Natural Hazards And Risk Aversion:

Experimental Evidence From Latin America

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Abstract

We use experimental and survey data from two natural-hazard prone countries in Latin America to test the hypothesis that natural hazards affect risk aversion. We use two methods to measure risk aversion: simple questions on the willingness to pay for a hypothetical lottery and more complicated experiments involving real pay-offs. We find that whereas the experiments provide reasonable estimates of risk aversion, the hypothetical questions result in unrealistic distributions of preferences. The experimental results strongly support the hypothesis that experiencing natural shocks makes people more risk averse, not only in the short run but also in the medium and long run.

Keywords: Latin America, Nicaragua, Peru, risk aversion, natural hazards, experiments

1. Introduction

Over the past decades, the number of natural disasters and their impact has been increasing. Munich Re estimates that global economic losses between 1992 and 2002 were more than seven times greater than during the 1960s (UNDP, 2008). Climate change will lead to an even further increase of damages in the near future. Many areas will most likely experience more intense precipitation events, resulting in increased flood, landslide, avalanche and mudslide damage and increased soil erosion (IPCC Working Group 1, 2001). While the effect of global warming on hurricane numbers and tracks is unclear, hurricane intensity and rainfall are expected to increase, resulting in a higher destructive potential and a substantial increase in losses (Emanuel, 2005; Trenberth, 2005). Similarly, droughts and floods associated with El Niño events are likely to become more intense (IPCC Working Group 1, 2001). These extreme weather events will hit hardest those who are least able to cope: 85 percent of the people exposed to earthquakes, tropical cyclones, floods and droughts live in countries having either medium or low levels of human development (UNDP, 2008), and natural catastrophes caused losses equal to 13.4% of the gross domestic product (GDP) in developing countries, as compared with only 2.5% in industrialized countries between 1985 and 1999 (Munich Re, 2006).

In developing countries, risk and poverty are intimately linked. A substantial share of poverty is so-called transient poverty, *i.e.* at any point in time a group of people is poor purely due to 'bad luck' combined with the inability to cope with this downward risk (Dercon and Krishnan, 2000; Dercon, 2003; Jalan and Ravallion, 2000; McCulloch and Baulch, 2000; Ravallion, 1988). In addition, risk may keep poor people poor. Risk management and coping are costly, especially so for poor people with limited access to financial and insurance markets. While wealthy households may be able to cope with fluctuations in income through (dis)savings, poor households in volatile environments will need to adopt a defensive portfolio strategy to smooth income and assets. They will diversify or skew towards low-risk low-return alternatives that avoid destitution but at the same time inhibit income growth and investment (Carter and Barrett, 2006; Dercon, 1998; 2002; Morduch, 1995; Ravallion, 1988; Rosenzweig and Binswanger, 1993; Zimmerman and Carter, 2003).

Depending on asset endowments and access to markets and institutions, risk may thus perpetuate poverty. Whether it does so depends at least partly on individual risk attitudes. The more risk-averse persons are, the more they will be inclined to forego income for stability. Economists mostly see this risk aversion as a relatively stable, innate characteristic, affected mostly by gender, wealth and age. There is, however, evidence of a more dynamic nature of risk aversion. Past experience in previous games of the same experiment appeared to affect preferences: persons who had consistently won had a greater tendency to chose a more risk-seeking alternative (Binswanger, 1980). This path-dependence of risk attitudes supposedly not only holds for games in a single experiment, but also for choices made in real life: psychologists have shown that hazard experience makes people more worried and fearful (Cutchin *et al.*, 2008; Weinstein, 1989), and that worry leads to more risk-averse choices (Lerner and Keltner, 2001;

Raghunathan and Pham, 1999). If natural hazards indeed affect preferences, they not only affect livelihoods directly by lowering income and destroying assets, but also indirectly through increasing the degree of risk aversion, thereby lowering the speed of recovery or even inhibiting recovery altogether. We, however, have not found a study that directly tests for the effect of natural shocks on risk aversion.

In the present paper we test the hypothesis that the occurrence and intensity of natural shocks affect household risk attitudes. We consider two experimental methods to measure risk aversion: hypothetical questions on the willingness to pay for a simple lottery and lottery games with real pay-offs. Section 2 presents a review of the economic and psychological literature on the measurement and determinants of risk attitudes with a specific focus on the role of natural hazards. Section 3 introduces the case study areas and survey households. We collected data in two risk-prone countries in Latin America: Nicaragua and Peru. In both countries, we did comparable risk experiments among smallholder farmers, who were included in an extensive survey covering questions about the past occurrence of shocks. The exact set-up of the experiments and the derivation of a measure of risk aversion are presented in Section 4. Section 5 and 6 present the descriptive statistics and the main findings, and section 7 concludes.

2. Risk attitudes: Measurement and determinants

2.1. Lotteries as indicators of risk attitude

Considerable research has attempted to estimate risk attitudes econometrically using data from actual behaviour (e.g.,Antle, 1989; Bar-Shira *et al.*, 1997; Cohen and Einav, 2007). This approach has, however, been criticized for confounding risk behaviour with the other behaviour determinants mentioned above: resource constraints and risk perceptions (Eswaran and Kotwal, 1990; Lybbert and Just, 2007). Isolating the differential effects of these factors from behavioural data is especially a problem for developing countries where markets a highly imperfect and production and consumption decisions are, therefore non-separable (De Janvry *et al.*, 1991; Singh *et al.*, 1986).

Alternatively, risk attitudes can be assessed using an experimental approach (Binswanger, 1980; Wik *et al.*, 2004). This approach involves hypothetical questions regarding risk alternatives or risky games with or without real payments. It has the advantage that probabilities are given and therefore risk attitudes and perceived probabilities are not confounded. Several studies have compared different methods. Binswanger (1980) finds that estimated risk attitudes had a severe investigator bias when based on choices between hypothetical but realistic farm alternatives and not when based on gambling experiments. Pennings and Smidts (2000) compared two risk measures: one based on lotteries and expected utility theory; and one using a psychometric approach based on Likert statements. They found that while there is some degree of convergence, risk attitude as inferred from lotteries is superior in predicting market behavior. Correspondingly, Fellner and Maciejeovsky (2007) found that individual risk attitude as elicited by binary lottery choices is systematically related to markets behavior: the higher the degree of risk aversion the lower the observed market activity.

