FONDATION POUR LES ÉTUDES ET RECHERCHES SUR LE DÉVELOPPEMENT INTERNATIONAL

Weather-indexed insurance and productivity of small-scale farmers: An impact evaluation of Mexico's CADENA program

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Abstract

Farmers in developing countries face substantial weather risk but often have few financial tools to deal with this risk. To address this issue, the Mexican government instituted a program in 2003 called CADENA that currently provides both agricultural and livestock insurance to small farmers. A large portion of the agricultural land that the program covers is insured via weather index insurance. This policy brief summarizes the preliminary results of an evaluation of CADENA's weather index insurance component. A regression discontinuity design using insurance thresholds allows us to determine the impact of receiving payment in the case of a weather shock among the set of insured municipalities. We find that payment results in an increase in the log hectares of maize sowed relative to the previous year. We also find evidence of positive effects on income and expenditure per capita in rural localities, particularly those where a large percentage of agricultural land is controlled by eligible producers. We hope to refine and expand this analysis with additional data in the future.

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1. I would like to thank Alan Fuchs at the World Bank and Artemio Coutiño at the Mexican Ministry of Agriculture (SAGARPA) for providing valuable information about the CADENA program and facilitating access to data.

Introduction and program background

Weather shocks are a major source of income fluctuations among rural populations in developing countries, and they can have catastrophic impacts on vulnerable populations. With a rural population of approximately 27 million and two-thirds of the country's poor living in rural localities (CONAPO, INEGI), weather risk is an important issue for poverty reduction efforts in Mexico. To address this issue the Mexican Ministry of Agriculture (SAGARPA) began an index insurance program named CADENA in 2003, offering weather index insurance (WII) to small maize farmers in one state in Mexico. As of 2013, CADENA had almost nationwide coverage insuring more than 6 million hectares (FAO, 2014). The program currently offers WII to farmers growing staple crops on less than 20 hectares of rainfed land (SAGARPA, 2014). The insurance provides coverage during three pre-determined phases that cover sowing through harvesting. If precipitation falls below (or above in the case flood insurance) the threshold in any of the three phases, the farmers receive indemnity payments. By having the state or federal governments instead of individual farmers pay the insurance premiums, the CADENA program has been able to achieve widespread coverage. Evaluating an existing program with national coverage is an important contribution to the literature on index insurance in developing countries, since much of evidence regarding the effectiveness of WII comes from smaller scale projects. The CADENA program has been previously evaluated in Fuchs and Wolff (2010), which uses the rollout of the program to estimate impacts on income and agricultural yields. Fuchs and Wolff find that the program increases maize yields and rural per capita expenditure and income, but not the area devoted to planting insured crops. The goal of this evaluation is to take advantage of additional data as the program has expanded in geographic scope and has now been in existence for over a decade. Furthermore, we hope to disentangle the direct effects of insurance payments and the effects of changes in investment behavior induced by the insurance. This evaluation focuses on a regression discontinuity design to analyze the effect of payment. The preliminary results suggest that insurance payments increase per capita income and expenditures in rural localities, echoing the findings in Fuchs and Wolff (2010). However, unlike Fuchs and Wolff, we find that insurance payments increase the land area devoted to insured crops, but not the yield of said crops.

Preliminary analysis

Providing insurance to previously uninsured farmers has two distinct, although interrelated, effects. Insurance has the direct effect of payment in case of a bad weather realization, which can help smooth consumption or ensure sufficient resources for production in subsequent seasons. The risk reduction that this entails can have indirect effects on economic outcomes by altering farmers' investment decisions; for example, encouraging them to adopt riskier but more profitable investments during the planting stage. We begin our evaluation of the CADENA program by focusing on the direct effect of providing payment. To identify this effect we limit our sample to municipalities that were insured through index insurance policies between the years of 2005 and 2012 and focus for the time being on drought events only. Using weather data provided by the National Water Commission (CONAGUA), we match policies to their corresponding weather stations and calculate deviations from the threshold specified in the policy for each of the three phases. In a regression discontinuity design, we use the minimum deviation from the threshold over the three phases as our running variable. A municipality should receive payment if its deviation from the drought threshold is negative in any of the three phases. This strategy allows us to estimate the impact of payment by comparing insured municipalities with very similar weather realizations, such that any difference in outcomes can plausibly be attributed solely to insurance payments.

