform*			-0.888	-1.093	-1.204
			(3.83)***	(11.27)***	(7.50)***
*ln(loss aversion)*Reform*			0.907	1.06	1.256
			(2.01)**	(3.62)***	(3.38)***
*probability weighting dummy*Reform*			-2.068	-1.548	-1.277
			(0.99)	(1.05)	(0.79)
*ln(time preference)*Reform*			-0.019	0.032	0.098
			(0.05)	(0.12)	(0.28)
Constant	-10.336	-7.897	-12.257	-6.743	-8.558
	(10.48)***	(1.09)	(7.80)***	(0.89)	(1.10)
Implied certification effect	-1.598	-1.753	-1.300	-2.063	-2.285
	(0.97)	(1.23)	(0.83)	(1.45)	(1.40)
N	414	414	414	414	414
R^2	0.03	0.37	0.09	0.40	0.43
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Note: Difference-in-differences regressions. Absolute value of t-statistic is in parentheses. Robust standard errors account for sample clustering. Plots with missing data excluded. Implied certification effects evaluated at the median *ln(risk aversion)*= -0.523, *ln(time preferance)* = -4.394, *ln(loss aversion)* = 0.713, and *probweightdum*=1. Household characteristic control variables include*: ln(risk), ln(loss), ln(probweight), ln(r_hyp), ln(agehead), ln(hhtotarea), hhnewplot, ln(num5and59age)*, and ln(assets). Forest characteristic control variables include: *fcert, ln(area), ln(disthome), ln(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 11. 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)	(5)
Reform	0.117	0.259	-6.470	-6.559	-6.865
	(0.08)	(0.17)	(2.28)**	(2.60)**	(3.06)***
ln(risk aversion)		-0.559	-0.549	-0.585	-0.528
		(3.72)***	(10.11)***	(4.31)***	(3.61)***
ln(loss aversion)		0.008	0.138	-0.019	-0.107
		(0.02)	(0.43)	(0.05)	(0.27)
probability weighting dummy		0.358	-1.211	-1.066	-1.244
		(0.19)	(0.77)	(0.65)	(0.77)
ln(time preference)		-0.234	-0.044	-0.080	-0.14
		(1.45)	(0.32)	(0.39)	(0.64)
*ln(risk aversion)*Reform*			0.473	0.461	0.281
			(2.85)***	(2.28)**	(1.17)
*ln(loss aversion)*Reform*			-0.32	-0.244	0.200
			(0.52)	(0.37)	(0.33)
*probability weighting dummy*Reform*			4.908	5.671	5.592
			(1.54)	(1.93)*	(2.04)**
*ln(time preference)*Reform*			-1.011	-0.811	-0.672
			(2.74)***	(1.78)*	(1.56)
Constant	-11.806	-7.135	-11.686	-1.76	-3.835
	(19.20)***	(0.78)	(7.33)***	(0.21)	(0.45)
Implied certification effect	0.117	0.259	2.404	2.261	1.674
	(0.06)	(0.17)	(1.45)	(1.17)	(0.96)
N	414	414	414	414	414
R^2	0.32	0.39	0.37	0.41	0.47
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Note: Same notes as appendix table 10.
Source: Authors' data.