While lotteries thus seem the preferred method for assessing risk aversion, there has been quite some discussion about the role of financial incentives. From a review of 74 experimental papers, Camerer and Hogarth (1999), conclude that in games and risky choices, the most typical result is that incentives do not affect mean performance, but often reduce the variance in responses. Holt and Laury (2002; 2005) directly address the incentive issue by conducting the same experiments with both hypothetical and real payoffs. They find that behavior is indeed slightly more erratic under the high-hypothetical treatments, but that the primary incentive effect is in levels. While behavior was largely unaffected when hypothetical payoffs were scaled up, risk aversion increased sharply when payoffs are scaled up with real payoffs.

2.2. Determinants of risk attitude in the economics literature

An increasing number of empirical studies have tried to assess the determinants and correlates of risk aversion as assessed using lotteries or other methodologies. The focus has been on individual characteristics such as wealth, education, gender and age. Only few studies that we know of have considered environmental characteristics.

One of the main variables of interest has been wealth. Wealthier individuals are often found to be more likely to undertake risky activities. While risk aversion is widely believed to decrease with wealth, this observed behavior can also be caused by the larger capacity of wealthy households to cope with risk (Rosenzweig and Binswanger, 1993). The empirical evidence on the link between measured risk aversion and wealth is mixed. Hartog *et al.*(2002) find substantial empirical support for the claim that risk aversion is falling with wealth in the Netherlands. Several studies present similar results for developing countries. Abreha (2007) finds that wealthier smallholder farmers in Northern Ethiopia are less likely to select the safest option in hypothetical lotteries, and Wik (2004) finds that risk aversion decreases as wealth increases using an experimental gambling approach with real payoffs for households in Northern Zambia. Miyata (2003) and Senkondo (2000) come to the same conclusion based on games with hypothetical pay-offs played with Indonesian households and Tanzanian farmers, respectively. Yet, the results of Senkondo are only significant for a few of his specifications. Similarly, Binswanger (1980) finds only a weak negative effect of wealth on risk aversion for low pay-off games and an insignificant effect for high-payoff games for Indian smallholders. The findings of Cohen and Einav (2007) even suggest that risk aversion increases with wealth in Israel. They interpret this as evidence for the endogeneity of wealth. Testing for the relation between wealth and risk would require observing the same individuals at different wealth levels, whereas Cohen and Einav, and the other studies we discuss, use cross-section data. Alternatively, the explanation could lie in the fact that Cohen and Einav estimate risk aversion from actual behavior, so that their risk aversion measure could be confounded with risk perception. Overall, empirical studies thus present a diverse picture of the (cross-sectional) association between wealth and risk aversion: most report a negative link, but we also found evidence of an insignificant or even positive relation.

As could be expected, the empirical findings for the relation between human wealth and risk aversion do not differ much from those for physical wealth. Again, Cohen and Einav (2007) find a positive association between human wealth and risk aversion, but most other studies conclude that the willingness to take risk increases with education (e.g., Dohmen *et al.*, 2005; Donkers *et al.*, 2001; Hartog *et al.*, 2002; Miyata, 2003; Senkondo, 2000). There is, however, some evidence that the effect of education is context sensitive. Senkondo (2000) finds that education decreases risk aversion when adequate food is available but not in other situations, and Binswanger (1980) finds little effect of education on risk aversion at low game levels, but negative and often, but not always, significant effects at intermediate and high pay-offs. Also, the effect of education may be small. The only study we know of that discusses not only the significance of the coefficient for education but also its size is that of Binswanger (1980). He concludes that, even in those specifications for which the effect of education is significant, fourteen years of schooling compared to one would hardly have affected the outcome of the games.

A third important correlate of risk aversion is gender. Women are generally found to be more risk averse than men (e.g., Byrnes *et al.*, 1999; Cohen and Einav, 2007; Dohmen *et al.*, 2005; Donkers *et al.*, 2001; Hartog *et al.*, 2002). Yet there are some interesting exceptions. Using hypothetical choice dilemmas, Ronay and Kim (2006) find no gender difference at the individual level. However, when placed in groups, males expressed the commonly observed stronger pro-risk position than females. Senkondo (2000) generally cannot confirm the existence of a relation between gender and risk attitude, but observes that male farmers were significantly more risk averse as compared to female farmers when faced by the situation of inadequate food stocks. He explains this counterintuitive results from the particularity that in his Tanzanian sample male farmers were responsible for food purchase during difficult times.

Evidence of the relation between age and risk attitude is extremely diverse. Donkers *et al.* (2001) and Dohmen *et al.* (2005) conclude that the willingness to take risk decreases with age. Hartog *et al.* (2002) confirm this finding for Dutch accountants but find the opposite for respondents to a Dutch newspaper survey. Abreha (2007) and Senkondo (2000) find no significant relation between age and risk aversion. Finally, Cohen and Einav (2007) conclude that risk preferences exhibit a U-shaped pattern over the life cycle. At age 18, individuals become less risk averse with age, but around the age of 48, they start becoming more risk averse.

Most of the studies described above test for the determinants of risk aversion in one specific context, often a country or region within a country. Environmental differences are ignored or controlled for using location dummies (Binswanger, 1980). Abreha (2007) is a positive exception to this tendency. She explicitly discusses the role of the environment when analyzing lottery choices for a two-year panel of smallholder farmers in two Ethiopian districts. She concludes that risk aversion was significantly higher for the district with lower average and more variable rainfall. Moreover, farmers behaved less risk averse in the good harvest year. These results clearly suggest that not only individual characteristics but also the opportunities and vagaries of the environment affect people's risk attitude. Below, we discuss this possibility from a more psychological perspective.

2.3. Hazards, feelings, and risk attitudes

Psychological research has shown that emotions play an important role in risky decision making (Taylor-Gooby and Zinn, 2006). Dual process theories acknowledge feelings and cognitive reasoning as two parallel, interacting determinants of behavior (e.g., Epstein, 1994; Sloman, 1996). Directly pertaining to risk, Loewenstein et al. (2001) propose a corresponding model they call "risk as feelings". They claim that behavior in risky situations is determined by the interplay between emotional responses and cognitive evaluations. Cognitive evaluations of risk are sensitive to the variables identified by decision theory, namely probabilities and outcomes. Emotional reactions are sensitive to the vividness of associated imagery, proximity in time, and a variety of other variables that play a minimal role in cognitive evaluations. Behavioral evidence suggests that, when the two systems are dissociated, risk preference is often determined by emotions. Moreover, emotional reactions guide responses not only at their first occurrence, but also through conditioning and memory at later points in time, serving as somatic markers (Loewenstein *et al.*, 2001).

Natural hazards affect emotions and therefore directly influence risk behavior. A large number of studies confirm that natural hazard preparedness increases due to experience with hazards, and more specifically with the severity of damage (for reviews see Lindell and Hwang, 2008; Weinstein, 1989).

