Behavioral Responses to Natural Disasters

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Abstract Can catastrophic events alter existing social and economic relationships and give rise to heterogeneity of behavior across populations? We investigate this question by estimating the impact of a large negative shock on altruism, trust and reciprocity in 30 small Honduran communities diversely affected by Hurricane Mitch in 1998. We find that the mean and variance of behavior are nonlinearly related to the severity of the shock: intermediate shocks help coordination around a higher equilibrium in an anonymous interaction game, while extreme shocks undercut such cooperation. Survey data also shows substitution from formal local organizations to informal arrangements after the shock.

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1. Introduction

It has been long argued that adaptation to the environment might favor the persistence of certain traits or behaviors that help the survival of the group (Darwin 1871, Becker 1976, Bowles 2006, 2008, 2009, Boyd et al. 2002). Recent cross-cultural experimental work has revealed that pro-social behavior correlates with the returns to cooperation in production and the institutions necessary for the development of impersonal relationships (Boyd et al. 2002, Henrich et al. 2001, 2004, Henrich et al. 2006, 2010). While this evolutionary perspective seems to suggests that norms evolve slowly in response to 'cooperation fundamentals,' this paper joins a small number of other studies that complement this perspective by asking if systemic or environmental shocks lead to rapid, but durable changes in pro-social behaviors.

If shocks do have these effects, it not only complements the evolutionary perspective, but also suggests why we might expect to see variation across communities with similar cooperation fundamentals, but different stochastic histories.

We address this question by using behavioral experiments to evaluate differences in pro-social behavior across communities that were differentially affected by the random walk of Hurricane Mitch across rural Honduras in 1998. Hurricane Mitch is ranked as the fourth strongest hurricane affecting the Atlantic basin on record (Morris et al. 2002). The hurricane was responsible for 5,657 deaths and significant damages that affected 1.5 million people. Not only were infrastructure, land and housing destroyed on a massive scale, but planted and stored staple foods consumed by the poor were washed away (ECLAC 1999).

The scale of destruction wrought by Mitch would be expected to increase returns to cooperation as individuals and communities faced the challenge of repairing both public goods and large-scale private goods, such as housing. While this shock to the returns to cooperation might be expected to encourage the emergence of cooperation-enhancing, pro-social norms, it is also at least plausible that too much stress could destroy cooperation if families who have lost housing, productive assets and savings struggle to simply make ends meet. The hurricane therefore gives us a unique opportunity to observe how behavior adapts to changing conditions (Smith 2003).

Other studies that have examined the impact of shocks on pro-social behavior include some that investigate the impacts of natural disasters, while others explore the impact of civil conflict and shocks engineered by human agency. Distinguishing between natural and 'unnatural' disasters may be important. While human-engineered disasters may certainly increase the gains from cooperative behavior, they may also change perceptions about the reliability and trustworthiness of other people, especially in those circumstances in which warring factions arise in the midst of what had been a single community.

A recent example of work that explores the impact of civil conflict on preferences is the Voors et al. (forthcoming) study of civil violence in Burundi. They find an increase in altruistic, risk taking and impatient behavior as a consequence to exposure to political violence.

Similarly, the work by Bellows and Miguel (2006, 2009) in Sierra Leone and Chen (2010) in Indonesia show that membership in civil and religious organizations are positively affected by violence and economic distress. Membership in groups is of course not an anonymous process, and aside from the usual concerns about the economic endogeneity of membership (Carter and Castillo, 2011), it is not clear if increased membership in groups signals a general increase in pro-social norms that would apply to interactions with anonymous individual, or simply a banding together of an out group for self-protection against a generally untrusted world.

Studies that exploit differential exposure to civil violence must of course also deal with the question of whether the treatment is randomly distributed, or if in fact those who suffer such calamity were targeted, precisely because they were leaders or others already pre-disposed to pro-social behavior. While the work on civil violence cited here expends significant attention on this question, studies based on shocks randomly distributed by nature are, prima facie, less likely to suffer this problem. Exploiting this kind of variation, Eckel, El-Gamal and Wilson (2009) have shown that survivors of Hurricane Katrina in New Orleans tended to act more risk lovingly, while Cassar, Healy and Kessler (2011) show that the tsunami in Thailand increased the level of risk aversion and trust, but had a lesser impact in trustworthiness and time preferences.

Our study is most closely related to these latter pieces of work. To gauge the severity of the natural shock generated by Hurricane Mitch, we used standard interpolation techniques to generate community-specific measures of the amount of rain that battered these communities during the hurricane. We show not only that this measure captures the damages suffered by these rural Honduran communities, but also that the rain variable is unlikely to capture unmeasured differences across communities. In short, the evidence suggests that Mitch indeed randomly distributed destruction across Honduras. Our measure of a natural shock provides us with a gradient of severity that allows us to test its impact on behavior.

Exploiting this randomly generated variation in exposure to shocks, we measure pro-social preferences through two economic experiments: a modified investment, or trust game

(Berg, Dickhaut and McCabe, 1995) and a modified dictator game (Forsythe et al., 1994), both played in the mid-2002, roughly four years after Mitch.[1] We find that behavior across communities is quite diverse. The average percent passed in the modified dictator game ranges from 22 percent to 69 percent, while the average percent passed in the modified trust game ranges from 26 percent to 67 percent. The lowest average percent sent back in the trust game is 25 percent while the highest is a 63 percent. This variation shows that measured social interactions can be quite different even among groups sharing many of the same characteristics. Most importantly, we find that not all of this variance is random. Individuals in communities experiencing more rain tend to send and return more in the trust game. We find that the weather shock not only affects the mean but also the variance of behavior (the latter as measured by an inter-quantile regression). This result is robust to several specifications and additional controls. Our estimates suggest that a 5 percentage points increase in rain in October 1998 yields 8.5 percentage points increase in the amount passed in the trust game. The effect, however, is nonlinear. A 10 percentage point increase in the amount of rain in October 1998 represents only 4 percentage point increase in the amount passed in the trust game. While negative shocks might promote cooperation, too large negative a shock appears to begin to diminish it.

