

## THE IMPACT OF NATURAL DISASTERS ON WOMEN'S EMPOWERMENT IN RURAL VIETNAM\*

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### *Abstract*

This study investigates the impact of natural disasters on women's empowerment in rural Vietnam. Using Vietnam Access to Resources Household Surveys 2008 and 2010, we find strong evidence on the impact of natural disasters on women's empowerment. Non-parametric methods also corroborate this finding. Our estimates are strong for different model specifications and different measures of women's empowerment. We also discuss channels through which natural disasters affect women's empowerment. In an agrarian society, men have an advantage in agricultural activities relative to women, therefore women have less power within households compared with men. Our empirical results show that higher number of natural disasters results in a reduction in agricultural income. This decreases men's power relative to women's power within households. The impact of number of natural disasters on women's empowerment is statistically insignificant for households with lower shares of farm income while it is statistically significant for households with higher shares of farm income. Leveraging a test of exogeneity by Caetano (2015), we document the causal relationship between natural disasters and women's empowerment.

*Keywords:* natural disasters, women's empowerment, test of exogeneity, household fixed-effects, rural Vietnam

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## I. *Introduction*

An influential paper by Alesina, Giuliano and Nunn (2013) shows that gender inequality is driven by differences in the form of agriculture traditionally practiced. In labor intensive agricultural societies where cultivation uses a hoe or a digging stick, the participation of women in agricultural activities is similar to that of men. In contrast, in agricultural societies with intensive cultivation where the plough is used to prepare soil. Men have an advantage in agricultural activities relative to women because using the plough requires significant strength. This finding explains the existence of patriarchal relations in almost all agricultural societies and shows that women have less power within households compared with men. Hansen et al. (2015) argue that gender inequality still exists even agriculture unaided by the plough because agricultural society relies on male brawn. The transformation from hunter-gatherer to agriculture led to a division of labor within the family, where the man had the advantage of physical strength over the woman, and he implemented food production activities in the field, the woman was responsible for domestic tasks such as child rearing, food processing, and other family-related duties. This shift in the division of labor led to an increase in male bargaining power with the family. The authors show that gender role are more unequal in countries more exposed to histories of agriculture. In fact, Ember (1983) and White et al. (1981) emphasize that women spend less time on working in the field in cereal-based agriculture than root crops agriculture. Therefore, cereal-based agriculture is related to less gender equality. Put it differently, area growing cereals has a more patriarchal form of agriculture. This observation is consistent with the historical account of Bauman (1928). Those findings suggest that negative shocks to agriculture may decrease the men's power relative to women's power.<sup>1</sup>

Using Vietnam Access to Resources Household Surveys 2008 and 2010, this study quantifies the impact of natural disasters on women's empowerment in rural Vietnam. Vietnam is an intensive cultivation society and the women's power in households has been limited (Newman, 2015). As women's increasing participation in households brings many benefits (Menon et al. 2013), efforts have been explored to encourage women's empowerment in Vietnamese households. For instance, the 2003 Land Law issued titling of land bearing the wife's and the husband's names. We find that number of natural disasters has a significant and positive impact on women's empowerment when we use econometric models. These results are consistent with those utilizing the nonparametric methods. Our estimates are strong and robust for different model specifications and different measures of women's empowerment. These findings suggest that larger number of natural disasters leads to an increase in women's power in rural Vietnam. We also discuss channels through which natural disasters affect women's empowerment. In agricultural society men's strength is necessary in cultivation, therefore women's power is weaker in households more involving in farming activities. We show that higher number of natural disasters results in a reduction in agricultural income, this decreases men's power within households. Indeed, the impact of number of natural disasters on women's

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<sup>1</sup> Although women perform many tasks in rice farming, such as planting, weeding, and harvesting in many countries in Asia and Africa, men carry out most of heavy tasks in agriculture, such as land preparation, threshing of rice, plowing, uprooting of rice seedling and carrying rice. Therefore, rice farming still depends on men's brawn.

empowerment is not statistically significant for households with lower shares of farm income while it is statistically significant for households with higher shares of farm income. We also indicate that number of natural disasters decreases households' farm income more for households with higher shares of farm income. Leveraging a test of exogeneity by Caetano (2015), which was successfully applied by Caetano and Maheshri (2018), we do a test of exogeneity for explanatory variable on number of natural disasters. We find that the variable on number of natural disasters is exogenous. This test corroborates the causal relationship between natural disasters and women's empowerment.

Vietnam is a developing country with about 75% of people living in rural area in 2008 (Vietnam Households Living Standards Survey 2008). Most of Vietnamese people depend on agricultural activities while agricultural income is very volatile. This is partly because agriculture is affected heavily by natural disasters such as: typhoons, storms, floods, droughts, landslides, animal and livestock epidemics, plant disease, and insects. According to the World Bank report (2010), natural disasters caused the loss of about 1 to 1.5 percent of annual GDP during the period 1989 – 2008 in Vietnam. Vietnam is also one of the most vulnerable countries to climate change in the world (Dasgupta, et al. 2009). In an agricultural society like Vietnam, men play an important role in cultivation, therefore gender inequality still exists. World Bank (2011) show that gender disparity remained although there have been a significant progress in poverty, wellbeing, employment and livelihoods, and political participation. Gender inequality is also reflected in the aspect of domestic violence. General Statistics Office of Vietnam (2010) shows that 58 percent of women had ever suffered at least one type of domestic violence: physical, sexual and emotional. Likewise, Luke et al. (2007) indicate that 37% of wives had ever experienced physical violence in a survey of Nghe An province. All these factors point that it is of interest to examine the relationship between natural disasters and women's empowerment in the context of rural Vietnam.

Our paper contributes directly to the emerging literature which considers the negative impact of natural disasters. Natural disasters cause serious physical and socio-economic damage (De Haen & Hemrich, 2007; Lindell & Prater, 2003; Pelling, Ozerdem, & Barakat, 2002) and annual estimated economic losses of \$143 billion during the period 2002-12 (Guha-Sapir et al. 2013). Specifically, natural disasters lead to reductions in output growth, household income and expenditure, and an increase in poverty and inequality (Ariouri, M et al. 2014; Bui et al. 2014; Cunado & Ferreira, 2014; Noy & Vu, 2010; Strobl, 2012). Meanwhile, natural disasters have negative impacts on the agricultural industry, rice production and cropland productivity, international tourism flows and the banking industry such as: increasing deposit withdrawals, reduced supply of lending and drawing on liquid assets (Barbhuiya et al. 2002; Benson & Clay, 2001; Blanc & Strobl, 2016; Brei et al. 2019; Israel, 2012; Rossello et al. 2020; Strobl, 2009). The children are also seriously affected by natural disasters. Children's education and physical health fall in the wake of natural disasters (Kousky, 2016; Mottaleb et al. 2013; Nguyen & Pham, 2018). Unlike this literature's focus on the negative impacts of natural disasters, we offer an investigation into the positive shock to women's empowerment. This positive shock is due to the decrease in agricultural income, which leads to lower men's power relative to women's power within households. To the best of our knowledge, this paper is the first to study the impact of natural disasters on women's empowerment. Meanwhile, this study also attempts to establish the causal relationship between natural disasters and women's empowerment in rural Vietnam.

