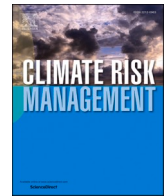


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High discount rates by private actors undermine climate change adaptation policies

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ABSTRACT

Adaptation requires investing now to avoid future damages, and thus adaptation is shaped by discount rates. Although the role of social discount rates in climate policy design has been well documented, the role of private discount rates has been ignored. We illustrate the importance of private discount rates in shaping adaptation investments by empirically demonstrating how household discount rates are negatively correlated with investments in water storage tanks in Central America. High private discount rates are common throughout the world and are a barrier to private adaptation investments. To overcome this barrier, adaptation policies targeted at private actors should ensure that benefits accrue sooner or that costs are lowered or accrue later. Governments or private companies could also offer long-term loans that exploit the differential between the discount rate of the lender and the private borrower.

1. Introduction

One of the biggest hurdles to encouraging citizens and businesses to invest in adaptation to climate change is the high discount rates among these private actors. We would thus expect a lot of the adaptation literature to focus on this challenge and how to overcome it. However *private* discount rates — in contrast to *social* discount rates — have not been sufficiently examined in the adaptation literature, and their policy implications (see Box 1) are commonly overlooked.

For example, IPCC adaptation reports starting in 1990 focus on *social* discount rates, whereas *private* discount rates have been mentioned only once in 6 assessment cycles: in the Fifth Assessment Report in 2014, where “high individual discount rate” is listed as a barrier to adopting adaptation options (see pg. 1407, Reisinger et al., 2014; IPCC, 2022). This limited attention to the crucial role of private discount rates can also be seen in the adaptation policy literature more broadly, including recent Green Climate Fund reports (see Krüger and Puri, 2020).

Empirically estimating the discount rates of individuals and households is challenging. Researchers have spent decades using experimental and observational data to estimate individual discount rates. The estimated rates are highly heterogeneous, even among experimental studies, which are believed to have higher internal validity than observational studies (Matousek, Havranek & Irsova,

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2022; Percoco & Nijkamp, 2009). Moreover, in experimental studies in low- and middle-income countries, the median reported annual discount rate is particularly high: 79% (Matousek et al., 2020). If this value was to accurately reflect the discount rates of individuals living in low and middle-income nations, most private adaptation investments would simply not be made: the only adaptation investments considered worthwhile by individuals would be those that are practically free.

Private adaptation investments are especially relevant in low and middle-income countries, whose citizens will be hit the hardest by climate change and whose governments are least capable of taking preventive adaptation measures on behalf of their citizens (Stern, 2007). Thus, in the design of adaptation policies and programs, the discount rates of private actors can be as relevant as the social discount rates of their governments.

We illustrate the importance of private discount rates in shaping adaptation investments by empirically demonstrating how household discount rates are negatively correlated with investments in water storage tanks in Central America. In water-scarce regions of the world, water storage tanks are prominent examples of private investments that can help households adapt to increasing water stress. Households without private storage tanks are directly exposed to water supply disruptions and may incur additional costs from having to purchase bottled drinking water. Water tanks are expensive investments that yield benefits for at least ten years, and thus the decision to invest in them will be shaped by the rate at which a household trades off costs now for benefits in the future; i.e., the discount rate. The higher the discount rate, the lower the expected investment in water storage tanks. We observe this relationship in our study population, and we explore the implications of high private discount rates in low-income and middle-income nations for the design of adaptation policies.

2. Methods

The field study took place in the driest area of Costa Rica, where climate simulations project a decrease in water availability. Surveys were conducted in 82 randomly chosen communities, 252 individuals were surveyed. We conducted one experimental session per community. Participants completed two tasks. The first task elicited time preferences and is the subject of this paper. The second task elicited risk preferences, which are only used in this study to adjust for the curvature of the participants' utility functions. For the time preferences task, we use a Multiple Price List design (MPL) with six tables. In each table, we had eight choices between a sooner payment of approx. US\$15 — roughly the daily minimum wage of a Costa Rican worker with a high school degree — and a later and higher payment. To obtain the discount rates, we estimate a structural model of the discounting and risk choices using a Maximum Likelihood Joint Estimation (Andersen et al., 2014). Full methodological details are provided in the Appendix.

3. Results

In our sample, 84% of the participants reported that the decision to invest in water tanks was a decision made by the couple jointly. The other 16% reported that the decision was made by the husband.