The comparison of individual behavior in the dictator game and the trust game allows us to directly contrast whether equilibrium behavior itself is affected by a negative shock or is simply a shift in preferences that makes people more altruistic.[2] We find robust evidence of the influence of the negative shock in the strategic environment of the trust game, but less so in the individual decision exercise which defines the dictator game. This study, and also Carter and Castillo (2005, 2011), therefore suggests that attention to equilibrium behavior, as well as to preferences, is necessary. Importantly, changes in equilibrium behavior

[1]Carter et al. (2007) examine Hurricane Mitch through the lens of poverty traps and find that it real economic effects that persisted for at least unitl the time of the experiments.

[2]As noted originally by Cox (2004), the trust game can conflate increases in trust and trustworthiness with increases in altruism. Two early efforts to further explore Cox's insight–both implemented in 2001–are reported in Ashraf, Bonhet and Piankov (2006) and Carter and Castillo (2011).

behavior at the local level might affect measured preferences making it possible that changes in the underlying conditions manifest themselves as changes in preferences (see Friedman and Sunder 2011 and the citations therein).

The remainder of this paper is organized as follows. Section 2 describes the impact of Hurricane Mitch. Section 3 describes experimental procedures. Section 4 presents the main results and robustness checks, while Section 5 concludes.

2. Measuring the Size and Impact of Hurricane Mitch

To estimate the differential impact of the hurricane across Honduran communities we rely on the monthly rainfall estimates produced by Willmott and Matsuura at University of Delaware (http://climate.geog.udel.edu/˜climate/). While other sources of rainfall data are available (*e.g.,* the Global Precipitation Climatology Project, http://precip.gsfc.nasa.gov/), we rely on the former because it is geographically more detailed. The data are based on a grid of half degree precision that gives us forty observations for Honduras. In addition, the data set compiles monthly information for a period of over fifty years. In our study, precipitation data is interpolated to the community level using a inverse-distance weighted method with a weight of 2 (Lam 1983, Kelway 1974). Our measure of the weather shock is the observed precipitation in October 1998, the month in which Hurricane Mitch hit Honduras (Oct 28 through Oct 31, 1998).

While these community-level rainfall data seem reasonable as a measure of the severity of the environmental shock, we can check their veracity by examining living standards data collected in 2001 from the same communities in which the experimental games were implemented in 2002. These living standard data come from a random sample of 850 rural households from 5 departments in Honduras. These households were surveyed regarding the 2000 agricultural year. In addition to current income and expenditure data, the 2001 survey also solicited detailed information on damages suffered during Hurricane Mitch. Assets shocks include the value of land washed away, permanent crops (primarily coffee plantations) destroyed, as well the value of livestock and machinery that were killed or destroyed. Income and expenditure shocks include the imputed net value of crops that were washed away, costs of medical expenses, lost off-farm earnings and reductions in remittances. Assets were priced using median values by geographic locale, and all the values of asset and income shocks were inflated to the price level at the time of the 2001 survey. For those households suffering loss of productive assets, the median loss varies from about 7500 to 13,000 Lempira. To help these figures in perspective, median (mean) household income in this sample was 13,500 (30,200) Lempira in 2001.

Table 1 presents descriptive statistics on the weather shock and other economic variables of interest. In addition to presenting overall sample means, Table 1 also presents measures broken down by the severity of the weather shock received by households. The first set of rows display information on the severity of Hurricane Mitch in the different study communities. As can be seen, in the lowest storm severity tercile, October 1998 rain was approximately 330% of the long-term average for the month of October. This figure is 299% and 195% for the medium and extreme storm severity groups.[3] As would be expected, average losses increase monotonically with the storm severity. The fraction of households suffering losses dips slightly from 43% to 40% when moving from low to medium storm severity, but then jumps to 61% for communities in the highest shock tercile. We conclude that the actual amount of rain received in October 1998 is a better measure of the weather shock than it is the excess amount of rain from long-term average.

The second block of rows in Table 1 report average behavior in the experimental games implemented in these communities (and described in more detail in Section 3 below). As can be seen, the severity of the shock significantly affects the behavior in the dictator game and of proposers in the trust game. Subjects in the lower tercile pass 37% of their endowment on average, while those in the middle range pass 50% of their endowment on average. A similar pattern is apparent in the behavior of receivers in the trust game, but these unconditional differences are not significant.

The final block of rows present information on pre- and post-Hurricane Mitch conditions in the different communities. We observe that only the level of education of the household

[3] To appreciate the severity of the hurricane, keep in mind that most of this excess monthly precipitation fell within the three days of the storm.

head in 2001 is statistically significantly different across terciles of the severity of the shock. Importantly, Table 1 shows that the 2001 retrospective estimates of the value of assets and land prior to Hurricane Mitch are not statistically different across groups. Finally, according to the Honduran living standard survey of 1997,[4] we find that the per-capita income of the rural households in the departments under study is not correlated with the severity of the weather shock in 1998.

As can be seen, based on these measures of pre-shock initial conditions, there is no evidence that areas that were hardest hit were either richer or poorer prior to the hurricane. Regression analysis of these data (results available upon request) confirms that our measure of the weather shock is strongly positively correlated with losses and not significantly correlated with per-capita income prior to the shock after controlling for socio-economic background.