A large body of literature shows that improving the socio-economic status of women can increase their power within households. Allendorf (2007) indicates that women's ownership of land improves their power in household decisions. Also, Panda and Agarwal (2005) find that women with immovable property (land or a house) tend to face a significantly lower risk of marital violence than women without property. And female participation in labor force increases women power and gives women more control to allocate the resources within households (Quisumbing and Maluccio 2003, Anderson and Eswaran 2009). Women's participation in micro credit programs is positively associated with women's empowerment while men's access to credit has negative impacts on women's empowerment (Pitt et al. 2006; Hashemi et al. 1996). Women with better educational level have more empowerment in decision making (Sofia and Pervaiz, 2018; Samarakoon and Parinduri, 2014). Employment of women also has positive impacts on their participation in decisions related to their own health care, large household purchases, visits to family or relatives and daily spending (Sofia and Pervaiz, 2018). All those findings suggest that women have more bargaining power within the family when they give their economic viability on their own. However, there is little known about the impact of a decrease in men's economic contribution to the family on women's empowerment. This study tries to fill this gap in the literature.

The paper is organized as follows: Section 2 describes the dataset which is used in this study. Section 3 provides the methodology and descriptive statistics. Section 4 illustrates the relationship between natural disasters and women's empowerment by graph and then reports the estimation results on the impact of natural disasters and women's empowerment. The robustness checks, a test for exogeneity of the explanatory variable – number of natural disasters –, and mechanism analysis are also presented in Section 4. Section 5 concludes.

## II. *Data*

This study uses two rounds of Vietnam Access to Resources Household Surveys (VARHSs) 2008 and 2010. Although VARHS was conducted in 2012, 2014 and 2016, there was no information on women's empowerment in those years. VARHSs were carried out in a co-operation between the University of Copenhagen and Vietnamese organizers including Institute for Labour Studies and Social Affairs (ILSSA), Central Institute for Economic Management (CIEM) and Institute for Policy and Strategy for Agriculture and Rural Development (IPSARD), with financial support from Danida. These surveys were implemented in 12 provinces in Vietnam. These surveys are representative of households living in rural areas of provinces. However, they are representative at the province level rather than at the national level. These surveys cover both a commune and a household questionnaire. The households were conducted in 466 communes and 161 districts. There is a lot of information at the commune level, including natural disasters, migration, shocks, agriculture, credit, infrastructure and access to services. The information on natural disasters was asked for the past three years, including flood, drought, typhoon, land slide, animal or livestock epidemics, plant disease, and insects or rats. The household questionnaire contains general information at the individual level and the household level. The individual-level information includes age, gender, education, marital status and so on. The household-level information cover housing, employment, agriculture, food expenditure, income, savings, assets, shocks, risks, migration, and social

capital. This study establishes a balanced panel dataset of 1929 households across two surveys in 2008 and 2010.

### III. *Methodology and descriptive statistics*

To investigate the impacts of natural disasters on women's empowerment, our model is specified as follows:

$$Y_{ijt} = \alpha_1 + \alpha_2 L_{jt} + \alpha_3 X_{ijt} + \alpha_4 C_{jt} + \alpha_5 T_t + \mu_i + \varepsilon_{it} \quad (1)$$

where  $Y_{ijt}$  is the interest outcomes, which is women's empowerment of household  $i$  in commune  $j$  in year  $t$ . Women's empowerment includes multidimensional aspect of livelihood – economic, social and cultural, legal, political, and psychological. In this study, we use eight measures of women's empowerment. Specifically, they are dummy variables on women's empowerment on visits to family or relatives, household purchases for daily goods, large household purchases, use of contraception, their own healthcare, schooling for children, health care for children and having a child. These variables equal one if the female household head or the female spouse of household head has the power to make household decisions alone, with husband, or with someone else, 0 otherwise. We also leverage Principal Component Analysis (PCA) to create women's empowerment index based on these eight dimensions of women's empowerment. Meanwhile, number of women's empowerment is generated by simply adding all eight dummy variables on women's empowerment above. The variable on total number of women's empowerment varies from 0 to 8. Table 1 of Appendix reports the correlations among eight dummy variables on women's empowerment on visits to family or relatives, daily purchases, large purchases, contraception, their own healthcare, schooling for children, health care for children and having a child. The results show that those variables are highly correlated and are statistically significant at the 1 percent level.

$L_{jt}$  is number of natural disasters containing floods, droughts, typhoon, landslides, animal/livestock epidemics, plant disease and insects, which happened in a commune  $j$  in the past three years.  $X_{ijt}$  is a vector of characteristics of a household  $i$  in commune  $j$  at time  $t$  such as household size, number of household members of working age (working age is defined as 15 to 55 years for females and 15 to 60 for males), number of girls aged less than 5, number of girls aged 5 to 15, number of females aged 15 to 60 and number of females aged above 60.  $C_{jt}$  is a vector of characteristics of a commune  $j$  at time  $t$  including dummy variable for bank for social policy, dummy variable for bank for agriculture and rural development, dummy variable for having irrigation facilities, dummy variable for good quality of main irrigation canals, dummy variable for good quality of tertiary canal, dummy variable for good quality of public well and dummy variable for good quality of dike. Although we control for observed variables at the household level, unobserved factors may affect our results. It means that our estimates would be biased. For instance, educated women in households would choose to live in communes that less experienced natural disasters. And women with higher level of education may have better empowerment within households. As such natural disasters may be correlated with the education level of women in households and women's empowerment simultaneously. This suggests that our estimation results on the impact of natural disasters on women's

empowerment are not causal. Further, communes not experiencing natural disasters may receive larger investment in infrastructures from government than those experiencing natural disasters. And communes with better infrastructures may provide more job opportunity for women. Women with better job may have better empowerment within households. All these issues point to the endogeneity of natural disasters on women's empowerment. To address the endogeneity problem, we use household-level fixed effects- $\mu_i$ , which control for unobserved time-invariant factors at the household level. This allows us to significantly cancel out the endogeneity issue. We also control for  $T_t$ , which is year fixed effects. All standard errors are clustered at the commune level. For simplicity, we use the linear probability model for dichotomous dependent variables. Tables 2 and 3 of Appendix report the descriptive statistics of dependent and independent variables.