Following Card and Lee (2008), we use the entire range of data but control for the conditional expectation of the outcome as a function of the running variable using a quadratic polynomial. Specifically, we estimate the following equations:

$$Pay_{mct} = \alpha + \beta Z_{mct} + \gamma f(X_{mct}) + \pi f(X_{mct}) \cdot Z_{mct} + \delta_c + \varepsilon_{mct} \quad (1)$$

$$y_{mct}+1 = \tilde{\alpha} + \tilde{\beta}\widehat{Pay_{mct}} + \tilde{\gamma} f(X_{mct}) + \tilde{\pi} f(X_{mct}) \cdot Z_{mct} + \delta_c + \tilde{\varepsilon}_{mct} \quad (2)$$

Pay_{mct} is an indicator for payment in municipality m for crop c, and year t, which is instrumented with X_{mct} in equation 2, and y_{mct+1} is our outcome of interest in the following year. X_{mct} is the minimum deviation from the threshold over the three phases ($X_{mct} = min_s \{Rain_{mst} – Threshold_{mcst}\}$ where s indexes phases), and Z_{mct} is an indicator for rainfall falling below the threshold in at least one phase $\mathbf{1}\{X_{mct} < 0\}$. The function $f(X_{mct})$ in our case is a quadratic polynomial in X_{mct} . Lastly, δ_c is a crop fixed effect. We restrict ourselves to the insured crops, which are rainfed corn, sorghum, barley, and beans.

Panel b of figure 1 (see page 6) illustrates the graphical equivalent of equation (1), which is the first stage of our regression discontinuity. In theory, all observations with a negative deviation from the threshold should receive payment, while none of those with a positive deviation should receive payment. However, this is not always the case given our data limitations. First of all, the weather stations used to determine if rainfall has fallen below the threshold are sometimes missing data. Secondly, we do not have data for outcome variables for any units smaller than a municipality. However, policies are assigned at the level of the weather station, and there may be multiple weather stations per municipality. To deal with this limitation, any observation within a municipality that receives payment (from any of its policies) is considered treated. This assumption results in some observations being designated as treated despite having rainfall that falls above the thresholds. However, this assumption is reasonable given that program directors have some discretion in allocating funds. Despite this limitation, we observe a strong first stage, as evidenced by the sharp decline in the probability of treatment for observations to the right of the threshold in panel b of figure 1.

In figure 2 (see page 7), we see the corresponding discontinuities in log maize yields in t+1 and the change in log hectares of insured crops sowed from t to t+1 (Δ log hectares sowed). We see a drop in Δ log hectares sowed to the right of the threshold but not so for yield. Considering that municipalities to the right of the threshold are less likely to receive payment, this implies that payment results in an increase in the area sowed for insured crops. This finding is reflected in the regression results reported in table 1, where we find no significant effect of payment on yield, but an increase of approximately .19 log points in the number of hectares sowed with insured crops.

Turning to the economic outcomes, panels a and b of figure 3 (see page 8) show the discontinuities in log total income per capita and log total expenditures per capita. The data for this analysis come from the Mexican Income and Expenditure Survey (ENIGH), and the sample is restricted to rural localities as defined in the survey. We see a sharp decline in both outcomes of interest at the threshold, implying that insurance payment increases income and expenditure per capita. Table 2 reports the regression equivalent of the discontinuity seen in figure 3. The two-stage least squares estimation shows effects of similar magnitude on expenditure and income per capita, around 27%. However, the estimates are somewhat noisy and the effect of payment is only significant for income (at the 10% level).

We further explore the effect of insurance payment, by testing heterogeneity with respect to the percentage of land that is farmed by eligible producers (as mentioned above, those farming corn, barley, beans or sorghum on rainfed land on less than 20 hectares). We would expect the effect of insurance to be proportional to the percentage of land that is farmed by those who are eligible for the program, since they should be the only individuals receiving payment in the case where the insurance is triggered. These results are reported in table 3. Interestingly, when looking at the change in hectares planted, the interaction term (Payment x % eligible) is not significant, while the main effect, Payment, remains significant and of the same magnitude. This implies that the effect of payment does not appear to vary according to the percentage of eligible land. The same is true for yield. However, when we look at economic outcomes, the interaction term is highly significant in both the case of log income and expenditure per capita. Moreover, once the interaction term is included, the main effect is no longer significant, implying that for municipalities with very low percentages of eligible land the effect of payment is almost null. The mean value of % eligible is approximately 50%. Thus, receiving payment increases expenditure and income per capita by approximately 45% and 37%, respectively, for the mean insured municipality. The pattern observed in these results in somewhat puzzling in that we would expect similar results for both the agricultural and economic outcomes. We hope that further analysis will help us elucidate the discrepancy between these results.