In sum, we find that our measure of weather shock is strongly correlated with measured losses and shows no clear relationship with other socio-economic conditions prior to the hurricane. The measure give us an opportunity to assess the impact of shocks on individual behavior free of endogeneity issues and measurement problems.

3. Experimental Design and Procedures

This study employed experiments based on the dictator game (Forsythe, Horowitz, Savin, and Sefton, 1994) and the investment game (Berg, Dickhaut, and McCabe, 1995). In the modified dictator game we use, the proposer was endowed with an amount of money that he had to decide to keep or share with a responder who was not given an endowment. Each unit of money passed by the proposer was tripled before reaching the responder, making it relatively cheap for the proposer to give money to the responder (i.e., the price of giving one unit of money was $\frac{1}{3}$. In the modified investment game, the sender was endowed with an amount of cash that she had to decide to keep or share with an individual without an

[4]source: Honduran 'Encuesta Permanente de Hogares de propósitos Múltiples (EPHPM)' for June and September 1997.

endowment[5] Money sent to the responder was again tripled, and the responder had the opportunity to send back none, part or all the amount received.

These experiments were implemented in 30 separate rural Honduran communities in mid-2002.[6] These communities were selected at random from the communities included in the 2001 living standards survey described in the prior section. The communities are spread across the major geographic regions of Honduras. One in seven of the experimental subjects was recruited from the respondents to the survey, while the others were selected from other families in the same communities. Recruitment of these other participants was made with the help of local leaders (typically school principals) who were asked to recruit adults among families of different backgrounds. Not more than one participant per household was allowed. All the participants were at least 18 years of age and they were not told about experimental payments at the time of recruitment.

Table 2 compares the age and education of the experimental sample to the 2002 Honduran census on the same communities. At 41 years of age, the average participant is slightly older than the average community member as measured by the census. Men are over-represented in the experiment, and educational level roughly match average levels in the community (though precise judgment on this point is not possible as the census information does not allow us to isolate average education levels for those older than 18 years).[7] On average, there were 24 subjects per session. Two sessions were smaller (16 participants), and three sessions were larger (32 participants). All participants in each session belonged to the same community or neighborhood. On average, participants knew 88% of the people in the session by name.

Before starting the experiment, participants were randomly assigned to one of three separate rooms at a local school.[8] A quarter of the participants were assigned to each of the

[5] In the original game, the responder also was given an endowment.

[6] We collected data in two additional communities, but we did not collect enough detailed personal information as to include them in the analysis.

[7] Twenty five percent of participants had at most 5 years of education and 25% of them had at least 6 years of schooling.

[8] A team of three people implemented the experiments.

two proposer rooms, Rooms A and B. The remaining 50% of the participants were assigned to a single responder room, Room C. This design holds community-level contextual effects constant across Rooms A and B. Two rounds of games were played, and all individuals ultimately participated in one round of the trust game and one round of the dictator game.

After all individuals had been assigned and physically separated into their room groups, the Room C responders were internally subdivided into two sub-groups. Sub-group C_{AB} served as the responders for the Room A senders in the first round game, and they were the responders for the Room B senders in the second game. Sub-group C_{BA} played the opposite roles This arrangement permitted us to tell senders that they would interact with two different responders for their first and second games and avoid dynamic effects. Responders did not know with which sender room they were interacting. Subjects were not allowed to talk to one another during the experiment. To protect each participant's privacy, subjects were given a privacy box where they could handle money without being seen by others. Each sender had two coded colored envelopes if she was playing the modified dictator game and 3 coded colored envelopes if she was playing the modified investment game. Decisions were made by passing money from one envelope to another. Experimenters then picked up the envelopes with the money to be passed to responders in a box without looking at the contents. A different experimenter added the necessary tripled amounts of money and delivered the envelopes to the responders' room.

The Room A senders played the dictator game first and the modified investment game second. To test for game order effects, Room B proposers first played the trust game and then the dictator game. The endowment for the dictator game was 40 Lempiras ($2.5) and the endowment for the trust game was 50 Lempiras ($3.1). Each Lempira sent to the other room was tripled in both games. The average payment to a participant in the experiment was 90 Lempira (or around $5), which amounts to two-days wage in rural areas. In all rooms, instructions were read out loud, and then a series of questions were asked to make sure that the games were clearly understood. To avoid letting trustee's decisions influence Room B dictator choices, Room B senders did not learn how responders had responded to their modified investment game decisions until after they had completed the dictator game. Finally, after all games had been played, we administered a post-experiment questionnaire that concentrated on game understanding and demographic and economic background.

Figure 1 shows the location of the visited communities in Honduras. Figure 1 also shows the path of Hurricane Mitch between Oct 28, 1998 and Oct 31, 1998. Communities are marked in different colors to represent the amount of rain received. On average, communities experienced three times the amount of rain than in an average month. The least affected communities received more than double the monthly average and the most affected received about four times the average amount of rain. The actual impact of the hurricane was heterogenous due to the diversity of geography.

4. Results

Table 1 reports the summary statistics of the experiments. Overall, subjects on average sent 42% of their endowment in the dictator game, 49% in the modified investment game, and the unconditional proportion returned by responders was 42% of the amount received.[9] In the dictator game, 7% of the subjects sent no money, and 12% sent all the money. In the modified investment game, 4% sent no money and 13% sent all the money. Average amounts passed in our dictator game are higher than commonly found in experiments with college students (Forsythe et al, 1994; Eckel and Grossman, 1996). However, results from both games are consistent with previous results with non-college students (see Burks, Carpenter, and Verhoogen, 2005). All decisions presented a high degree of variability at the individual level. This variability is also present at the community level; the lowest community average share passed in the dictator game was 22% and the highest was 69%, and the lowest average share passed in the modified investment game was 26% and the highest was 67%.