In our sample, households that discounted future benefits more heavily were less likely to have purchased a water tank (Fig. 1). The correlation between couples' discount rates and their past decisions to purchase a water tank is negative and statistically significant at the 5% level. Couples that invested in water tanks had an average annual discount rate that was 31 percentage points lower than couples that had not invested in tanks, a large difference.

Box 1 Key Policy Highlights

- i. The *social* discount rates used in the adaptation literature — with values ranging from 3 to 10% (IPCC, 2022) — contrast with much higher *private* discount rates —17 to 48% in our study and even higher in other studies. This difference implies that adaptation investments that are highly profitable from a social perspective may be ignored by private actors.
- ii. While there is a shared responsibility between public and private actors on climate change adaptation action, realizing a vision of shared responsibility is far more challenging than has been recognized in the climate adaptation literature, especially in low and middle-income nations where adaptation investment needs are greatest. Higher discount rates among private actors imply that adaptation policies based exclusively on education and persuasion are unlikely to succeed in encouraging private investments in adaptation.
- iii. To avoid the barrier of high individual discount rates, adaptation policies targeted at private actors should ensure that the benefits from adaptation accrue sooner to private actors or that the costs of adaptation are lower or accrue later.
- iv. Using a discount rate based on market rates, a business might have an incentive to serve as an intermediary that installs the technologies in consumers' homes in return for a share of the financial savings on the consumer. Governments or private companies could also offer long-term loans that exploit the differential between the discount rate of the lender and the borrower.