Community–level hazard awareness is only part of the explanation, as there are usually significant differences within communities between those who have and those who do not have personal experiences (Weinstein, 1989). The question is what causes this increased preparedness: an increase in perceived personal risk or (also) a changed evaluation of these risks. Lindell and Prater's (2000) data on households in seismic hazard areas in the US suggest that hazard experience has not only an indirect effect via perceived personal risk but also a direct effect on hazard adjustment adoption. A change in risk aversion presumably causes at least part of the direct effect. Victims of natural hazards or other shocks feel more worried or fearful than nonvictims (Cutchin *et al.*, 2008; Weinstein, 1989), and fear and anxiety have been shown to lead individuals to make risk-averse choices (Lerner and Keltner, 2001; Raghunathan and Pham, 1999).

3. The case study areas and the survey households

3.1. Nicaragua

Nicaragua is the second poorest country in Latin America after Haiti. After years of political conflict and civil war, Nicaragua rapidly became a market economy during the first half of the nineties. Poverty rates decreased slightly, from 50 percent in 1993 to 48 percent in 1998 (World Bank, 2001). In that year, Hurricane Mitch devastated the country's infrastructure and destroyed a large part of agricultural production. The government was overwhelmed by the short-term emergency needs of its population and lost its long-term development focus. Yet, post-Hurricane Mitch investments boosted poverty reduction, which resulted in an average poverty rate of 46 percent in 2001 (World Bank, 2003). This number was about the same four years later, despite moderate economic growth and low inflation (World Bank, 2007).

While Mitch was one of the most violent hydro-meteorological phenomena to have struck Central America last century, it was by far not the only natural disaster that hit the country: between 1980 and 2000, Nicaragua suffered from three major droughts, five floods, and seven hurricanes. The political situation adds to the general instability of the farmers' environment: Former large land owners have reclaimed lands distributed to peasant farmers during the Sandinista period of the 1980s. To add to this, the 2006 election as president of Daniel Ortega, the leader of the Sandinista National Liberation Front and president during the earlier land reforms, has raised expectations of new land reforms.

For our study, we selected the department of Chinandega, which was hit relatively hard by hurricane Mitch and is situated in the Pacific lowlands, economically the strongest region of Nicaragua. Although there is a lot of interdepartmental difference, Chinandega has the lowest percentage of poor in the country. The department's strategic location close to the capital of Managua and the Honduran border and its high agricultural potential have resulted in a strong agro-industry with related services and commercial activities (CODECHI, 2004). Yet the current economic activities are not enough to absorb the total labor force, causing a migration stream to Costa Rica, Honduras and the USA.

Early 2007, we interviewed 222 farm households in different communities in Chinandega. We randomly selected 131 households in communities that were heavily affected by Mitch, 51 households from communities that were only mildly affected by Mitch, and 40 households from resettlement areas. Besides the interviews, we did a risk experiment with about half of the people interviewed in each of the different zones.

3.2. Peru

After several years of inconsistent economic performance, the Peruvian economy grew by more than 4% per year during the period 2002-06, with a stable exchange rate and low inflation. Growth jumped to 7.5% in 2007, driven by higher world prices for minerals and metals, and making the Peruvian economy one of the faster growing economies in the region. Despite the strong macroeconomic performance, underemployment and poverty have stayed persistently high. More than 50% of the total population lives under the poverty line, and the percentages for people living in rural areas is close to 70% (INEI, 2007).

Given its geographical location in the continent, Peru is one of the countries severely affected by *El Niño* phenomenon. This ocean-atmosphere phenomenon changes the distribution of rainfall, causing floods and droughts in many regions of the country. The last two strong episodes occurred in 1983 and 1997, and affected a vast majority of people particularly in the North Coast of the country as well as in some parts of the North Andean region. The agricultural sector is traditionally the one most affected by these weather oscillations, losing an estimate of US$140 millions during the last Niño manifestation.

Apart from this regular source of weather shocks, the Andean region of the country presents two other sources of natural disasters that commonly affect its population. *Huaicos* are extreme landslides of wood and rocks from the mountains to the lower parts of the valley, which constantly threaten small towns and agricultural plantations. The second one is a sudden reduction in temperature levels, called a *Freeze*, which seriously damages crop's productivity. These weather characteristics make agriculture in Peru a particularly risky activity to pursue.

The information that will be used for this study comes from a household survey held at the end of 2004 with the purpose of evaluating the impact of the Peruvian national land titling program. The database has information for more than 2,000 farmers distributed over 5 different regional domains of the Coast and Andean regions of Peru, regarding income strategies, investments, socio-economic characteristics, and a series of questions about risk perceptions and attitudes as well as negative shocks confronted by the household in the last years. We complemented this information with a risk experiment taken for a sample of farmers in four different departments. We decided to select two zones located in the Coast region and two in the Andean region, with similar altitude levels and agricultural conditions within the region but different between regions. The zones finally selected are located in the departments of Ancash and Cajamarca in the Center and North Andean region, respectively, and Piura and Tumbes in the North Coast of Peru. Each experiment involved an approximate number of 25 persons making a total sample of 100 individuals.

4. Methodology

4.1. The set-up of the lotteries

Risk experiments in rural areas of countries like Nicaragua and Peru have to meet certain specific criteria. First, because a large share of the population of interest is illiterate, the games have to be simple. Second, playing games with real potential losses is not viable with poor people. If some of the potential losses are outside the budget of a respondent, it may be this constraint and not preferences determining choices. Also, there are moral problems associated with engaging low income people in gambles involving losses. Whenever we wanted to use real payoffs, we therefore limited our experiments to gambles leading to gains.

Our main experiments involved the choice between a lottery and a fixed payment of money. In Nicaragua, experiments were done directly after the completion of the questionnaire at the home of the respondent. In Peru, participants were invited to come to a nearby location two months after the survey and were paid a daily wage rate before the game started. We used limited framing, as frames may cue norm-driven behavior (Cardenas and Carpenter, 2008) and tended to confuse people. Subjects were asked to imagine themselves having to choose between a Project A, with profits determined by a 50-50 chance of success or failure, and Project B, with profits fixed and secure. The two possible pay-offs of Project A were linked to the toss of a coin, so that it would be simpler for subjects to identify the probability of each pay-off.

The highest pay-off of Project A was set at 20 soles in Peru and C$ 80 in Nicaragua and the lower at 8 soles/32 C$. Previous research has shown that risk aversion depends on the size of the stake and may be negligible for low pay-off decisions (Holt and Laury, 2002; 2005). By selecting a maximum pay-off of approximately double the daily agricultural wage rate in both cases, we ensured that risks were not trivial to the participants while the costs of the experiments were not excessive. The fixed return for Project B started at 8 soles/32 C$ and went up to 20 soles/C$80. In total, 13 games were played sequentially, each of them with the same values for Project A but increasing the value of the fixed-reward Project B by one sol/4 C$.