While the experiments resulted in substantial variation in individual behavior, it is possible that observed differences are an artifact of the relatively small size of sessions. It is therefore necessary to test whether the behavior across communities is a reflection of real behavioral differences. We conduct two such tests. First, we estimate a linear regression

[9] In other words, senders on average profited on money sent to receivers.

model where the only explanatory variables are dummy variables for each community. This model explains 21 percent of the variance in the dictator game, 14 percent of the variance in the behavior of senders and 23 percent of the variance in the behavior of responders in the modified investment game.[10] This suggests the existence of systematic difference across communities.

Second, we perform a test of the hypothesis that all sessions are drawn from the same distribution. To do this, we create an indicator variable that equals one if a subject passes strictly more than half of the available money to other subject. This redefinition of individual decisions is done to minimize the potential unreliability of χ^2 tests when not all individual cells are well populated. We can reject the null hypothesis that all sessions belong to the same distribution for all three decision (p-values of 0.000 for the dictator game, and 0.056 for senders and 0.000 for responders in the modified investment game.) The results are similar if we construct indicator functions for the case in which the share passed exceeds sixty and seventy percent. We now explore whether or not this variation in behavior can be explained by differential exposure to the shock of Hurricane Mitch.

4.1. Environmental Shocks and Pro-social Behavior

Figure 2 shows scatter plots of average behavior by community as a function of our environmental shock variable, the total amount of rain (in mm) received in October 1998. The graphs show that behavior across communities is quite varied. The figure also includes the prediction of a regression of individual behavior on the amount of rain experienced and its square. These regressions indicate that the relation between a negative shock and behavior in the experiments might be nonlinear. A first look at regression results is given in Table 3. Since weather patterns might be ex-ante correlated with local characteristics and institutions, these regressions also control for the amount of rain in an average month and its square. All estimates in the paper allow for correlation in behavior at the community level.

[10]The corresponding p-values for the F-test of joint significant of the dummy variables are 0.000, 0.003 and 0.000.

Table 3 illustrates that the effect of the hurricane can be sizable as shown by the large and significant impact of the Mitch shock variables on play in the modified investment game. Controlling for average historical rainfall levels, the estimates indicate that a subject in a community that experienced 725mm of rain in October 1998 versus another that received 675mm will on average pass 10.45% more as a sender and return 7.35% more as a responder in the modified investment or trust game.[11] Due to the nonlinearity of the effect of a negative shock on behavior, the same difference in 50mm across communities receiving above 725mm of rain in October of 1998 will represent a decrease in the amount passed and returned in the modified investment game. The estimates therefore suggests that while negative shocks might promote cooperation, too large a shock might actually destroy cooperation. This finding seems to harken to a Toynbee perspective on history: without environmental challenge and stress, societies find if difficult to evolve. But too much challenge can similarly overwhelm such evolutionary development.[12]

The expanded specification for the receivers decision shows that the amount returned to the sender is a modestly, but statistically significant, decreasing function of the amount received. The estimated coefficient implies that a person passing an extra L10 (the receiver gets L15 more) in the trust game must expect a drop in the return rate of 5.8 percentage points. When interacted with the environmental shock variable (results not reported here), this negative response to amount received was flattened, although the estimated coefficient was not significant. In particular, we find that the difference in return rates of a person experiencing the maximum amount of rain and passing an extra L10 is 3.8 percentage points higher than a person that experience the least level of rain and passing L10 more.

Finally, while the estimates show a positive effect of weather shocks on giving, as measured by the dictator game, we have not been able to find a robust, statistically significant, relationship in this game. When coupled with the findings on the trust game, the lack of a

[11]To make the parameter estimates more readable, estimations used the amount of rain in mm divided by 100.

[12]While not without its detractors, Toynbee's (1946) theory of 'challenge and response' remains an intriguing effort to account for very broad patterns in the development of human societies.

robust impact on play in the dictator game suggests that the shock of Hurricane Mitch had less impact on primitive, other-regarding preferences, and instead allowed communities to to coordinate around a more cooperative equilibrium in which senders send more and receivers in turn reciprocate and behave in a more trustworthy fashion, returning more to senders.

While these results are intriguing evidence that environmental shocks move local social norms and expectations, we might worry that they reflect a spurious correlation between the environmental shock and other factors. To explore this possibility, Table 4 explores the robustness of these results to the inclusion of extra covariates. Additional covariates include socio-economic characteristics of the subjects, how well a subject knows those participating in the experiment, the average characteristic of the subjects in the room, geographical characteristics of community and game order and experimenter controls. We find that the measured effect of the negative shock diminishes, but it remains large and statistically significant. This is remarkable considering that our measure of the negative shock is not only measured with error, but that the hurricane itself is expected to have had a direct impact on many of the covariates included as controls. For instance, one might expect that community members might become better acquainted due to the emergency and than some segments of the population might have been more able to migrate away from the region. Nonetheless, the estimated direct impact of the hurricane remains robust to the inclusion of these variables.

While there are a variety of reasons to prefer norms revealed through games as opposed to self-reported trust or economically endogenous group memberships (Carter and Castillo 2011), our data allow us to further explore the robustness of the impact of environmental shock by looking at these other kinds of indicators of pro-social behavior. Table 6 presents linear regression estimates of the effect of the weather shock on the answer to the questions: 'When a lot of money is at stake, how much do you trust others?', 'When little money is at stake, how much do you trust others?', 'In thinking of people other than your household members; how many close friends would you say you have?', 'How many people can you count on in case of an emergency?' In addition, the table presents linear regression estimates on membership in local organizations. All the regressions follow the same specification as in

Table 5 and include subjects that participated in different roles in the experiments. The number of observations per question varies due to attrition.