Discussion of Results

While this is a preliminary analysis, the results suggest that the insurance payments provided by CADENA increase the amount of land devoted to insured crops, but have no effect on yield. We also find some evidence that payments increase income and expenditure per capita in rural areas, particularly in those with a large number of beneficiaries. One reason why our results could differ from those of Fuchs and Wolff (2010) would be if the increase in yields observed in Fuchs and Wolff is due to changes in investment choices, such as increased fertilizer user at planting, prompted by the reduction in risk for insured producers. We should observe this effect primarily when comparing insured and uninsured municipalities as they do, instead of when the sample is limited to insured municipalities as is the case for this analysis. One caveat with this explanation is that if farmers are credit constrained, we may still find that receipt of insurance payments impacts investment decisions, and consequently yield. Another potential explanation could arise from the fact that the insurance payments provided by CADENA are not sufficient to cover one hundred percent of the planting costs. Thus, they might not provide a strong incentive to increase investment. The government notes that the goal of the insurance is to provide a safety net so that farmers are able to plant the year following a bad weather shock. Insurance payments then allow producers to plant land they may have otherwise left fallow for lack of funds. This proposed mechanism would explain the observed increase in hectares sowed for municipalities that receive payment. We plan to continue this analysis in order to better understand the mechanisms through which insurance impacts agricultural productivity and economic outcomes, which should also help clarify differences between the results of this analysis and those in Fuchs and Wolff (2010). Furthermore, we plan to estimate the impact of insurance on the volatility of state budgets, since one of the aims of CADENA is to insure state governments against large unforeseen expenditures in the case of weather shocks.

Tables

Table 1. Agricultural outcomes, Subsequent year

	(1) First Stage: Payment	(2) Reduced form: Δ log ha sowed	(3) Reduced form: log yield	(4) 2SLS: Δ log ha sowed	(5) 2SLS: log yield
Payment				0.189**	0.144
				(0.0784)	(0.0938)
Below threshold	0.531***	0.0996**	0.0762		
	(0.0526)	(0.0398)	(0.0470)		
Years insured		0.00545	0.0134	0.00559	0.0135
		(0.00480)	(0.00865)	(0.00486)	(0.00864)
N	5152	5152	5152	5152	5152
F-statistic	100.11				

Standard errors are clustered at the municipality level. All specifications include a quadratic polynomial in the running variable interacted with an indicator for being below the threshold. Hectares sowed and yield is for rainfed insured crops only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2. Economic outcomes, Subsequent year

	(1) First Stage: Payment	(2) Reduced form: Expenditure p.c.	(3) Reduced form: Income p.c.	(4) 2SLS: Expenditure p.c.	(5) 2SLS: Income p.c.
Payment				0.270	0.269*
				(0.165)	(0.159)
Below threshold	0.887***	0.240	0.238		
	(0.153)	(0.158)	(0.159)		
Years insured		0.0948**	0.0929**	0.0939**	0.0920**
		(0.0405)	(0.0430)	(0.0398)	(0.0422)
N	5021	5021	5021	5021	5021
F-statistic	33.91				

Standard errors are clustered at the municipality level. All specifications include a quadratic polynomial in the running variable interacted with an indicator for being below the threshold. Dependent variables in (2)-(5) are in logs. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