We also analyze channels through which natural disasters affect women's empowerment. Women's empowerment would be weaker in households more involving in agricultural activities because agriculture needs men strength. We hypothesize that natural disasters would decrease agricultural income, this leads to a reduction in men's power relative to women's power. To test this hypothesis we divide our sample into three subsamples based on share of farm income in 2008: low share of farm income, average share of farm income and high share of farm income. We expect that natural disasters increase women's empowerment with share of farm income.

Table 1 reports the women's empowerment in 2008 and 2010. Generally speaking, women's empowerment in all aspects increased during the period 2008-2010. For instance, the percentage of women having empowerment on visits to family or relatives increased from 71% in 2008 to 87% in 2010. Similarly, the percentage of women having empowerment on daily

TABLE 1. WOMEN'S EMPOWERMENT OVER TIME

Women's empowerment on	2008	2010
Visits	0.71	0.87
Daily purchases	0.73	0.88
Large purchases	0.7	0.84
Contraception	0.62	0.68
Their own health	0.73	0.88
Child schooling	0.69	0.78
Child health	0.7	0.8
Having a baby	0.65	0.73

TABLE 2. WOMEN'S EMPOWERMENT BY SHARE OF FARM INCOME OF 2008

Women's empowerment on	Low share of farm income	Average share of farm income	High share of farm income
Visits	0.802	0.799	0.778
Daily purchases	0.809	0.813	0.791
Large purchases	0.788	0.772	0.744
Contraception	0.610	0.670	0.671
Their own health	0.813	0.814	0.780
Child schooling	0.733	0.747	0.733
Child health	0.742	0.767	0.747
Having a baby	0.671	0.693	0.705

purchases mounted up to 88% in 2010 from 70% in 2008. Besides, the percentage of women having empowerment on contraception was lowest among other measures of women's empowerment in both 2008 and 2010. The percentage of women having empowerment on daily purchases and percentage of women having empowerment on their own health were highest among other measures of women's empowerment in both 2008 and 2010. Those results suggest that women's empowerment was improved over time in rural Vietnam.

To examine women's empowerment by share of farm income, we divide the sample into three sub-samples: low share of farm income, average share of farm income and high share of farm income. Share of farm income is calculated in the initial year – 2008. Table 2 shows that the percentage of women having empowerment on visits to family or relatives is largest in subsample with low share of farm income and lowest in subsample with high share of farm income. The results are similar for women's empowerment on large purchases. This suggests that women's empowerment is weaker in family more exposed to agricultural activities. The results do not show clear trend on women's empowerment on daily purchases, their own health, child schooling, and child health. While women's empowerment on contraception increases with share of farm income.

#### IV. *Impacts of Natural Disasters on Women's Empowerment*

##### 1. **Empirical Results**

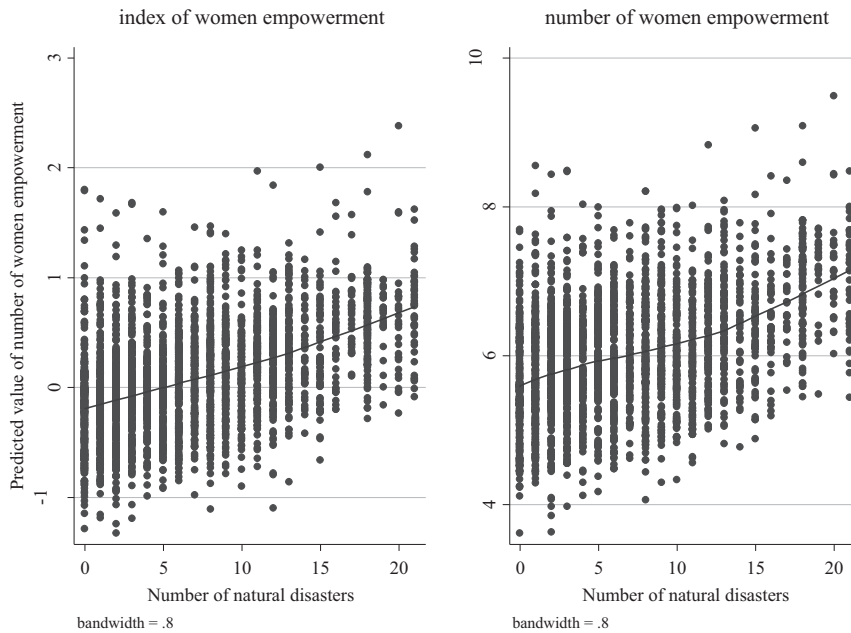
First, we illustrate the relationship between natural disasters and women's empowerment by graph. To estimate non-parametrically the relationship between the likelihood of women's empowerment and number of natural disasters, we regress women's empowerment on control variables:  $X_{ijt}$  and  $C_{jt}$ . We also control for year dummy and household-level fixed effects. We take turn regressing the interest outcomes – the index of women's empowerment, number of women's empowerment and eight dummy variables for women's empowerment – on control variables to get the predicted values and probability of the interest outcomes. And then, we estimate non-parametric relationship between the predicted values and probability of women's empowerment and number of natural disasters.

Non-parametric relationship between the predicted values of women's empowerment and number of natural disasters is illustrated in Figure 1, which shows that higher number of natural disasters is positively associated with the predicted value of index of women's empowerment and the predicted value of number of women's empowerment. It suggests that an increase in number of natural disasters leads to higher women's empowerment.

Figure 2 depicts the non-parametric relationship between number of natural disasters and the probability of women's empowerment on household activities. The results show that number of natural disasters is positively correlated to the probability of women having empowerment on visits to family or relatives, empowerment on purchases for daily goods, empowerment on large household purchases, empowerment on use of contraception and empowerment on their healthcare. Those findings suggest that number of natural disasters increases the women's empowerment on household activities.