The first thing to notice in Table 5 is that our measure of a weather shock has a large and significant impact on these measures as well. This not only gives us confidence that the experimental results are capturing a true change in behavior, but also allow us to see what potential mechanisms might be behind this change. Table 6 shows that personal relationships are positively, yet nonlinearly, correlated with a negative shock. Subjects in communities that experienced larger weather shocks are more likely to express trust in others and have a larger numbers of friends and emergency contacts. Also, subjects experiencing larger negative shocks are more likely to say that they do not belong to local formal organizations. Specifically, we find a significant drop in membership to local government organizations, e.g. producers' associations, water management authority, parents' association and local council.

Given that our estimates on the effect of a negative shock on unconditional giving in the dictator game are not robust, these additional regressions suggests that part of the change in these communities have been a change from formal relations to informal reciprocal relations. The fact that losses in consumption and assets and increases in the amounts shared with others are both related to the weather shock suggests that the result might be an expression of a change in economic conditions. If we assume that sharing is a normal good, this finding would suggest that it is a result of larger benefits to sharing. However, as already shown by Goette, Huffman and Meier (2006), sharing an experience can affect preferences directly. If the main mechanism by which behavior is correlated with excess rainfall is through increased affection towards those sharing the experience, we would expect a general increase in sharing by all subjects.

4.2. Impact Heterogeneity

In contrast to similar work on the impact of civil violence and environmental shocks on behavior (reviewed in the introduction above), our results point to a non-linear impact of shocks on the extent of pro-social behavior. Digging a little deeper, we ask whether the average (non-linear) tendency revealed by this analysis adequately represents the full distribution of impacts or whether there is further evidence of impact heterogeneity. To explore this question, we estimate the quantile regressions of the form for outcome y and explanatory variables x:

$$Q_q(y) = \beta_q x_i$$

where q indicates the regression quantile. Table 5 presents the interquantile differences defined as the difference $\beta_{0.75} - \beta_{0.25}$. That is, the estimates allows to see how different are the impacts of shocks on the upper and lower quantiles of the conditional error distribution. The estimation included the full set of covariates as in Table 4. As can be seen, the average effects of shocks reported in Tables 3 and 4 appear to be an average of quite heterogeneous impacts. Some observations–those in the upper quantiles–respond much more strongly than average to the environmental shock, while the lower quantile respond much less. Interestingly, the interquantile differences reveal no differences in the impact of the other covariates. It thus appears that negative shocks create opportunities for community members to cooperate with one another, but it cannot at all be taken for granted that all communities will respond similarly to these incentives. Increased cooperation is not a foregone conclusion.

4.2. Placebo Tests

While our core results are robust to the inclusion of a suite of covariates, including average historical rainfall levels, the small number of communities in the sample might still raise concerns that the estimated impacts of shocks is the result of a spurious correlation between the shock and unmeasured community characteristics. To explore this possibility, Table 7 replicates the core Table 4 regression, except that the Hurricane Mitch shock measure is replaced by placebo measures of weather shocks. The placebo measures of weather shocks are the amounts of rain in the months of October 1958, 1968, 1978 and 1988. These regressions allow us to evaluate to what extent our results are the result of chance. Keeping in mind that the level of rain in these periods are correlated with the level of rain in October 1998,[13] we find that none of these measures can reproduce the patterns or magnitude of the

[13]The correlation coefficients between the level of rain in October 1998 and October 1958, 1968, 1978 and

effect of rain reported in this paper. Our main results are therefore unlikely due solely to spurious correlation.

5. Conclusions

We set out to investigate the impact of environmental changes on social norms and social interactions. To do this, we implemented a series of experiments measuring giving and trust along the path of Hurricane Mitch that ravished Honduras in October 1998. The experiments were conducted in small stable communities that share socio-economic characteristics. To minimize procedural variance across communities, the experiments were implemented following identical protocols by the same set of experimenters. All the interactions in the experiment were anonymous.

Our main result is that environmental changes have a direct impact on trust and reciprocity. Negative weather shocks are associated with an increase in cooperative behavior, but this relationship is not linear. A negative shock might foster cooperation, but too large a shock might not. An extra 5 percentage points in rain in October 1998 yields 8.5 percentage points increase in the amount passed in the trust game, but a 10 percentage point increase in the amount of rain in October 1998 represents only 4 percentage point increase.

While the communities affected by the shock might not have fully recovered by the time of the experiments (four years later), our results are robust to a series of controls for socio-economic background of participants and experimental sessions. Importantly, we present evidence suggesting that a strengthening of informal relationships might have occurred as a result of the weather shock. Negative events are related to increased variance in behavior, suggesting that new norms are developing or that different groups have different contingent norms. This is consistent with behavior in experiments being a reflection of local social norms and norms being an expression of multiple equilibria.

Our study shows that field experimental methods can be very useful in investigating the reasons behind observed heterogeneity in equilibrium behavior across populations. While personal experiences can have an impact on individual behavior, our study shows that this

1988 in the sample are 0.91, 0.45, 0.89, and 0.94.

naturally extends to equilibrium behavior.