The subjects received a booklet with 13 pages, each containing one game, and were asked to chose between Project A and B in each game. Only after choosing, subjects could pass to the next game. As the pay-offs from Project B increases, choosing Project A looks less attractive to a risk-averse respondent and at some point they are likely to switch from choosing A to choosing B. The pay-off from Project B at which they switch reveals the value of the respondent's certainty equivalent to the gamble represented by Project A.

At the start of the session, subjects were informed that one of the games would be randomly selected to determine their final pay-off. At the end of the interview, subjects selected a game by pulling a token from a bag containing tokens numbered from 1 to 13. If they had chosen Project A (the gamble) in the selected game, a coin was tossed to determine their pay-off. If they chose Project B in the selected game, they were directly given the amount of money stated there.

Besides doing the experiment, we included two hypothetical questions in our survey questionnaires on the maximum price that people were willing to pay for a lottery ticket. Both lotteries had one prize for 10 participants (chance of 10%). The prize in the first lottery was C$500/100 soles, about 12.5 daily wages. The prize of the second lottery was 20 times higher at C$ 10,000/2,000 soles. Given the evidence presented in the existing literature, we expected these measures to give a less accurate indication of risk aversion than the experiments. However, it is interesting to test if using such simple questions would in our case have presented an alternative, time and money saving method of assessing risk aversion.

4.2. A simple measure of risk aversion

Following Cramer *et* al. (2002) we use the Arrow-Pratt measure of absolute risk-aversion

$$\rho = \frac{-U''}{U'}, \tag{1}$$

where U is a common utility function $U(W)$ of wealth or rewards W. To deduce the value of ρ, consider two alternatives X and Y. X offers a certain reward X, and Y gives additional benefits B with probability α or irretrievable costs C with probability 1- α.

In standard expected utility theory,

$$E(U_Y) = \alpha U(X+B) + (1-\alpha)U(X-C). \tag{2}$$

Approximation of the two terms by Taylor series gives:

$$E(U_Y) = U(X) + \{\alpha B - (1-\alpha)C\}U'(X) + \tfrac{1}{2}\{\alpha B^2 + (1-\alpha)C^2\}U''(X). \tag{3}$$

We apply this model taking the lottery as the uncertain option Y and not participating as the certain reward X. If α is the probability of winning a single prize Z and the price of the ticket equals Λ, then the benefit B equals Z-Λ and the cost C is Λ. At the maximum price that the individual is willing to pay for the lottery ticket, the reservation price λ, the utility of participating in the lottery $E(U_y)$ equals the utility of not participating U(X), which gives:

$$U(X) = U(X) + \{\alpha(Z-\lambda) - (1-\alpha)\lambda\}U'(X) + \tfrac{1}{2}\{\alpha(Z-\lambda)^2 + (1-\alpha)\lambda^2\}U''(X), \tag{4}$$

so that

$$\rho = \frac{-U''}{U'} = \frac{\alpha Z - \lambda}{\tfrac{1}{2}\times(\alpha Z^2 - 2\alpha\lambda Z + \lambda^2)} \tag{5}$$

This ρ is an almost linear downward sloping function of λ, with a value of 0 (risk-neutrality) when λ equals the expected pay-off of αZ.

The same framework can be applied to our experiment. In this case, α equals ½, B is the high payoff Z^h minus the fixed payoff X, and minus C equals the low payoff Z^L minus X. Again, at the equilibrium level of *X*, λ, $E(U_y)$ equals U(λ), such that

$$U(\lambda) = U(\lambda) + \left\{\tfrac{1}{2}(Z_H - \lambda) + \tfrac{1}{2}(Z_L - \lambda)\right\}U'(\lambda) + \tfrac{1}{2}\left\{\tfrac{1}{2}(Z_H - \lambda)^2 + \tfrac{1}{2}(Z_L - \lambda)^2\right\}U''(\lambda). \quad (6)$$

Solving for *ρ* gives:

$$\rho = \frac{(Z_H + Z_L - 2\lambda)}{\tfrac{1}{2}\left(Z_H{}^2 + Z_L{}^2 - 2\lambda(Z_H + Z_L) + 2\lambda^2\right)}. \quad (7)$$

This ρ is a sigmoid, downward sloping function of λ, with a value of 0 (risk-neutrality) when λ equals the mean of Z_H and Z_L, which is the average pay-off.

4.3. Measuring risk exposure and risk perceptions

In order to link risk aversion to risk exposure, we needed to define measures of exposure at the individual level. Most shocks experienced by households include both idiosyncratic and common risk features (Dercon, 2002), and the idiosyncratic part of income risk is relatively large, even when climatic hazards are considered important (Deaton, 1992; Townsend, 1994; Townsend, 1995). Low rainfall, for example, may harm production on certain fields within a village, but not all, depending on soil type, slope, and crop grown. Similarly, a flood will affect only low-lying fields, whereas landslides destroy fields on or below steep or unstable slopes. General shock indicators such as average rainfall or the passage of a hurricane therefore obscure differences in risk exposure between households. We therefore used household-level questionnaires to gather information on risk exposure.

Together with risk exposure, we collected information on risk perceptions. Our measurements are based on the "Participatory Risk Mapping" methodology introduced by Smith *et al.* (2000), but contrary to these authors, we use individual level surveys and not community-level interview. Also, we did not use open interviews, but defined a pre-selection of different sources of risk based on previous studies, expert knowledge and field tests.

The first step of the elicitation process was to ask the farmers to identify the main sources of risk they faced in crop and livestock production. They could chose as many as they wanted from our pre-defined lists. The second step consisted of asking the respondents to rank order the risks they identified in the first step. We used a simple ordinal scheme assigning the value of (1) to the risk identified as the most severe, (2) to the second most severe and so on. With this information we can derive representations of subjective risk incidence and severity for each specific type of risk.

After we had obtained information about their worries, we informed about the actual frequency of occurrence of each shock and the approximate losses of income and productive assets encountered. Asking each individual for occurrence may seem a futile exercise for natural hazards, which are generally considered covariate. However, even a drought not always affects an entire village (Walker and Ryan, 1990). For Peru, we took a recall period of two years, a relatively short period which is easy to recall to mind. For Nicaragua, we used a longer period of nine years. We feel that this was a realistic period, since it was the period directly following hurricane Mitch, a defining moment in people's lives.

In the case of Nicaragua, we also asked a detailed set of questions about Mitch-related losses. These questions involved losses of productive assets and income, but also more personal losses, like the death of family members and damage to the home.