Figure 3 illustrates the non-parametric relationship between number of natural disasters and the probability of women's empowerment on their own children. We find that number of natural

FIGURE 1. NON-PARAMETRIC RELATIONSHIP BETWEEN THE PREDICTED VALUES OF WOMEN'S EMPOWERMENT AND NUMBER OF NATURAL DISASTERS (LOWESS SMOOTHER)



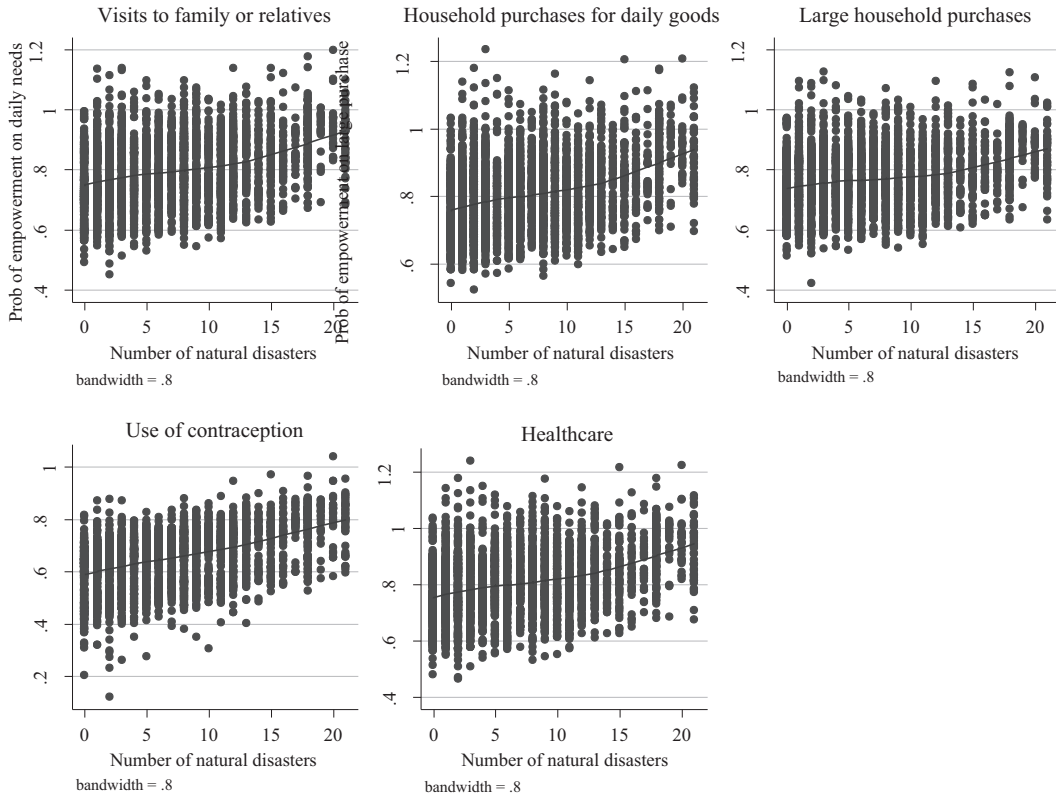
disasters is positively associated with the probability of women having empowerment on schooling for their children, empowerment on health care for their children and empowerment on having a child. In other words, an increase in number of natural disasters leads to improved women's empowerment on their own children.

To investigate the impact of natural disasters on women's empowerment, we run regressions of equation (1). Table 3 provides the results on index and number of women's empowerment. Both measures of women's empowerment are statistically significant at the 5 percent level. An additional number of natural disasters rises the index of women's empowerment and number of women's empowerment by the average of 0.038 point and 0.05, respectively. Number of girls aged less than 5 is also positively and statistically significant for index of women's empowerment and number of women's empowerment. This result is consistent with the finding by Samari (2017), who shows that a first birth and subsequent births are positively associated with women empowerment in Egypt. Also, Rife (2010) find that women who have had abortions are more likely to experience domestic violence in India. Those findings suggest that having children may improve women's empowerment by increasing their value in society and to their families.

Table 4 provides the estimation results on women's empowerment on household activities, which show that natural disasters are statistically significant for women's empowerment on visits to family or relatives, on daily purchases, on the use of contraception and on their own health. Specifically, an additional number of natural disasters causes an increase of 0.5



FIGURE 2. NON-PARAMETRIC RELATIONSHIP BETWEEN THE PROBABILITY OF WOMEN'S EMPOWERMENT ON HOUSEHOLD ACTIVITIES AND NUMBER OF NATURAL DISASTERS (LOWESS SMOOTHER)

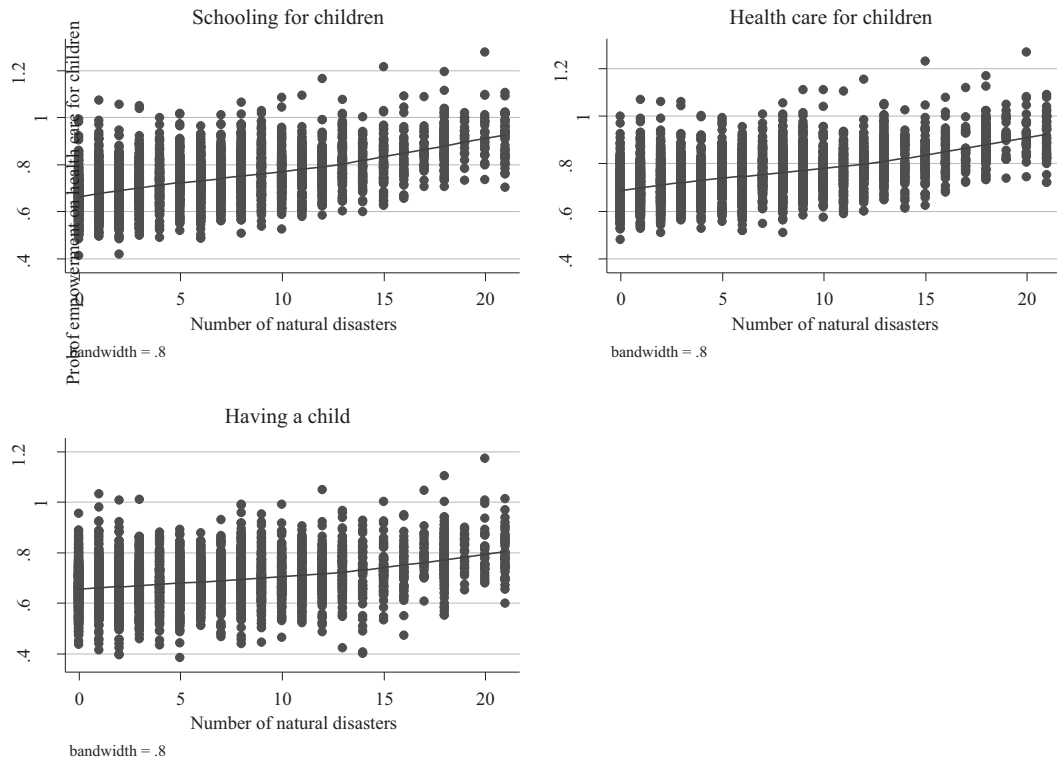


percentage points in the probability of women having empowerment on visits to family or relatives (Column 1), the figures are also similar to the probability of women having empowerment on daily purchases and their own health (Columns 2 and 5). An additional number of natural disasters increases the likelihood of women having empowerment on contraception by 0.8 percent (Column 4). The result is not statistically significant for women's empowerment on large purchases (Column 3). This is probably because households do not have much income to purchase big or expensive items in the wake of natural disasters.