6. References

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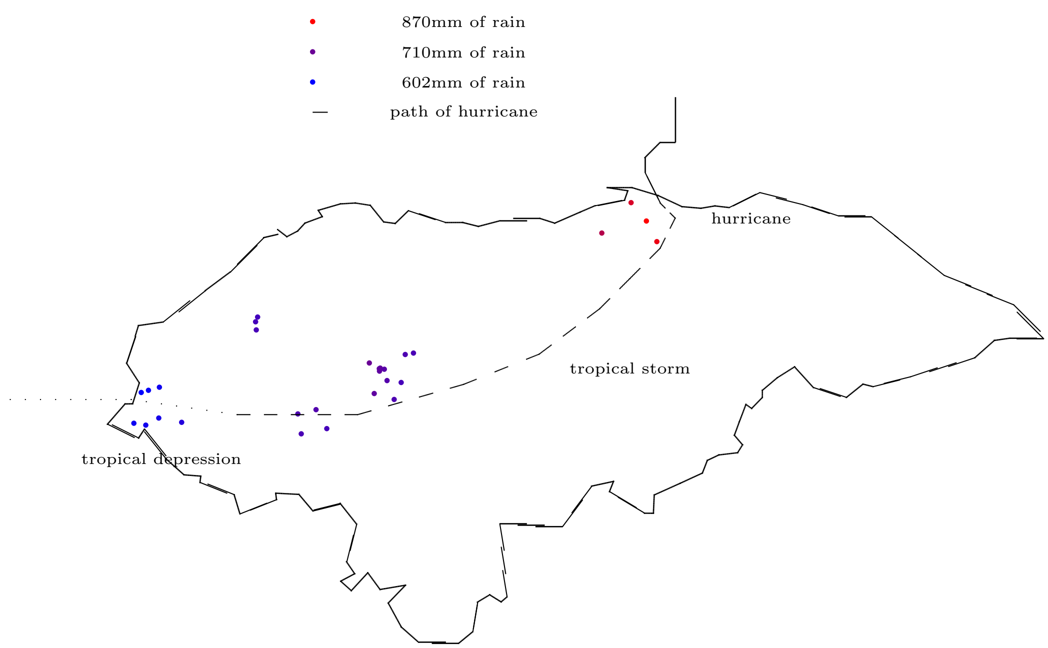
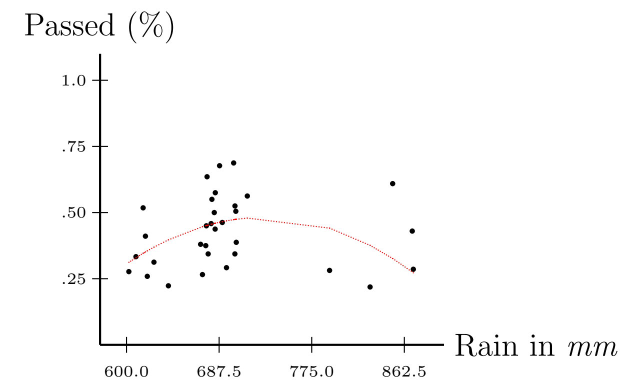
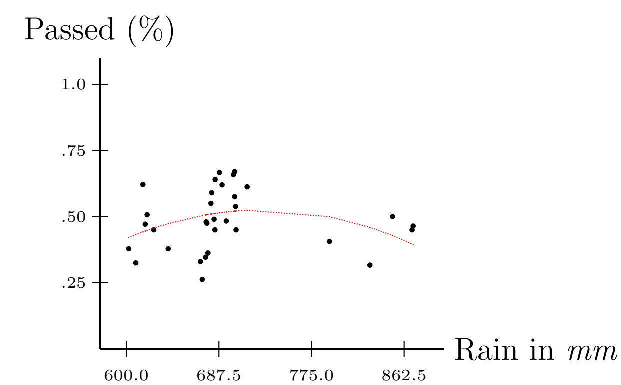


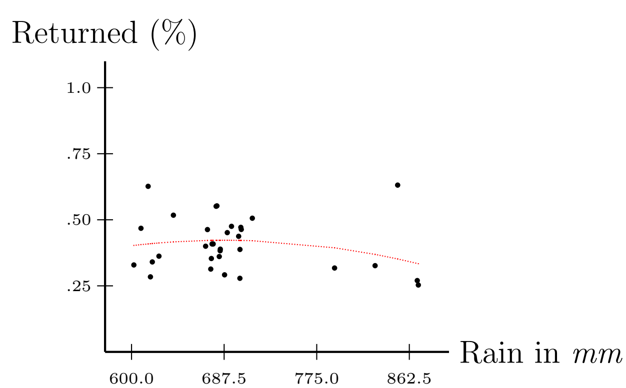
Figure 1. Communities visited along hurricane Mitch path



Dictators



Senders



Responders

Figure 2. Rainfall and Community Level Behavior

Table 1. Relation between hurricane and economic variables

	Rain impact in October 1998			
	Low	Medium	High	
Shock magnitude and damages				
Average amount of rain in October 1998 (mm)	639.8	680.1	757.7	***
	(28.6)	(3.7)	(61.1)	
Average amount of rain in October 1950-99 (mm)$^{+}$	148.6	170.3	256.7	***
	(13.9)	(4.8)	(66.5)	
Losses due to Hurricane Mitch (Lempiras)	-8,558.2	-9,671.2	-21,440.6	***
	(26,545.9)	(54,359.6)	(58,275.2)	
Percent of household reporting losses	43.3%	40.6%	60.9%	***
	(49.6%)	(49.2%)	(48.9%)	
Behavioral patterns				
Percent sent in dictator game	36.8%	49.8%	44.9%	***
	(27.1%)	(30.5%)	(31.5%)	
Percent sent in trust game	42.7%	53.8%	53.2%	***
	(25.2%)	(30.7%)	(30.2%)	
Percent returned in trust game	40.3%	45.3%	40.4%	
	(26.6%)	(33.2%)	(30.1%)	

*** p<0.01, ** p<0.05, * p<0.10, $^{+}$ excluding October 1998

(continue in next page...)