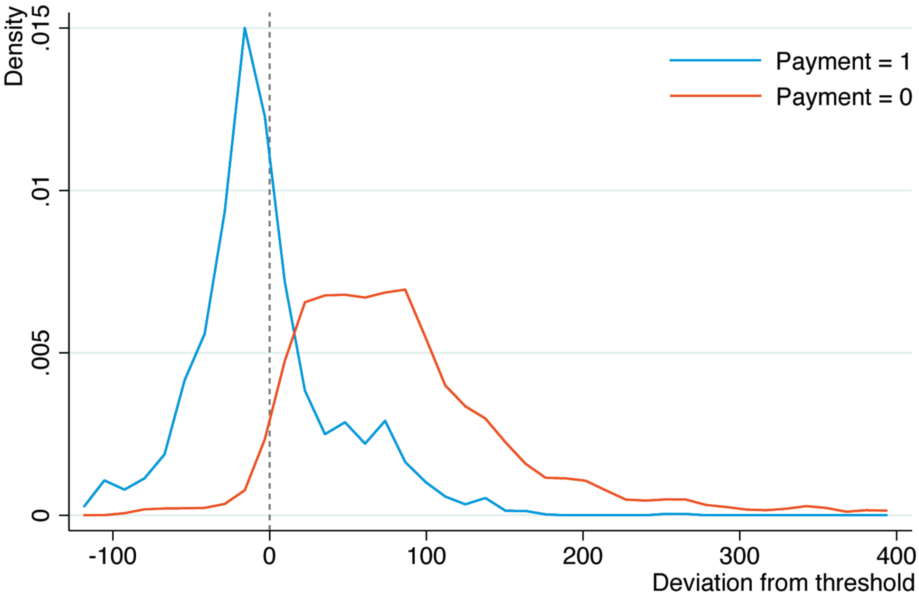
Table 3. Heterogeneity by % eligible

	(1) 2SLS: Δ log ha sowed	(2) 2SLS: log yield	(3) 2SLS: Expenditure p.c.	(4) 2SLS: Income p.c.
Payment	0.274**	0.117	-0.124	-0.0585
	(0.133)	(0.143)	(0.177)	(0.191)
Payment × % eligible	-0.177	0.0580	0.889***	0.744**
	(0.189)	(0.246)	(0.329)	(0.354)
% eligible	0.0500	-0.0275	-0.739***	-0.800***
	(0.0396)	(0.0768)	(0.140)	(0.146)
Years insured	0.00586	0.0134	0.0675*	0.0588
	(0.00487)	(0.00878)	(0.0396)	(0.0407)
N	5152	5152	5021	5021

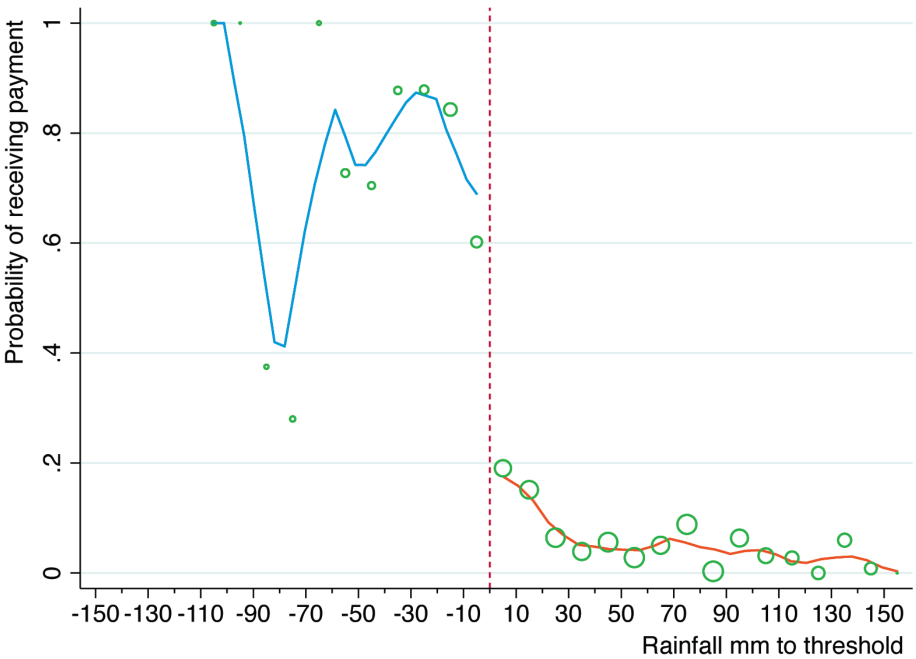
Standard errors are clustered at the municipality level. All specifications include a quadratic polynomial in the running variable interacted with an indicator for being below the threshold. Dependent variables in (3)-(4) are in logs. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figures