Appendix Table 12. 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)	(5)
Reform	-2.091	-2.274	-0.653	-2.015	-2.500
	(1.03)	(1.30)	(0.24)	(0.99)	(0.99)
ln(risk aversion)		0.726	0.449	0.961	0.94
		(2.92)***	(4.94)***	(4.09)***	(4.18)***
ln(loss aversion)		-0.055	-0.975	-0.429	0.467
		(0.11)	(2.35)**	(0.84)	(0.90)
probability weighting dummy		2.361	4.494	2.648	2.377
		(2.03)**	(2.63)**	(1.76)*	(1.45)
ln(exponential discounting parameter)		0.127	-0.030	0.124	0.148
		(0.69)	(0.09)	(0.61)	(0.68)
*ln(risk aversion)*Reform*			-1.126	-1.37	-1.531
			(3.90)***	(12.15)***	(7.71)***
*ln(loss aversion)*Reform*			1.114	1.319	1.585
			(2.04)**	(3.70)***	(3.39)***
*probability weighting dummy*Reform*			-2.638	-2.044	-1.714
			(1.02)	(1.10)	(0.84)
*ln(exponential discounting parameter)*Reform*			-0.048	-2.044	0.200
			(0.09)	(1.10)	(0.41)
Constant	-9.624	-6.741	-11.837	-5.554	-7.953
	(8.07)***	(0.74)	(6.42)***	(0.59)	(0.84)
Implied certification effect	-2.091	-2.274	-1.721	-2.744	-3.068
	(1.03)	(1.30)	(0.86)	(1.50)	(1.46)
N	414	414	414	414	414
R^2	0.03	0.37	0.09	0.40	0.43
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Note: Same notes as appendix table 10.
Source: Authors' data.

Appendix Table 13. 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)	(5)
Reform	0.117	0.363	-7.861	-8.076	-8.248
	(0.06)	(0.19)	(2.38)**	(2.75)***	(3.13)***
ln(risk aversion)		-0.674	-0.671	-0.704	-0.633
		(3.76)***	(10.41)***	(4.37)***	(3.66)***
ln(loss aversion)		-0.023	0.142	-0.035	-0.148
		(0.06)	(0.38)	(0.08)	(0.33)
probability weighting dummy		0.604	-1.297	-1.133	-1.357
		(0.27)	(0.69)	(0.58)	(0.70)
ln(exponential discounting parameter)		-0.245	-0.035	-0.052	-0.147
		(1.20)	(0.21)	(0.20)	(0.52)
*ln(risk aversion)*Reform*			0.588	0.562	0.336
			(2.76)***	(2.23)**	(1.15)
*ln(loss aversion)*Reform*			-0.481	-0.378	0.194
			(0.64)	(0.48)	(0.27)
*probability weighting dummy*Reform*			6.112	7.042	6.924
			(1.63)	(2.00)*	(2.09)**
*ln(exponential discounting parameter)*Reform*			-1.469	-1.222	-0.961
			(2.83)***	(1.96)*	(1.61)
Constant	-11.417	-4.754	-11.270	1.955	-0.871
	(15.49)***	(0.43)	(6.06)***	(0.19)	(0.09)
Implied certification effect	0.117	0.363	2.582	2.548	2.41
	(0.06)	(0.19)	(1.33)	(1.14)	(1.08)
N	414	414	414	414	414
R^2	0.32	0.40	0.38	0.42	0.48
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Notes: Same notes as appendix table 10.
Source: Authors' data.

Appendix Table 14. 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)	(5)
Reform	-1.380	0.649	-7.836	-6.752	-6.182
	(0.50)	(0.23)	(1.97)*	(1.85)*	(1.29)
ln(risk aversion)		-1.046	-0.433	-1.001	-0.919
		(5.06)***	(3.53)***	(5.12)***	(5.02)***
ln(loss aversion)		-0.831	-0.291	-0.715	-0.848
		(1.96)*	(0.44)	(1.20)	(1.45)
probability weighting dummy		2.268	0.213	1.403	1.212
		(1.64)	(0.09)	(0.86)	(0.68)
ln(time preference - exponential discounting parameter)		0.044	0.283	0.314	0.206
		(0.17)	(0.91)	(0.84)	(0.56)
*ln(risk aversion)*Reform*			-0.106	0.016	-0.29
			(0.37)	(0.05)	(1.01)
*ln(loss aversion)*Reform*			-0.929	-0.96	-0.052
			(0.82)	(0.84)	(0.05)
*probability weighting dummy*Reform*			2.66	4.047	4.205
			(0.58)	(0.95)	(0.80)
*ln(time preference – exponential discounting parameter)*Reform*			-1.833	-1.664	-1.243
			(2.67)**	(2.19)**	(1.72)*
Constant	-9.783	-37.028	-8.894	-29.541	-27.787
	(8.15)***	(2.15)**	(3.45)**	(1.73)*	(1.61)
Implied certification effect	-1.38	0.649	0.436	2.246	3.026
	(0.50)	(0.23)	(0.14)	(0.72)	(0.93)
N	414	414	414	414	414
R^2	0.05	0.24	0.11	0.26	0.31
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Notes: Same notes as appendix table 10.
Source: Authors' data.