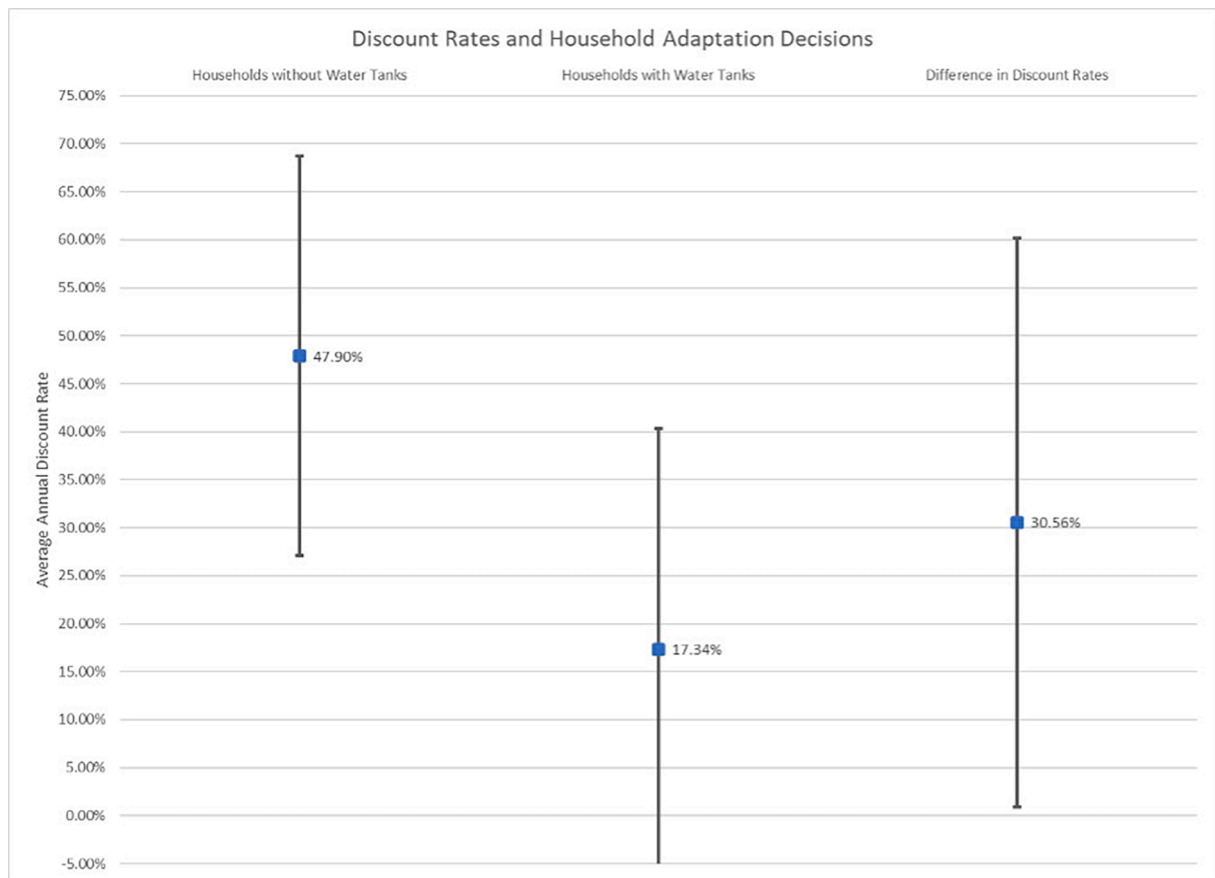


Fig. 1. Households who invest in private adaptation have much lower annual discount rates than other households, on average. Whisker lines represent 95% confidence intervals. The estimated discount rates are based on 98 households without tanks (7643 decision observations) and 25 households with tanks (1950 decision observations).

4. Discussion

The high private discount rates in our study population, and in low- and middle-income country populations more generally (Matousek et al., 2020), contrast with the much lower social discount rates used in the adaptation literature. As reported in the IPCC AR6 WGII, these social discount rates range from 3 to 10% (IPCC, 2022). The large difference between the social discount rate and the private discount rate means that adaptation investments that are highly profitable from a social perspective may be ignored if left solely to the initiative of households. To encourage more widespread adoption of adaptation options, a government may therefore consider a subsidy, adjusted to citizens' time preferences (Cremades et al., 2015).

While there is a shared responsibility between public and private actors on climate change adaptation action, realizing a vision of shared responsibility is far more challenging than has been recognized in the climate adaptation literature, especially in low and middle-income nations where adaptation investment needs are greatest.

Moving forward will require concerted efforts to innovate in ways that consider differences in discount rates among private actors. Businesses, for instance, have higher discount rates than governments but lower rates than households (Matousek, Havranek & Irsova, 2022; Möller & Priestley, 2021; Fujii & Karp, 2008). Using a discount rate based on market rates, a business might thus have an incentive to serve as an intermediary that installs the technologies in consumers' homes in return for a share of the financial savings on the consumers' water bills. Governments, private companies, or public-private partnerships could also offer long-term loans that exploit the differential between the discount rate of the lender and the borrower.

In the specific case of water tanks, for example, water utilities could offer to install tanks with no upfront payment by the users, and then recover the investment with payments added to the average monthly water bill for a pre-established number of years, preferably with higher payments accruing later in the recovery period. This kind of interest rate arbitrage is very similar to how leases and loans for the installation of household photovoltaic equipment work (Qiu et al., 2014).

We do recognize that the behavioral failure associated with high individual discount rates is compounded with capital constraints and limited access to capital. Because investment on new technology and climate change adaptation in general is the result of a combination of multiple factors beyond the crucial influence of high discount rates, more research is needed not only to understand the

underlying drivers of high discount rates, but also to explore how they interact with other important factors like access to capital, education, institutions, and economic development.

5. Conclusion

To be successful, adaptation policies and programs targeted at private actors must be designed to do at least one of two things: they need to either ensure that the benefits from adaptation accrue sooner to private actors or that the costs of adaptation are lower or accrue later. High discount rates among private actors imply that adaptation policies and programs that aim to encourage private investments in adaptation only via education and persuasion are unlikely to succeed.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data and code needed to reproduce Figure 1 are available at <https://osf.io/kvcfj/>.

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Appendix. Full methodological details

Study context

The field study took place in the driest area of Costa Rica, which covers the provinces of Guanacaste and part of Puntarenas, close to the border with Nicaragua. The experiment was part of a larger Canadian government-funded research project on climate change adaptation and water scarcity in Central America. Since 2014, the area has been experiencing high temperatures and drought associated with a very strong El Niño-Southern Oscillation. Moreover, climate modelers in the project have projected that water availability in this area (like most of Central America) will decline by more than 20% in 2050 (Imbach et al., 2015).

Around 85% of the communities in these provinces use groundwater, which is pumped to homes via a community system of pipes. In about half of the communities, water is managed by the Costa Rican Water Agency "Instituto Costarricense de Acueductos y Alcantarillados" (AyA). The other communities manage their own water systems through community-based water management organizations (CBWMO). In almost all the cases, each CBWMO serves one community.