Figure 1: Probability of payment status by deviations from threshold

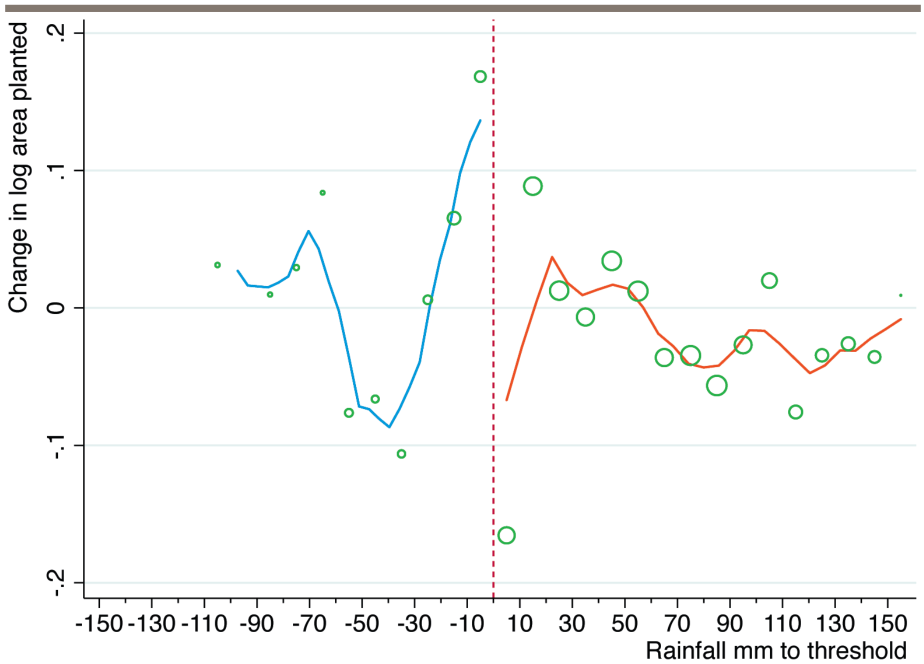


(a) Distribution of deviations from threshold

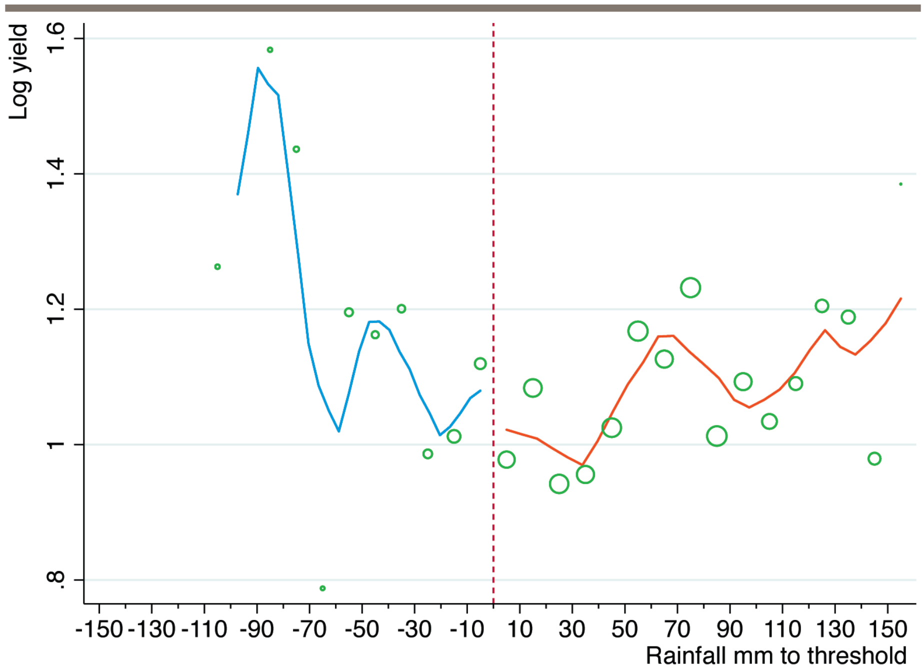


(b) Probability of payment

Figure 2: Discontinuity in agricultural outcomes at payment threshold

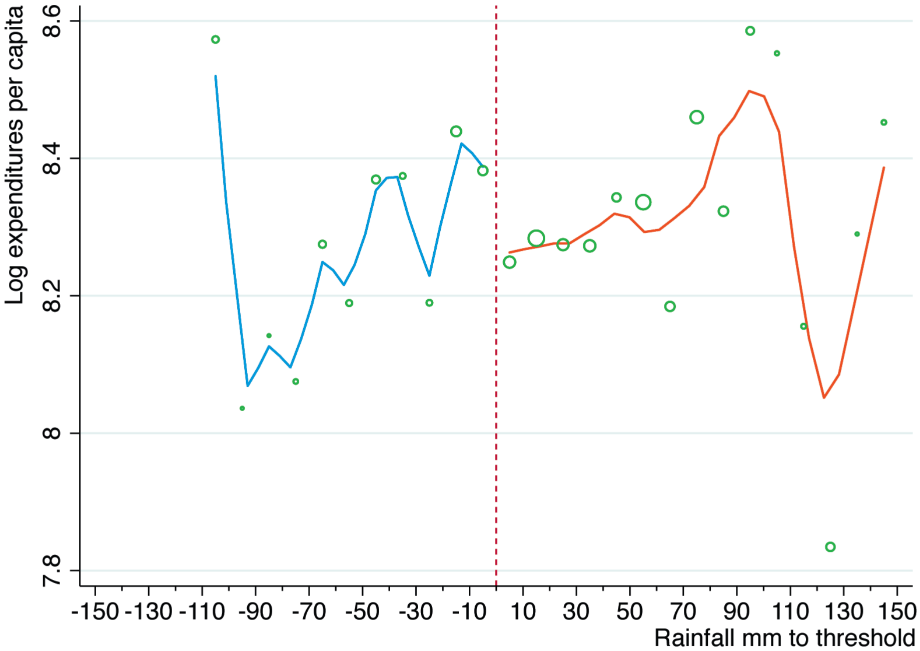