5 Descriptive statistics

5.1 Natural hazards and losses

The households in our Nicaraguan survey all lived in an area that hurricane Mitch affected at least moderately. 91 percent lost crops and 67 percent lost livestock due to the hurricane. 50 percent reported severe damage to or a complete loss of their home. Other losses were less frequently reported, but still 28 and 27 percent of households reported losses of land and equipment/farm buildings. Those households losing land or livestock, reported losses of 48 and 55 percent of the pre-Mitch value on average. The size of losses of crops and physical assets were difficult to value and relate to pre-Mitch values, so we will not use these values in our analysis. Fortunately, human losses were relatively rare with only seven percent reporting death and two percent permanent disability of family members.

While Mitch was a defining moment in the lives of the people we interviewed, it was far from the only natural shock they experienced in the past ten years (see Table 1). Drought, volcanic gases or ashes, excessive rains, floods, and landslides appear to be a normal part of life that each reportedly occurred to between 3 and 81 percent of the people interviewed. The production activity most affected was annual cropping and the hazard causing most losses and worries was drought.

<<INSERT TABLE 1 ABOUT HERE >>

As in the case of Nicaragua, drought was the event that caused most concern for the Peruvians in our sample, with a sudden change of temperature (commonly a freeze) ranking second (Table 2). These events are also the ones that occurred most often in the last two years. While almost no household suffered damages from landslides or floods in the last two years, half of them suffered some type of loss because of droughts, and a quarter of them due to sudden changes in temperature. In both cases, losses were more concentrated in crops than in livestock. On average, losses from droughts are more than four times bigger than losses caused by changes in temperature.

<<INSERT TABLE 2 ABOUT HERE >>

5.2 Risk aversion indicators

The results from the experiment and lotteries show that most households are risk averse, as expected given the high levels of poverty and the particularly unpredictable feature of agriculture in both countries (Table 3). Unfortunately, we could only use 83 percent of the observations for the experiments in both cases, as the other subjects did not seem to understand the game. We think that this has not affected the general findings of our research, as we found no significant difference in level of education, age, gender, and asset holdings between those respondents with valid and those with invalid games. In the case of the lotteries, all but three people in the Peruvian case answered the questions.

<< INSERT TABLE 3 ABOUT HERE >>

Comparison of the two lotteries for each case confirms the finding from other studies that people are more risk averse when more money is involved. Comparing these risk aversion measurements seems legitimate, as the correlation between the answers is positive and significant at the one percent level for both cases (0.48 for Peru and 0.33 for Nicaragua). Comparison of the lotteries with the experiments is, however, problematic, as correlation rates between the different certainty equivalents and coefficients of risk aversion are not significant between the experiment and the lotteries. This suggests that one or both of the approaches does not give a good indication of actual risk aversion.

The average values found for ρ in the two experiments are 0.021 in Nicaragua and 0.12 in Peru. To interpret these outcomes, we note that $\rho = -U''/U'$. Hence, multiplying ρ by the mean income from the experiment would give us the coefficient of relative risk aversion *R*, or, as it equals the income elasticity of the marginal utility, (the negative of) the money flexibility. For Nicaragua the expected return is 56, hence $R = 1.2$, and for Peru, where the expected return is 14, an *R* results of 1.6. These values are quite in line with earlier findings, both for the relative risk aversion and for the money flexibility. For the lottery questions, the relative risk aversion coefficients are somewhat less plausible: 0.1 for the low-value lottery in both countries and 0.2 and 2.2 for the high-value lottery in Peru and Nicaragua, respectively.

To gain further insight in the validity of the various results, we made plots of the distribution of the answers. Figure 1 presents the results for the experiments. Peruvians on average exhibit more risk-averse choices than Nicaraguans, but the general patterns is very similar. Most households chose the certain amount of money over the gamble already at low certainty equivalents. A smaller group of households switches around the expected value (page 7) and only a few reveal very risk-taking behavior. The results of the lotteries are much more erratic and choices are clearly biased to “nice” values like 10 or 50 (Figure 2). These differences, combined with our prior expectation that the experiments would give more realistic answers, made use decide to focus our further analysis on the experimental results.

<<INSERT FIGURES 1 AND 2 ABOUT HERE >>

According to the experiments, 76 percent of participants in Nicaragua and 86 percent of participants in Peru was risk averse, and the ratio of the certainty equivalent to the expected value of the experiment was lower in Peru. It may seem surprising that the Peruvian respondents behaved more risk averse, as risk aversion is generally negatively correlated with wealth and income, and Nicaragua scores lower on per capita income and HDI than Peru. The Nicaraguan respondents, however, live in the most developed rural region of the country, whereas the Peruvians are from relatively poor parts of the nation. In the capital of Lima, risk aversion was found to be much lower: In a very similar experiment, Barr and Packard (2005) found that only 60 percent of a sample of almost a thousand Peruvian workers in the urban areas of Lima could be considered risk averse.

6 Determinants of risk aversion

6.1 The impact of Mitch and subsequent shocks in Nicaragua

To assess the impact of natural hazards on risk aversion for our Nicaraguan sample, we regressed the coefficient of absolute risk aversion from the experiments on a set of personal characteristics, indicators for the impact of Mitch and other natural hazards on the respondent’s household, and a two location dummies related to the effects of hurricane Mitch (Tables 4 and 5). In a first regression, we excluded the post-Mitch shock variables, as we suspect that they could cause endogeneity problems. Whereas hurricane Mitch was a well-defined shock, some of the other hazards are slightly less objective: when do you call rainfall excessive and when is rainfall so little that you call it a drought? It is possible that households that are generally concerned report more occurrences and higher damage, especially when looking back over a long period of nine years. In a second regression, we included post-Mitch shocks as dummies of occurrence. The effect of the inclusion of these variables on the results for the remainder of the equation was minor.

<<INSERT TABLES 4 AND 5 ABOUT HERE >>

The results consistently indicate that past experience has a large and significant effect on risk aversion. Ceteris paribus, individuals who lost their family home show a coefficient of absolute risk aversion that is about thirty percent higher. Similarly, the risk aversion of those losing all their animals was almost fifty percent higher than of those not losing animals at all. The effect of losing crops was unexpectedly high: a more than sixty percent increase in risk aversion. Losing crops is a one-time income loss, and we assumed this to have a smaller effect that the loss of assets, which has a more persistent effect. However, by far most people lost crops, and the crop loss dummy basically distinguishes those that did not lose anything, not even some crops, from those that were at least to some extent personally affected. In fact, out of the 55 households that lost cattle, 53 also lost their crops. Apparently, this distinction has a large impact on risk aversion. Finally, we find that farmers reporting at least one drought after Mitch were almost fifty percent more risk averse than others. It is not surprising that this hazard stands out, as our risk mapping exercise indicated that this was the natural hazard affecting most people and causing most worry.