Table 1. Relation between hurricane and economic variables

(continuation...)

	Rain impact in October 1998			
	Low	Medium	High	
Pre- and post-hurricane conditions				
Per capita income in 1997 (Lempiras)	421.7	338.6	389.2	
	(735.2)	(456.2)	(491.6)	
Household Assets pre-Mitch (Lempiras) - median	106,729.8	83,309.0	117,628.4	
	(2'761,907)	(589,365.0)	(836,705.7)	
Value of land pre-Mitch (Lempiras) - median	52,111.7	48,854.7	52,111.7	
	(1'491,086.0)	(475,007.7)	(533,597.9)	
Household head years of age	50.0	52.9	51.9	
	(16.2)	(16.8)	(15.6)	
Household head years of education	6.6	6.1	7.2	**
	(5.1)	(4.5)	(4.5)	
Household size	9.0	8.0	9.0	
	(3.5)	(3.7)	(3.9)	

*** $p<0.01$, ** $p<0.05$, * $p<0.10$, $^{+}$ excluding October 1998

Table 2. Descriptive Statistics

	Communities	2001 Population Census				2002 Experimental Study			
Province	Visited	N[a]	Age[b]	%Men	Education[c,d]	N[e]	Age[b]	%Men	Education[b,d]
Colon	4	361.0	37.9	49%	1.9	24.5	46.7	62%	1.1
Comayagua	12	79.2	37.5	49%	1.9	22.0	39.9	50%	1.1
Intibuca	4	88.3	36.7	51%	1.7	20.5	39.1	56%	0.8
Ocotepeque	7	240.4	38.0	50%	2.0	25.4	39.5	72%	1.1
Santa Barbara	3	83.0	38.9	56%	1.9	24.7	44.3	64%	0.7

[a]Average number of households per community, [b]conditional on being older than 18 years of age,[c]all ages, [d]0=no education,1=Grade School,2=High School,3=college, [e]Average number of subjects per session

Table 3. Descriptive Statistics for Shares Sent and Returned

	Trustor	Trustee	Dictator
N	389	336*	389
Mean	49%	41%	43%
Std. Deviation	29%	29%	30%
% who sent no money	4%	7%	7%
% who sent all the endowment	13%	12%	12%

* some data was lost due to miscoding

Table 4. Linear regression estimates of the effect of rainfall on individual decisions

	Amount Passed			
VARIABLES	Sender	Responder	Responder	Dictator
Rain in Oct 98 (cm×10)	3.583***	3.250***	4.091***	2.640
	(0.008)	(0.004)	(0.001)	(0.148)
Rain in Oct 98 squared (cm×10)	-0.241***	-0.219***	-0.276***	-0.179
	(0.009)	(0.004)	(0.001)	(0.139)
Average monthly rain (cm×10)	0.701	-6.381	-6.688	3.512
	(0.888)	(0.413)	(0.434)	(0.672)
Average monthly rain sq. (cm×10)	0.029	2.202	2.349	-0.966
	(0.985)	(0.367)	(0.378)	(0.712)
Amount Received			-0.002***	
			(0.004)	
Constant	-13.831***	-6.944	-9.786*	-12.300*
	(0.010)	(0.183)	(0.091)	(0.078)
Observations	384	367	367	384
R-squared	0.038	0.023	0.073	0.047

Clustered errors at the community level, p-values in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 5. Linear regression estimates of the effect of rainfall on individual decisions

	Amount Passed			
VARIABLES	Sender	Responder	Responder	Dictator
Rain in Oct 98 (cm×10)	2.919***	1.855	2.474**	1.735
	(0.006)	(0.154)	(0.044)	(0.243)
Rain in Oct 98 squared (cm×10)	-0.195***	-0.122	-0.163*	-0.118
	(0.006)	(0.167)	(0.051)	(0.227)
Average monthly rain (cm×10)	1.227	-8.197	-9.268	0.668
	(0.796)	(0.236)	(0.170)	(0.929)
Average monthly rain sq. (cm×10)	-0.213	2.619	3.005	-0.131
	(0.886)	(0.221)	(0.151)	(0.9560
Years of age	0.001	-0.001	-0.001	0.002**
	(0.332)	(0.664)	(0.718)	(0.041)
Male	-0.016	0.017	0.004	0.060
	(0.654)	(0.657)	(0.900)	(0.132)
Primary education	0.023	0.010	0.026	0.081
	(0.707)	(0.868)	(0.631)	(0.101)
Secondary education	-0.066*	-0.045	-0.054	0.017
	(0.054)	(0.483)	(0.358)	(0.709)
Family size	-0.003	-0.007	-0.005	0.003
	(0.553)	(0.237)	(0.286)	(0.607)
People known by name	0.178***	-0.036	-0.043	0.135**
	(0.006)	(0.590)	(0.536)	(0.032)
Poor	-0.042	-0.011	-0.007	-0.053*
	(0.298)	(0.800)	(0.868)	(0.057)
Distance to Municipality	-0.002**	0.000	0.000	-0.002**
	(0.025)	(0.867)	(0.682)	(0.037)

Clustered errors at the community level, p-values in parentheses

*** p<0.01, ** p<0.05, * p<0.10

(continue in next page...)

Table 5. Linear regression estimates of the effect of rainfall on individual decisions (continuation...)