As part of the larger climate adaptation project, surveys were conducted in 82 communities that met three conditions: 1) they belonged to the first decile of driest communities in Costa Rica, 2) their water supply came from one or more community wells, and 3) their water supply was managed by a CBWMO. Out of the 82 communities, we selected 30 to participate in our experimental sessions the following year. These communities satisfied the following criteria: 1) they had the lowest number of hours per day with water availability according to household survey; 2) their community leaders were willing to provide a sheltered location for the experimental session; and 3) at least 25 participants in the household survey expressed an interest in participating in the experimental sessions. Within these selected communities, the local organization in charge of water provision sent, on behalf of the field team, an invitation to a water-related activity to households in the communities. Sample selection bias was not considered a major threat given that communities in study region are very homogeneous in terms of socio-economic characteristics that may shape responses to participate in a water-related event that would involve participant payment. Income, for example, is in general low and not too different among households. Nevertheless, to mitigate potential sample selection bias, the invitation provided no information about the size of potential participant payments. That information was only provided after describing the decisions that participants would be asked to make, and the field team observed no attrition after this description and information was shared.

A year after the household survey, our field team phoned couples that were married or living together (both members of the couple) and single heads of households to invite them to participate in the workshops. For this analysis, we only use the data from the 126 couples that participated (252 individuals). In another study, we use the data from 210 individuals that came alone to the session (Bernedo Del Carpio et al., 2021).

Experimental procedures

We conducted one experimental session per community. Following CBWMO committee recommendations, we conducted most sessions in the community schools after workhours. Since the elicitation design had payments that could be made the next morning or four days after the session, and banks were closed during the weekend, all sessions took place from Sunday to Thursday.

Upon arriving, every participant received a unique identification (ID) number, and every couple also received a unique couple-ID.

Once registered, we divided couples sequentially into both sides of the session room (block A and block B).

Using paper and pencil, our participants completed two tasks. The first task elicited time preferences and is the subject of this paper. The second task elicited risk preferences, which are only used in this study to adjust for the curvature of the participants' utility functions. All participants solve these tasks individually and in couples. To avoid order effects, participants in block A completed the tasks in couples first, while participants in block B started with the individual tasks.

For the discounting task, we use a Multiple Price List design (MPL) with six tables. In each table, we had eight choices between a sooner payment (€ 8 000, or ~ US\$15) and a later and higher payment. The payment of € 8 000 was approximately the official daily minimum wage of a Costa Rican worker with a high school degree in 2013 (€ 8 619). The six tables corresponded to six different time horizons: 3 days, 1 week, 2 weeks, 1 month, 3 months and 6 months. To control for the horizon order, half of the communities were selected randomly to see the horizons in ascending order while the other half saw them in descending order.

We randomly divided the communities in two groups so that one received a one-month Front-End-Delay (FED) and in the other received a next-morning FED (i.e., people could withdraw the money from the bank the morning after the session). We used bank transfers for both payments to make the payments comparable in terms of transaction costs and participants' confidence that the payments would be made.

All the participants received a participation fee of € 5 000 and the payment from one randomly chosen decision from among the decisions they made in the session (participants were aware of this design feature). The participation fee was paid in cash on site.

After people completed the tasks, we conducted a survey. Water storage tanks are typically made of plastic, with capacities commonly ranging from 1-2 m³, and an installed cost of about USD \$300 per m³ of capacity. In our survey, 20% of the households reported having a water tank. We asked them whether the decision to purchase the tank was taken by the couple jointly or by one of them as individuals. In 84% of the cases, the decision was reported to be taken by the couple.

Statistics

To obtain the discount rates of couples, we estimate a structural model of the discounting and risk choices using a Maximum Likelihood Joint Estimation (Andersen et al., 2014; Andersen et al., 2008). Following the literature on discount rates, we use the discounted utility model where consumers discount the utility of money (Samuelson, 1937). We use the risk choices to model the shape of the utility function. We compare different discounting functions and find that the exponential discounting function best fits the data. As a robustness check, we estimate the correlation between discount rates and tank ownership with alternative models and reach the same conclusions regarding the sign and statistical significance of the correlation (see analysis code).

To test for the correlation between water tank investment and the experimentally elicited discount rate estimate, we assume a functional form for the discount parameter, namely $\delta_i = d_i + \alpha_i \cdot \text{Tanks}$; where d_i is the annual discount rate without a water tank and $d_i + \alpha_i$ is the discount rate with a water tank.

While the values elicited in experimental contexts may not correlate with naturally occurring behaviors that theoretically should be influenced by these preferences (Carvalho et al., 2016; Cardenas & Carpenter, 2013; Voors et al., 2012; Cassar et al., 2007), we address this concern by eliciting discount rates for decisions made jointly by couples in a drought-prone area of Central America, and estimating the correlation between those estimated discount rates and a real adaptation decision.

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