The coefficients of the location dummies were somewhat surprising, but they are only significant in one of the specifications. *Ceteris paribus*, people living in a resettlement area seem to have a risk aversion that is about forty percent lower. These are people who were generally very heavily affected by the hurricane, which is taken up by the individual shock variables, and subsequently moved to a different area, where they could make a new start, possibly with external support. Apparently, this made up for at least part of the high risk aversion they had due to their losses. Unexpectedly, residents of the heavily affected zones *ceteris paribus* were less risk averse, although this effect is only significant when all shocks are included. There are two aspects of this effect. One is that households that did not experience damage, but live in the heavily affected area, apparently are less risk-averse, despite the fact that they witnessed so much damage. The other effect, however, is more common: affected households in the heavily affected area are less risk averse than equally affected households outside this area. Hence there is a mitigating effect of sharing the fate with neighbors.

Men and women appeared to be equally risk averse. In tabular analysis women showed a higher level of risk aversion than men did, but this effect can apparently be attributed to other factors. Also the effect of wealth turned out to be insignificant. We tried a number of different specifications and none of them revealed a significant relation between wealth and risk aversion. This coincides with the findings of Binswanger (1980) for Indian smallholders, and could reflect the real absence of an effect or simply be the result of strong non-linearity or the cross-sectional nature of the data. Similar to Cohen and Einav (2007), we find a positive effect of education on risk aversion. Finally, risk aversion increases with age and there is some evidence that this effect is quadratic, with a relatively strong increase in risk aversion of three percent per year at the age of 23, the age of the youngest respondent, after which it slowly levels off to become negative after the age of 55. This is exactly the opposite pattern as found by Cohen and Einav (2007) and adds to the diversity of empirical results.

6.2 Agricultural losses and risk aversion in Peru

In the case of Peru, we regressed the coefficient of absolute risk aversion from the experiments on measures of the relative value of losses caused by natural disasters in the last two years. Using the information presented in Table 2, we constructed a variable for the relative agricultural loss by dividing the loss value over the reported value of land. A similar variable is created for livestock losses over the total value of all household animals. Apart from these measures, we take advantage of an exogenous weather shock that occurred in one of the experiment areas (Cajamarca, in the North Andean region) just one week before we ran the experiment. About one half of our sample of players there (14 individuals) experienced a sudden drop of temperature (freeze) which seriously damaged their crops. The other half were located on the other side of the valley and so remained unaffected. The inclusion of this dummy variable in the regression will allow us to test the effect on risk aversion of very recent weather shocks.

Together with these variables, we include the total number of events that individuals worry about, as a measure of subjective risk perception, and the total number of parcels that the household holds as a measure of a potential diversification strategy to deal with risky scenarios. Finally, we incorporate in the regression several individual characteristics and dummy variables for the different areas where the experiment was performed. A summary of all these variables is presented in Table 6.

<< INSERT TABLE 6 ABOUT HERE>>

Our findings indicate that, like in the case of Nicaragua, the occurrence of weather shocks have a very important effect in determining the degree of risk aversion (Table 7). In terms of losses by weather shocks in the last two years, our results indicate that a change of one standard deviation (0.3) from the mean share of agricultural losses induces an increase in the risk aversion coefficient of 8%, while increasing the share of livestock losses by one standard deviation (0.94) raises it by 6%. Despite this similar marginal effect, it is important to note that more than a half of the individuals in our sample reported crop losses, and only 16 of them experienced events that damaged livestock. The crop losses appear to be a more significant determinant of risk aversion in our case.

<< INSERT TABLE 7 ABOUT HERE >>

Furthermore, the very high impact of the dummy variable for the individuals experiencing the freeze just before the experiment could be suggesting that risk aversion, as measured by this type of experiment, is even more influenced by the occurrence of more recent negative shocks. Individuals who experienced this shock are on average 40 percent more risk averse than individuals who did not.

We also found a very strong inverse relationship between the level of wealth and risk aversion in our sample, and a similar one for the number of plots hold by the household. These results could also be indicating that diversification strategies and availability of coping mechanisms give more security to individuals and influence their decisions under risky scenarios.

Finally, the only personal characteristics found to be significant in our regression is gender. Contrary to the Nicaraguan case, the Peruvian men are more risk averse than women in the sample. This outcome might have to do with the fact that in our study areas men are usually the ones who take production decisions and also the ones more aware of the different types of risk for their activity.

7. Conclusion

The frequency and damages created by natural hazards has increased substantially over the past decades and will probably continue to do so in the near future, especially in developing countries. This study has tested the hypothesis that experiencing these hazards affects risk attitudes. Poor households in volatile environments adopt defensive portfolio strategies to smooth income and assets. The cost of such strategies is forgone income growth and profitable investment. Portfolios will be more defensive and the associated costs in terms of development will be larger when individuals are more risk averse. Psychologists have shown that hazard experience makes people more worried and fearful, and that worry leads to more risk-averse choices. This finding has, however, been ignored in the economics literature.

We use experimental and survey data from two natural-hazard prone countries in Latin America: Nicaragua and Peru. We use two methods to measure risk aversion: simple questions on the willingness to pay for a hypothetical lottery and more complicated games involving real pay-offs. We find that the hypothetical questions result in unrealistic distributions of preferences, with clear peaks at “nice” values of reservation prices, whereas the experiments present reasonable distributions with most people revealing risk averse behavior. We therefore conclude that, although very easy to include in standard surveys, simple questions are not a suitable substitute for more complicated choice experiments. As all our choice games had real pay-offs and our questions were hypothetical, we cannot tell to what extent the payoff played a role in these findings.

Our results strongly support the hypothesis that experiencing natural shocks makes people more risk averse. In both Nicaragua and Peru, experimentally measured risk aversion was substantially higher for farmers who experienced more damages due to natural shocks, not only in the short-run –as a result of a sudden drop of temperature damaging crops only a week earlier– but also in the medium run –due to droughts and/or other shocks one or a couple of years before– and even in the long run –owing to a major hurricane almost a decade before the fieldwork took place. This indicates that such disasters not only change the asset base of the affected population, but also the nature of their preferences and the weighing of alternative survival strategies. Put differently, risk management and coping strategies and policies that *ex ante* seemed optimal are not necessarily so after a major disaster has taken place. Interestingly, we find a mitigating effect of sharing a disaster with neighbors: Affected households in the heavily affected area are less risk averse than equally affected households outside this area.