Appendix Table 15. 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)	(5)
YearsPostFC	-0.874	-0.912	-0.213	-0.484	-0.747
	(1.57)	(1.75)*	(0.32)	(0.85)	(1.23)
ln(risk aversion)		0.759	0.44	0.962	0.935
		(2.92)***	(4.91)***	(3.85)***	(3.78)***
ln(loss aversion)		-0.131	-0.891	-0.455	-0.47
		(0.25)	(2.32)**	(0.84)	(0.85)
probability weighting dummy		2.259	4.520	2.945	2.727
		(2.17)**	(2.99)***	(2.27)**	(1.98)*
ln(time preference)		0.120	-0.071	0.135	0.167
		(0.64)	(0.23)	(0.66)	(0.77)
ln(risk aversion) YearsPostFC*			-0.398	-0.506	-0.556
			(3.38)***	(8.57)***	(7.46)***
ln(loss aversion) YearsPostFC*			0.234	0.351	0.387
			(1.56)	(2.75)***	(2.57)**
probability weighting dummy YearsPostFC*			-0.802	-0.763	-0.632
			(1.59)	(1.64)	(1.26)
*ln(time preference)*YearsPostFC*			0.06	0.029	0.054
			(0.53)	(0.24)	(0.34)
Constant	-9.702	-5.869	-12.314	-4.126	-6.087
	(8.04)***	(0.66)	(6.61)***	(0.44)	(0.63)
Implied certification effect	-0.874	-0.912	-0.905	-0.860	-1.050
	(1.57)	(1.75)*	(1.47)	(1.34)	(1.59)
N	414	414	414	414	414
R^2	0.04	0.37	0.09	0.40	0.43
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Note: Same notes as appendix table 10.
Source: Authors' data.

Appendix Table 16. 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)	(5)
YearsPostFC	-0.331	-0.460	-3.057	-3.214	-3.565
	(0.51)	(0.73)	(2.48)**	(2.72)***	(3.14)***
ln(risk aversion)		-0.657	-0.66	-0.662	-0.612
		(3.55)***	(9.55)	(3.73)***	(3.59)***
ln(loss aversion)		0.015	0.074	-0.109	-0.170
		(0.04)	(0.19)	(0.23)	(0.38)
probability weighting dummy		0.492	-1.261	-0.852	-1.474
		(0.23)	(0.71)	(0.46)	(0.84)
ln(time preference)		-0.24	-0.07	-0.064	-0.181
		(1.23)	(0.42)	(0.26)	(0.71)
ln(risk aversion) YearsPostFC*			0.206	0.199	0.131
			(2.51)**	(1.87)*	(1.01)
ln(loss aversion) YearsPostFC*			-0.038	0.061	0.212
			(0.17)	(0.23)	(0.98)
probability weighting dummy YearsPostFC*			2.121	2.180	2.774
			(1.86)*	(2.03)**	(2.63)**
*ln(time preference)*YearsPostFC*			-0.407	-0.353	-0.176
			(1.85)*	(1.41)	(0.78)
Constant	-11.664	-4.732	-11.617	1.837	-2.233
	(15.64)***	(0.42)	(6.25)***	(0.17)	(0.21)
Implied certification effect	-0.331	-0.460	0.717	0.456	0.064
	(0.51)	(0.73)	(0.88	(0.50)	(0.08)
N	414	414	414	414	414
R^2	0.32	0.40	0.38	0.42	0.49
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Notes: Same notes as appendix table 10.
Source: Authors' data.