The results of Table 4 also indicate that number of girls aged less than 5 improves significantly the women's empowerment on visits to family or relatives, on daily purchases, on large purchases and on their own health. Having irrigation facilities decreases the women's empowerment on visits to family or relatives, on daily purchases, on their own health. This result may suggest that women would have lower empowerment within households who are more exposed to agricultural activities.

Table 5 presents the estimation results on the impact of natural disasters on women's empowerment on their own children. Number of natural disasters is statistically significant for

FIGURE 3. NON-PARAMETRIC RELATIONSHIP BETWEEN NUMBER OF NATURAL DISASTERS AND THE PROBABILITY OF WOMEN'S EMPOWERMENT ON THEIR OWN CHILDREN (LOWESS SMOOTHER)



dummy variable for women's empowerment on child schooling and on child health at the 1 percent level. The result is statistically significant for dummy variable for women's empowerment on having a child at the 10 percent level. We find that an additional number of natural disasters increases the women's empowerment on child schooling by 1 percent, on child health by 0.9 percent and on having a child by 0.6 percent. Those results also suggest that natural disasters have larger impact on women's empowerment on child schooling and on child health compared with women's empowerment on having a child.

## 2. Robustness Checks and Test for Exogeneity

We concern that our model specification may be biased. To test for the robustness of the estimation results, we remove all control variables at the household level and the commune level of equation (1) and re-run regressions for Tables 3 to 5. Table 6 reports the estimation results with year and household-level fixed-effects, but without control variables. The results are quantitatively similar. Number of natural disasters is statistically significant for all measures of women's empowerment, except for dummy variable for women's empowerment on large

TABLE 3. IMPACTS OF NATURAL DISASTERS ON INDEX AND NUMBER OF WOMEN'S EMPOWERMENT

	Index of women's empowerment	Number of women's empowerment
	(1)	(2)
Number of natural disasters	0.038** (0.018)	0.050** (0.022)
Household size	-0.037 (0.145)	0.010 (0.177)
Number of household members of working age	0.166 (0.131)	0.173 (0.159)
Number of girls aged less than 5	0.753** (0.303)	0.870** (0.378)
Number of girls aged 5 to 15	0.055 (0.353)	0.002 (0.429)
Number of females aged 15 to 60	-0.117 (0.190)	-0.171 (0.230)
Number of females aged over 60	-0.401 (0.470)	-0.630 (0.562)
Dummy variable for bank for social policy	0.105 (0.144)	0.123 (0.178)
Dummy variable for bank for agriculture and rural development	-0.030 (0.234)	-0.056 (0.289)
Dummy variable for having irrigation facilities	-0.301 (0.221)	-0.371 (0.269)
Dummy variable for good quality of main irrigation canals	0.161 (0.196)	0.215 (0.238)
Dummy variable for good quality of tertiary canal	-0.120 (0.297)	-0.156 (0.370)
Dummy variable for good quality of public well	-0.501 (0.418)	-0.551 (0.504)
Dummy variable for good quality of dike	-0.297 (0.303)	-0.389 (0.374)
Dummy variable for 2010	-0.120 (0.113)	0.843*** (0.137)
Constant	0.006 (0.380)	5.375*** (0.456)
<i>N</i>	3858	3858
adj. <i>R</i> <sup>2</sup>	0.014	0.068

Notes: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Standard errors in parentheses. All regressions control for household-level fixed effects and year fixed effects. Standard errors are clustered at the commune level.

purchases. Also, the magnitude of the coefficients on women's empowerment in the model specification without control variables is similar to that of the coefficients on women's empowerment in the model specification with control variables. For instance, an additional number of natural disasters increases the index of women's empowerment by 0.041 point in the model without control variables while this figure is 0.038 point in the model with control variables. Similarly, an additional number of natural disasters causes a rise of 0.053 point in the model without control variables and 0.05 point in the model with control variables. Those findings show that our estimation results are strong.

TABLE 4. IMPACTS OF NATURAL DISASTERS ON WOMEN'S EMPOWERMENT  
ON HOUSEHOLD ACTIVITIES

	Visits	Daily purchases	Large purchases	Contraception	Their own health
	(1)	(2)	(3)	(4)	(5)
Number of natural disasters	0.005*	0.005*	0.003	0.008**	0.005*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Household size	-0.013	-0.007	-0.020	0.013	-0.006
	(0.024)	(0.023)	(0.025)	(0.027)	(0.023)
Number of household members of working age	0.026	0.022	0.024	0.003	0.022
	(0.021)	(0.020)	(0.022)	(0.024)	(0.020)
Number of girls aged less than 5	0.123**	0.128**	0.135**	0.053	0.123**
	(0.052)	(0.050)	(0.052)	(0.056)	(0.049)
Number of girls aged 5 to 15	0.003	0.047	0.031	-0.032	0.044
	(0.058)	(0.060)	(0.061)	(0.078)	(0.063)
Number of females aged 15 to 60	-0.006	-0.008	0.010	-0.014	-0.013
	(0.031)	(0.029)	(0.032)	(0.036)	(0.030)
Number of females aged over 60	-0.073	-0.041	-0.051	-0.177***	-0.086
	(0.078)	(0.080)	(0.075)	(0.065)	(0.078)
Dummy variable for bank for social policy	0.019	0.024	0.005	0.028	0.028
	(0.024)	(0.023)	(0.024)	(0.027)	(0.022)
Dummy variable for bank for agriculture and rural development	-0.004	-0.001	-0.001	-0.022	0.000
	(0.040)	(0.038)	(0.037)	(0.041)	(0.037)
Dummy variable for having irrigation facilities	-0.077**	-0.073*	-0.063	0.000	-0.074**
	(0.038)	(0.039)	(0.044)	(0.050)	(0.037)
Dummy variable for good quality of main irrigation canals	0.035	0.035	0.031	0.018	0.023
	(0.033)	(0.032)	(0.034)	(0.033)	(0.032)
Dummy variable for good quality of tertiary canal	-0.008	-0.009	0.001	-0.052	0.002
	(0.044)	(0.043)	(0.044)	(0.050)	(0.043)
Dummy variable for good quality of public well	-0.071	-0.066	-0.064	-0.036	-0.076
	(0.072)	(0.069)	(0.070)	(0.067)	(0.069)
Dummy variable for good quality of dike	-0.034	-0.045	-0.039	-0.046	-0.042
	(0.050)	(0.046)	(0.048)	(0.053)	(0.044)
Dummy variable for 2010	0.147***	0.141***	0.129***	0.047**	0.136***
	(0.017)	(0.017)	(0.017)	(0.021)	(0.017)
Constant	0.747***	0.721***	0.731***	0.583***	0.734***
	(0.065)	(0.065)	(0.070)	(0.075)	(0.066)
<i>N</i>	3858	3858	3858	3858	3858
adj. <i>R</i> <sup>2</sup>	0.092	0.091	0.062	0.024	0.088