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Table 1. Post-Mitch natural shocks in Nicaragua (N=222)

	Risk index[a]	Occurrence		% of households reporting damage to				
		%	avg nr[b]	annuals	perennials	livestock	nonfarm	wage
Flood	0.24	17	1.9	11	0	1	0	0
Landslide	0.17	3	1.0	3	0	0	0	0
Volcanic gases/ashes	0.37	54	2.9	40	0	1	1	1
Drought	0.65	81	2.2	78	0	1	0	0
Excessive rain	0.15	43	2.2	37	0	0	0	0

[a] Average risk assessment index. Respondents were presented a list of 5 natural and 8 non-natural hazards and were asked which caused them worries and in which order. The risk index is $R_{ij} = 1 - ((r_{ij} - 1)/n_i)$ for individuals $i = 1,\ldots,m$ and risks $j = 1,\ldots,n_i$, where r_{ij} is the risk ranking reported by the respondent and n_i is the number of risks ranked by individual i. Hazards not causing worry are given $R_{ij} = 0$ (Doss *et al.*, 2008)

[b] Average number for those individuals reporting occurrences. Note that not all of them also reported losses.

Table 2 Natural shocks in Peru

			Occurrences		% of households reporting damage				Average Loss if affected (soles)		
Event	% worries	risk index	%	avg. numb.	Crop	cattle	assets	total	crop	cattle	total
Landslide	15	9	3	1.0	1	0	0	1	10	0	10
Flood	28	20	1	2.0	0	0	0	0	0	0	0
Drought	81	65	50	1.7	47	12	-	50	3,404	588	3,341
Temp. change	37	23	25	1.9	21	8	-	24	803	205	771
Total				1.3	56	16	0	58	3,158	544	3,199

Note: See table 1 for explanation

Table 3. Risk attitudes in Nicaragua and Peru: sample characteristics (N=107)

	Nicaragua (N = 107)			Peru (N = 101)		
	Experiment (C$32-C80)	Lottery (C$500, 10)	Lottery (C$10,000; 10)	Experiment (S/.8-S/.20)	Lottery (S/.100; 10)	Lottery (S/.2,000; 10)
Frequencies (%)						
Invalid due to						
No gamble	3	0	0	4	3	3
Always gamble	1			5		
Recurrent switching	14			8		
Risk aversion[1]						
Risk averse	76%	60%	90%	86%	76%	99%
Risk neutral	6%	30%	8%	4%	23%	1%
Risk loving	18%	10%	2%	10%	1%	0%
Coefficients[2]						
λ,	47.3	33.3	239.4	10.4	4.6	16.3
	(11.3)	(30.6)	(642.1)	(2.7)	(3.6)	(26.9)
ρ	0.021	0.0015 (0.002)	0.0022	0.12	0.011	0.001
	(0.025)		(0.0008)	(0.09)	(0.007)	(0.0001)

Notes: [1] Percentages calculated based on valid answers
[2] Standard errors in parentheses

Table 4 Summary of variables included in the regression, Nicaragua (N=84)

Variable	Mean	Std. Dev.	Min	Max
1000*ρ	23.12	22.94	-40.98	40.98
Gender (1 = male)	0.87	0.34	0	1
Age of player	47.62	15.48	23	86
Education of player (years)	2.69	3.24	0	14
Log(productive assets)	10.22	1.87	5.25	14.09
Home severely damaged/lost (yes = 1)	0.49	0.50	0	1
Share of land lost (mz/mz)	0.08	0.23	0	1
Share of animals lost (C$/C$)	0.35	0.40	0	1
Equipment or farm buildings lost (yes=1)	0.36	0.48	0	1
Crops lost (yes = 1)	0.76	0.34	0	1
Volcanic gases/ashes	0.42	0.50	0	1
Flood	0.05	0.21	0	1
Excessive rains (without flood)	0.44	0.50	0	1
Landslide	0.02	0.15	0	1
Drought	0.77	0.42	0	1
Heavily affected area	0.57	0.50	0	1
Resettlement area	0.21	0.41	0	1

Table 5 Determinants of risk aversion in Nicaragua (N=84)

Independent variable: 1000*ρ	Mitch losses only		All shocks	
	Coefficient	% change	Coefficient	% change
Personal characteristics				
Gender (male = 1)	0.370		5.619	
	(6.894)		(6.964)	
Age	2.110**	6	1.714*	5
	(0.985)		(1.021)	
Age squared	-0.019**	-3/-6/-7[b]	-0.015	
	(0.009)		(0.009)	
Education (years)	1.989**	6	2.327***	7
	(0.766)		(0.764)	
log of productive assets (C$)	-0.195		0.137	
	(1.514)		(1.536)	
Mitch-related losses				
Home severely damaged/lost (yes = 1)	10.825**	33	8.870*	27
	(4.950)		(5.212)	
Share of land lost (mz/mz)	7.943		8.052	
	(10.439)		(10.197)	
Share of animals lost (C$/C$)	15.680**	47	15.361**	46
	(6.475)		(6.427)	
Equipment or farm buildings lost (yes=1)	-6.454		-6.944	
	(5.067)		(5.049)	
Crops lost (yes = 1)	20.897**	63	21.822**	66
	(9.863)		(10.165)	
Occurrence of post-Mitch shocks (yes=1)				
Volcanic gases/ashes			1.510	
			(4.918)	
Flood			-8.505	
			(11.110)	
Excessive rains (without flood)			3.088	
			(4.759)	
Landslide			1.439	
			(15.197)	
Drought			16.133***	48
			(5.776)	
Location dummies				
Heavily affected area	-9.097		-10.209*	-31
	(5.796)		(5.933)	
Resettlement area	-13.151*	-39	-10.696	
	(7.271)		(7.314)	
Constant	-54.969**		-61.659**	
	(24.769)		(24.850)	
Adjusted R-squared	0.22		0.26	

Notes: Standard errors in parentheses

% changes are computed at median ρ for increasing the independent variable by one unit.