Appendix Table 17. 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)	(5)
YearsPostFC	-0.630	-0.145	-3.08	-2.56	-2.477
	(0.86)	(0.21)	(2.08)**	(1.73)*	(1.50)
ln(risk aversion)		-1.032	-0.422	-0.976	-0.907
		(5.01)***	(3.48)***	(4.94)***	(4.92)***
ln(loss aversion)		-0.817	-0.468	-0.831	-0.937
		(1.83)*	(0.76)	(1.48)	(1.67)
probability weighting dummy		2.17	-0.006	1.284	0.891
		(1.56)	(0.00)	(0.77)	(0.52)
ln(time preference)		0.04	0.227	0.25	0.126
		(0.16)	(0.83)	(0.75)	(0.39)
*ln(risk aversion)*YearsPostFC*			-0.026	0.015	-0.095
			(0.28)	(0.11)	(1.08)
*ln(loss aversion)*YearsPostFC*			-0.172	-0.098	0.200
			(0.58)	(0.33)	(0.76)
*probability weighting dummy*YearsPostFC*			1.239	1.422	1.875
			(0.86)	(1.05)	(1.15)
*ln(time preference)*YearsPostFC*			-0.478	-0.420	-0.230
			(1.86)*	(1.43)	(0.97)
Constant	-9.872	-36.868	-8.74	-29.90	-28.932
	(8.12)***	(2.18)**	(3.37)***	(1.71)*	(1.68)*
Implied certification effect	-0.630	-0.145	0.150	0.628	0.600
	(0.86)	(0.21)	(0.15)	(0.62)	(0.65)
N	414	414	414	414	414
R^2	0.05	0.24	0.10	0.25	0.31
Household characteristics	No	Yes	No	Yes	Yes
Plot characteristics	No	Yes	No	Yes	Yes
Village fixed effect	No	Yes	No	Yes	Yes
Time*village fixed effect	No	No	No	No	Yes

Notes: Same notes as appendix table 10.
Source: Authors' data.

[1] Most households in our sample participate in income generating activities other than forestry such as farming and off-farm work, which would be potential investment channels for profits gained by harvesting forest in period. While this manuscript focuses on the effects of the reform on forest management, Sullivan (2011) examines the impact of forest certification on different measures of wealth and finds weak evidence that reform led to an increase in revenues from bamboo and non-timber forest products but no impact on other forest sources of wealth. The study is available from the author upon request.

[2] Hagos and Holden (2006) elicited risk and time preferences from households using hypothetical questions. 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.

[3] Appendix table 1 summarizes the key changes in China and Fujian Province's forest tenure policies since the 1950s.

[4] For comparison, values estimated here for σ and α are very similar to those found by Liu (2013) in a sample of Chinese farmers and by Tanaka et al. (2010) in a sample of Vietnamese farmers. Additionally, our parameter value of 0.42 is within the range of constant relative risk

aversion measured in choose lottery experiment conducted in developing countries, which range from 0.17 in Uganda to 0.84 in India (Cardenas and Carpenter 2008). For loss aversion, the value for λ is approximately twice as much as the values in Liu (2013) and Tanaka et al. (2010), indicating that our sample exhibits on average a higher degree of loss aversion.

[5] Appendix table 7 provides a description of each variable used in the analysis.

[6] Tables VII, VIII and IX summarize results for the variables of interest. Appendix table 9 shows results with coefficients for all plot and household level control variables for the full models (column 5 in tables VII, VIII and IX).

[7] We also estimated the model for the full sample (without pre-processing the data using matching techniques). Estimate results from the full sample were consistent with results from using the restricted pre-processed sample. Results using the full model are available from the authors upon request.

[10] 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).