Notes: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Standard errors in parentheses. All regressions control for household-level fixed effects and year fixed effects. Standard errors are clustered at the commune level.

Some households lost their original male household head to natural disasters or spouse of male household head got a divorce and women gained the household head status. These factors may drive our estimation results. There are 24 households in which male household head died or spouse of male household head got a divorce between 2008 and 2010. We remove those households from our sample and rerun regressions of Tables 3 to 5. Our estimation results are mostly unchanged (the results are reported in Table 4 of Appendix).

Our estimation results may be biased if the explanatory variable on number of natural

TABLE 5. IMPACTS OF NATURAL DISASTERS ON WOMEN'S EMPOWERMENT ON THEIR OWN CHILDREN

	Child schooling	Child health	Having a child
	(1)	(2)	(3)
Number of natural disasters	0.010*** (0.003)	0.009*** (0.003)	0.006* (0.003)
Household size	0.016 (0.025)	0.024 (0.026)	0.003 (0.027)
Number of household members of working age	0.028 (0.023)	0.018 (0.022)	0.030 (0.025)
Number of girls less than 5 years of age	0.103* (0.056)	0.091* (0.053)	0.114* (0.059)
Number of girls between 5 and 15 years of age	-0.019 (0.058)	-0.013 (0.056)	-0.060 (0.065)
Number of females between 15 and 60 years of age	-0.046 (0.036)	-0.048 (0.034)	-0.045 (0.039)
Number of females aged over 60	-0.089 (0.082)	-0.066 (0.081)	-0.047 (0.079)
Dummy variable for bank for social policy	0.002 (0.025)	0.009 (0.025)	0.008 (0.028)
Dummy variable for bank for agriculture and rural development	0.005 (0.038)	-0.001 (0.041)	-0.033 (0.044)
Dummy variable for having irrigation facilities	-0.060 (0.039)	-0.042 (0.036)	0.017 (0.046)
Dummy variable for good quality of main irrigation canals	0.017 (0.035)	0.007 (0.034)	0.050 (0.036)
Dummy variable for good quality of tertiary canal	-0.016 (0.058)	-0.018 (0.059)	-0.057 (0.060)
Dummy variable for good quality of public well	-0.092 (0.070)	-0.092 (0.070)	-0.054 (0.066)
Dummy variable for good quality of dike	-0.043 (0.054)	-0.057 (0.052)	-0.083 (0.054)
Dummy variable for 2010	0.081*** (0.021)	0.090*** (0.021)	0.072*** (0.023)
Constant	0.633*** (0.067)	0.624*** (0.066)	0.602*** (0.079)
<i>N</i>	3858	3858	3858
adj. <i>R</i> <sup>2</sup>	0.044	0.047	0.030

Notes: \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Standard errors in parentheses. All regressions control for household-level fixed effects and year fixed effects. Standard errors are clustered at the commune level.

disasters is endogenous. Failure to address the endogeneity problem might lead to wrong conclusions. There are several techniques designed to estimate the causal relationship such as: instrumental variables, difference-in-differences, and regression discontinuity. Indeed, it is not easy to apply these techniques because it relies on the existence of specific dataset and natural or policy shocks. Thus, it is useful to have a test to detect endogeneity. Caetano (2015) developed a test of exogeneity to check whether the parameters of interest outcomes in an empirical model can be interpreted as causal. Unlike the other tests of exogeneity requiring the existence of instrumental variables (e.g., Hausman (1978) and Blundell and Horowitz (2007)),

TABLE 6. ROBUSTNESS CHECKS WITHOUT CONTROL VARIABLES

	Index of women's empowerment	Number of women's empowerment	Visits	Daily purchases	Large purchases	Contraception	Their own health	Child schooling	Child health	Having a child
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of natural disasters	0.041 <sup>**</sup> (0.018)	0.053 <sup>**</sup> (0.023)	0.005 <sup>*</sup> (0.003)	0.005 <sup>*</sup> (0.003)	0.003 (0.003)	0.008 <sup>**</sup> (0.003)	0.006 <sup>*</sup> (0.003)	0.010 <sup>***</sup> (0.003)	0.009 <sup>***</sup> (0.003)	0.006 <sup>*</sup> (0.003)
<i>N</i>	3858	3858	3858	3858	3858	3858	3858	3858	3858	3858
adj. <i>R</i> <sup>2</sup>	0.006	0.060	0.086	0.083	0.057	0.019	0.079	0.037	0.040	0.022

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Standard errors in parentheses. The regressions control for household-level fixed-effects and year fixed-effects. Standard errors are clustered at the commune level.