[b] % change at 23 years (youngest) / 48 years (mean) / 63 years

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

Table 6. Summary of variables included in the regression, Peru (N=82)

Variable	Mean	Std. Dev.	Min	Max
Value of productive assets (S/.)	2,162	3,019	16	18,658
Log productive assets (S/.)	6.91	1.37	2.77	9.83
Value of land (S/.)	28,895	46,713	70	254,000
Value of livestock (S/.)	1,176	2,182	0	12,010
Value agricultural losses (S/.)	1,820	6,052	0	50,000
Value livestock losses (S/.)	69	239	0	1,500
% agricultural loss over value of land	0.11	0.30	0.00	2.26
% livestock loss over livestock value	0.16	0.94	0.00	7.50
Freeze dummy	0.15	0.36	0.00	1.00
Number of events that she/he worries about	1.56	0.79	0.00	4.00
Number of hh owned parcels	2.59	2.08	1.00	13.00
Gender of the player (1 if male)	0.57	0.50	0.00	1.00
Years of education of the player	4.84	3.98	0.00	15.00
Age of the player	55	16	23	87
Dummy Zone1	0.24	0.43	0.00	1.00
Dummy Zone2	0.28	0.45	0.00	1.00
Dummy Zone3	0.23	0.42	0.00	1.00
Dummy Zone4	0.24	0.43	0.00	1.00

Table 7. Determinants of risk aversion in Peru (N=82)

Independent variable: 100*ρ	Coefficient	% change
Personal characteristics		
Gender (1 if male)	5.181**	33
	(2.423)	
Age	0.268	
	(0.345)	
Age squared	-0.002	
	(0.003)	
Education (years)	-0.024	
	(0.326)	
Log productive assets (S/.)	-2.230***	-19
	(0.751)	
Number of household owned parcels	-1.067**	-7
	(0.509)	
Number of events that she/he worries about	0.808	
	(1.254)	
Losses due to natural hazards		
Crop losses/value of land	4.312***	8
	(1.517)	
Share of livestock lost	0.936**	6
	(0.401)	
Freeze dummy	6.315*	40
	(3.366)	
Location dummies		
Zone2	-3.306	
	(4.162)	
Zone3	-3.363	
	(3.673)	
Zone4	-1.882	
	(3.814)	
Constant	19.676*	
	(10.871)	
Adjusted R-squared	0.29	

Notes: Standard errors in parenthesis
% changes are computed at median ρ for increasing the independent variable by one SD for continuous variables and shares, except for the number of household owned parcels where a unitary change is used, and a unitary change for dummy variables.
*** p<0.01, ** p<0.05, * p<0.1

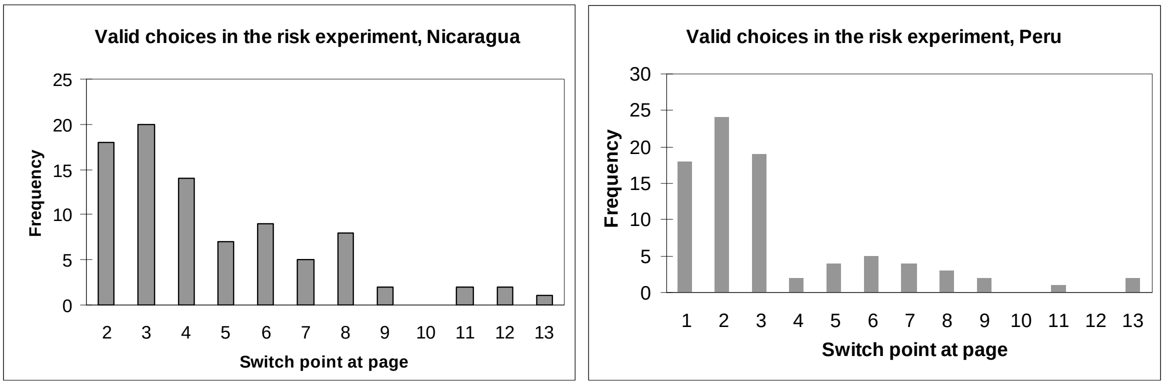
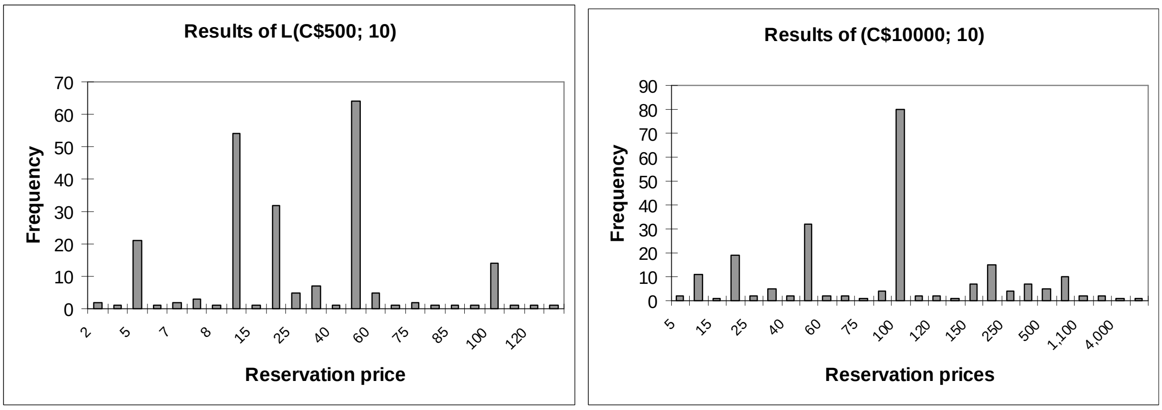


Figure 1 Distribution of the experimental results

A Nicaragua



B Peru

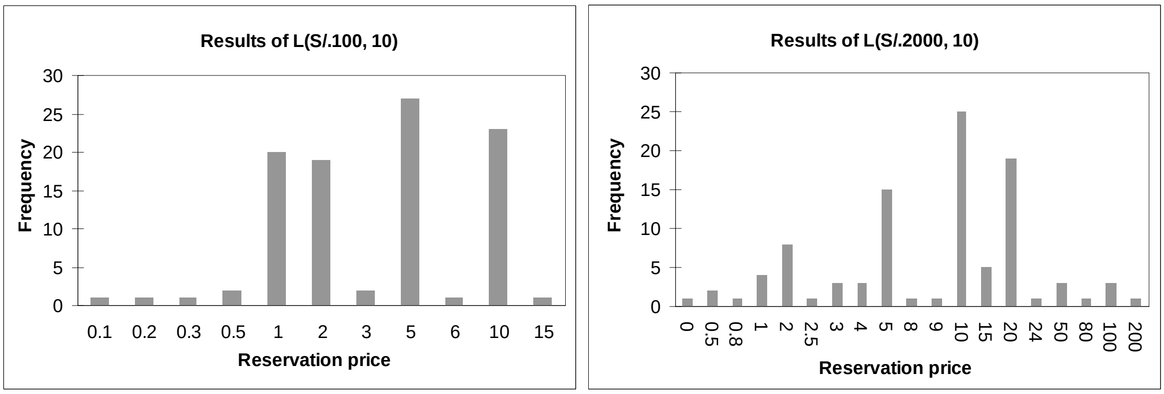


Figure 2 Distribution of the lottery results