	Amount Passed			
VARIABLES	Sender	Responder	Responder	Dictator
Altitude	-0.000	0.000	0.000	-0.000
	(0.474)	(0.384)	(0.218)	(0.274)
Urban	0.075	0.053	0.032	0.004
	(0.107)	(0.226)	(0.500)	(0.917)
Amount Received			-0.002***	
			(0.001)	
Room level averages, order and experimenter controls	Yes	Yes	Yes	Yes
Constant	-11.247***	-0.349	-1.777	-6.035
	(0.009)	(0.961)	(0.795)	(0.235)
Observations	351	331	331	351
R-squared	0.185	0.066	0.135	0.245

Clustered errors at the community level, p-values in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Table 6. Interquantile regression of the effect of rainfall on individual decisions

	Amount Passed			
VARIABLES	Sender	Responder	Responder	Dictator
Rain in Oct 98 (cm×10)	6.270***	6.235**	6.223**	3.062
	(0.005)	(0.036)	(0.012)	(0.269)
Rain in Oct 98 squared (cm×10)	-0.422***	-0.413**	-0.416**	-0.212
	(0.005)	(0.039)	(0.014)	(0.248)
Average monthly rain (cm×10)	6.053	-18.008	-15.021	12.729
	(0.640)	(0.268)	(0.211)	(0.334)
Average monthly rain sq. (cm×10)	-1.530	5.909	4.996	-3.805
	(0.708)	(0.250)	(0.186)	(0.362)
Amount received			-0.001	
			(0.117)	
Controls as in Table 5	Yes	Yes	Yes	Yes
Constant	-28.231***	-8.991	-11.327	-21.247***
	(0.001)	(0.443)	(0.306)	(0.010)
Observations	351	331	331	351
Pseudo-R2	0.1048	0.0788	0.0993	0.0979

p-values in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Table 7. Linear regression estimates of the effect of rainfall on individual decisions

	Percent Sent				
VARIABLES	Trust Game - Sender				
	Oct 1998	Oct 1988	Oct 1978	Oct 1968	Oct 1958
Rain in Oct (cm×10)	2.754***	-0.075	0.136	0.595	0.415***
	(0.006)	(0.525)	(0.372)	(0.210)	(0.002)
Rain in Oct. squared (cm×10)	-0.184***	0.011	-0.032	-0.085	-0.059***
	(0.007)	(0.768)	(0.283)	(0.356)	(0.003)
Average monthly rain (cm×10)	0.825	7.356*	2.165	0.675	-3.160
	(0.864)	(0.085)	(0.682)	(0.879)	(0.401)
Average monthly rain sq. (cm×10)	-0.102	-2.331*	-0.722	-0.207	1.065
	(0.946)	(0.079)	(0.657)	(0.881)	(0.362)
Amount Received					
Constant	-10.338**	-4.850	-0.851	-0.672	2.513
	(0.018)	(0.148)	(0.839)	(0.849)	(0.383)
Observations	351	351	351	351	351
R-squared	0.181	0.173	0.173	0.181	0.197

Clustered errors at the community level, p-values in parentheses.

All regression include the same controls as in Table 5.

*** p<0.01, ** p<0.05, * p<0.10

(continue in next page)

Table 7. Linear regression estimates of the effect of rainfall on individual decisions

VARIABLES	Percent Returned Trust Game - Receiver				
	Oct 1998	Oct 1988	Oct 1978	Oct 1968	Oct 1958
Rain in Oct (cm×10)	2.474**	-0.005	0.438*	0.037	0.069
	(0.044)	(0.971)	(0.053)	(0.958)	(0.628)
Rain in Oct. squared (cm×10)	-0.163*	0.008	-0.087*	0.007	-0.006
	(0.051)	(0.861)	(0.056)	(0.960)	(0.773)
Average monthly rain (cm×10)	-9.268	-1.584	-6.806	-2.654	-4.970
	(0.170)	(0.791)	(0.238)	(0.612)	(0.397)
Average monthly rain sq. (cm×10)	3.005	0.432	2.021	0.782	1.504
	(0.151)	(0.812)	(0.256)	(0.628)	(0.407)
Amount Received	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	-1.777	1.732	5.478	2.423	4.306
	(0.795)	(0.730)	(0.240)	(0.575)	(0.375)
Observations	331	331	331	331	331
R-squared	0.135	0.124	0.130	0.126	0.127

Clustered errors at the community level, p-values in parentheses.

All regression include the same controls as in Table 5.

*** p<0.01, ** p<0.05, * p<0.10

(continuation)

Table 8. Linear regression estimates of the effect of rainfall on survey questions

	Trust others...		Organizations		Informal relationships		
VARIABLES	much money	little money	All	Local government*	Number of close friends	Help contacts	Relative help contacts
Rain in Oct 98 (cm×10)	3.917	6.366**	-18.090**	-5.372*	20.648	12.327*	11.730**
	(0.186)	(0.027)	(0.018)	(0.086)	(0.163)	(0.085)	(0.019)
Rain in Oct 98 sq. (cm×10)	-0.266	-0.434**	1.218**	0.366*	-1.423	-0.803*	-0.789**
	(0.187)	(0.026)	(0.016)	(0.079)	(0.153)	(0.097)	(0.018)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-4.132	-22.637*	52.592**	14.744	-182.371***	18.339	-24.593
	(0.683)	(0.063)	(0.044)	(0.218)	(0.001)	(0.461)	(0.171)
Observations	683	681	578	578	668	531	531
R-squared	0.178	0.178	0.162	0.192	0.061	0.107	0.131

Clustered errors at the community level, p-values in parentheses. All regression include the same controls as in Table 5.

Number of observations varies due to item non-response.

* Local government and producers' associations.

*** p<0.01, ** p<0.05, * p<0.10