TABLE 7. TEST FOR EXOGENEITY

	Index of women's empowerment	Number of women's empowerment	Visits	Daily purchases	Large purchases	Contraception	Their own health	Child schooling	Child health	Having a child
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Number of natural disasters	0.043 <sup>**</sup> (0.018)	0.056 <sup>**</sup> (0.023)	0.006 <sup>*</sup> (0.003)	0.005 <sup>*</sup> (0.003)	0.004 (0.003)	0.008 <sup>**</sup> (0.003)	0.005 <sup>*</sup> (0.003)	0.011 <sup>***</sup> (0.003)	0.010 <sup>***</sup> (0.003)	0.007 <sup>**</sup> (0.003)
<i>D</i>	0.348 (0.295)	0.418 (0.369)	0.054 (0.037)	0.031 (0.038)	0.058 (0.037)	0.004 (0.059)	0.031 (0.037)	0.087 (0.060)	0.082 (0.064)	0.071 (0.087)
<i>N</i>	3858	3858	3858	3858	3858	3858	3858	3858	3858	3858
adj. <i>R</i> <sup>2</sup>	0.015	0.069	0.094	0.092	0.064	0.024	0.088	0.047	0.050	0.031

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Standard errors in parentheses. The regressions control for characteristics of households such as: household size, education of household head, number of household members of active age (15-55/66), number of girls aged less than 5, number of females aged 15 to 60, number of females aged 60 above, and characteristics of communes such as: dummy variable for bank for social policy, dummy variable for bank for agriculture and rural development, dummy variable for having irrigation facilities, dummy variable for good quality of main irrigation canals, dummy variable for good quality of tertiary canal, dummy variable for good quality of public well, dummy variable for good quality of dike. The regressions also control for household-level fixed-effects and year fixed-effects. Standard errors are clustered at the commune level.

this test does not require instrumental variables, instead it requires structural function must be continuous at a known threshold of the main explanatory variable of interest in which observations bunch at this threshold. In our study, we check the discontinuity at the threshold of zero number of natural disasters. In particular, number of natural disasters must have a continuous impact on the measures of women's empowerment at the threshold of zero number of natural disasters. If dependent variables on women's empowerment are discontinuous at zero number of natural disasters, this discontinuity cannot be due to natural disasters nor selection on observables. This discontinuity is caused by the confounding factors that are not controlled in the structural equation, and natural disasters are endogenous. Leveraging a test of exogeneity by Caetano (2015), Caetano and Maheshri (2018) successfully establish the causal effects of crime on future crime. They have a panel on crime per week per neighborhood and they run the test adding dummies for zero crime. They have several types of crime, so they add one dummy per type of crime. To do a test of exogeneity for variable on number of natural disasters, we generate the dummy variable-D, which is equal to 1 if number of natural disasters is zero, and 0 otherwise. And then we add this dummy variable into equation (1). If D is statistically significant, it means that the discontinuity exists at zero number of natural disasters and the confounding factors affect our estimation results. In this case, the impact of number of natural disasters on women's empowerment is biased. In contrast, if D is statistically insignificant, there is no discontinuity at zero number of natural disasters. This suggests that the variable on number of natural disasters is exogenous.

Table 7 reports the results on the test for exogeneity by adding the dummy variable-D into equation (1). We re-run regressions for all dependent variables of Tables 3 to 5. We find that the results remain unchanged when we add the explanatory variable-D. Importantly, D is not statistically significant for all measures of women's empowerment (Columns 1 to 10). It means that our variable on number of natural disasters is exogenous and the estimation results on the impact of number of natural disasters on women's empowerment are causal.

### 3. Channels

The estimates on women's empowerment by share of farm income of 2008 are reported in Table 8. Panel A1 indicates that number of natural disasters is statistically insignificant for index of women's empowerment for households with low share of farm income, however the estimates are statistically significant for both households with average share of farm income and high share of farm income. Further, the magnitude of the coefficient of the impact of number of natural disasters on index of women's empowerment is larger in households with high share of farm income compared with those with average share of farm income. An additional number of natural disasters increases index of women's empowerment by 0.048 point for households with average share of farm income and 0.058 point for households with high share of farm income. Also, Panel A2 shows no evidence on the impact of number of natural disasters on women's empowerment for households with low share of farm income. In contrast, number of natural disasters has significant and positive impacts on number of women's empowerment for both households with average share of farm income and high share of farm income. And the magnitude of the coefficient of number of natural disasters is greater in households with high share of farm income than in those with average share of farm income.

Panel B1 shows that natural disasters are statistically insignificant for women's empowerment on visits to relatives or friends for both households with low share of farm income and average share of farm income. However, the result is statistically significant for households with high share of farm income. Particularly, an additional number of natural disasters increases the probability of women having empowerment on visits to relatives or friends by 0.8 percent. Comparing the magnitude of the coefficients among subsamples, we find that the magnitude of the coefficient of the impact of number of natural disasters on women's empowerment on visits to relatives or friends is smallest and nearly zero in the subsample with low share of farm income. In similar vein, Panel B2 indicates that number of natural disasters is statistically significant for women's empowerment on daily needs in households with high share of farm income at the 5 percent level. One more number of natural disasters leads to a 0.9 percentage increase in the probability of women having empowerment on daily purchases. We find no evidence on the impact of number of natural disasters on women's empowerment on daily purchases for both households with low share of farm income and average share of farm income. Panel B3 reports the results on women's empowerment on large purchases, however the estimation results are not statistically significant for all subsamples. This result is consistent with that using whole sample in Table 4. Regarding women's empowerment on contraception, Panel B4 suggests that number of natural disasters has a significant and positive impact on women's empowerment on contraception in households with average share of farm income. And the estimates are statistically insignificant for both households with low and high share of farm income. Again, Panel B5 implies that number of natural disasters is positively associated with women's empowerment on their own health in households with high share of farm income. An additional number of natural disasters increases women's empowerment on their own health by 0.9 percent. The estimation results are not statistically significant for both households with low share of farm income and average share of farm income.

In terms of women's empowerment on raising their children, Panels C1, C2 and C3 analyze the impact of number of natural disasters on women's empowerment on child schooling, child health and having a baby. We find strong evidence on the impact of natural disasters on women's empowerment on child schooling in two subsamples: average share of farm income and high share of farm income (Panel C1). Importantly, the magnitude of the coefficient of the impact of number of natural disasters on women's empowerment on child schooling is a bit larger in the subsample with high share of farm income than in the subsample with average share of farm income. Particularly, an additional number of natural disasters increases the probability of women having empowerment on their child schooling by 1.1% in the subsample with average share of farm income, and by 1.2% in the subsample with high share of farm income. Also, Panel C2 shows the significant impact of natural disasters on women's empowerment on their child health in the subsamples with average share of farm income and high share of farm income. The result is not statistically significant in the subsample with low share of farm income. The impact of number of natural disasters is greater for households with high share of farm income compared with households with average share of farm income. One more number of natural disasters increases the probability of women having empowerment on their child health by 0.9 percent for households with average share of farm income and by 1.3 percent for households with high share of farm income. Finally, Panel C3 also indicates a significant and positive impact of number of natural disasters on women's empowerment on having a baby for households with high share of farm income. The results are not statistically significant for households with low share of farm income and average share of farm income.