(a) Δ log maize sowed (ha) in t+1

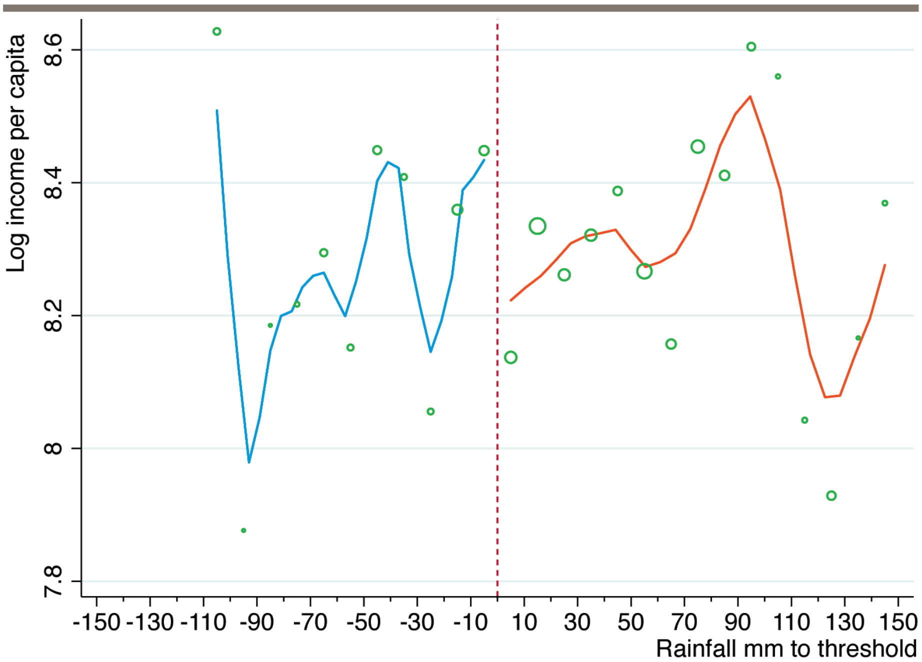


(c) Log maize yield in t+1

Figure 3: Discontinuity in economic outcomes at payment threshold



(a) Log total income per capita in t+1



(b) Log expenditures per capita in t+1

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