TABLE 8. IMPACTS OF NATURAL DISASTERS ON WOMEN'S EMPOWERMENT  
BY SHARE OF FARM INCOME OF 2008

	Low share of farm income (1)	Average share of farm income (2)	High share of farm income (3)
<b>Panel A1: Index of women's empowerment</b>			
Number of natural disasters	0.009 (0.025)	0.048** (0.024)	0.058** (0.026)
adj. $R^2$	0.019	0.023	0.022
<b>Panel A2: Number of women's empowerment</b>			
Number of natural disasters	0.015 (0.031)	0.063** (0.029)	0.072** (0.033)
adj. $R^2$	0.061	0.053	0.104
<b>Panel B1: women's empowerment on visits</b>			
Number of natural disasters	0.000 (0.004)	0.005 (0.004)	0.008* (0.004)
adj. $R^2$	0.080	0.075	0.141
<b>Panel B2: women's empowerment on daily purchases</b>			
Number of natural disasters	0.000 (0.004)	0.005 (0.004)	0.009** (0.004)
adj. $R^2$	0.088	0.076	0.125
<b>Panel B3: women's empowerment on large purchases</b>			
Number of natural disasters	0.001 (0.004)	0.005 (0.004)	0.004 (0.004)
adj. $R^2$	0.067	0.048	0.094
<b>Panel B4: women's empowerment on contraception</b>			
Number of natural disasters	0.004 (0.005)	0.015*** (0.004)	0.006 (0.005)
adj. $R^2$	0.034	0.041	0.050
<b>Panel B5: women's empowerment on their own health</b>			
Number of natural disasters	0.000 (0.004)	0.006 (0.004)	0.009** (0.004)
adj. $R^2$	0.090	0.075	0.117
<b>Panel C1: women's empowerment on child schooling</b>			
Number of natural disasters	0.006 (0.005)	0.011** (0.004)	0.012*** (0.005)
adj. $R^2$	0.040	0.032	0.071
<b>Panel C2: women's empowerment on child health</b>			
Number of natural disasters	0.004 (0.005)	0.009** (0.004)	0.013*** (0.005)
adj. $R^2$	0.038	0.030	0.084
<b>Panel C3: women's empowerment on having a baby</b>			
Number of natural disasters	-0.001 (0.005)	0.007 (0.005)	0.011** (0.005)
adj. $R^2$	0.027	0.023	0.061
$N$	1286	1286	1286

Notes: \* $p < 0.10$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . Standard errors in parentheses. The regressions control for characteristics of households such as: household size, education of household head, number of household members of active age (15-55/66), number of girls aged less than 5, number of females aged 15 to 60, number of females aged 60 above, and characteristics of communes such as: dummy variable for bank for social policy, dummy variable for bank for agriculture and rural development, dummy variable for having irrigation facilities, dummy variable for good quality of main irrigation canals, dummy variable for good quality of tertiary canal, dummy variable for good quality of public well, dummy variable for good quality of dike. The regressions also control for household-level fixed-effects and year fixed-effects. Standard errors are clustered at the commune level.

TABLE 9. IMPACTS OF NATURAL DISASTERS ON THE HOUSEHOLD LOSS BY SHARE OF FARM INCOME

	Whole sample	Low share of farm income	Average share of farm income	High share of farm income
	(1)	(2)	(3)	(4)
Number of natural disasters	0.118*** (0.028)	0.087** (0.036)	0.100** (0.042)	0.146*** (0.043)
<i>N</i>	3858	1286	1286	1286
adj. <i>R</i> <sup>2</sup>	0.039	0.037	0.043	0.060

\* $p < 0.10$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . Standard errors in parentheses. The regressions control for characteristics of households such as: household size, education of household head, number of household members of active age (15-55/66), number of girls aged less than 5, number of females aged 15 to 60, number of females aged 60 above, and characteristics of communes such as: dummy variable for bank for social policy, dummy variable for bank for agriculture and rural development, dummy variable for having irrigation facilities, dummy variable for good quality of main irrigation canals, dummy variable for good quality of tertiary canal, dummy variable for good quality of public well, dummy variable for good quality of dike. The regressions also control for household-level fixed-effects and year fixed-effects. Standard errors are clustered at the commune level.

The findings of Table 8 suggest that natural disasters would cause larger household loss depending on agricultural income. In other words, the loss increases with share of farm income. Table 9 reports the estimation results on the household loss by share of farm income, which is defined as above. We find strong evidence on the positive impact of number of natural disasters on the household loss due to the natural disasters (Column 1). Number of natural disasters also has significant and positive impacts on household loss for all subsamples (Columns 2 to 4), however natural disasters have greater impacts for households with larger share of farm income. An additional number of natural disasters increases the household loss by 8.7 percent for households with low share of farm income, by 10 percent for households with average share of farm income and by 14.6 percent for households with high share of farm income.

## V. Conclusion

Most of previous literature focus on the impact of natural disasters on economic loss and physical damage. Little is known about the positive side of natural disasters. The main objective of this study is to investigate the association between natural disasters and women's empowerment in rural Vietnam and establish the causal relationship. We show that number of natural disasters is positively associated with women's empowerment. The results are strong for different measures of women's empowerment and different model specifications. These results are corroborated by those using the nonparametric methods. Our study also indicates that number of natural disasters undermine men's power relative to women's power due to a fall in agricultural income. In an agricultural society men's strength plays an essential role in cultivating activities. As such the decrease in agricultural income leads to a fall in men's power and an increase in women's power. Indeed, the study finds strong evidence on the positive impact of number of natural disasters on women's empowerment in households with high share of farm income of 2008 and no evidence on the impact of number of natural disasters on

women's empowerment in households with low share of farm income of 2008. Leveraging a test of exogeneity by Caetano (2015), which was successfully applied by Caetano and Maheshri (2018), we do a test of exogeneity for explanatory variable on number of natural disasters. We find that there is no discontinuity existing at zero number of natural disasters. It means that our explanatory variable on number of natural disasters is exogenous. And the estimates on the impact of number of natural disasters on women's empowerment is causal.

To draw solid conclusion, we put our findings into perspective. Other negative shocks such as current COVID-19 and war also change the gender inequality in a positive way. For instance, Alon et al. (2020) find that the economic downturn due to the current COVID-19 pandemic increases gender equality. Child care needs have increased dramatically following closures of schools and daycare centers. Many fathers have to take main responsibility for child care, which lead to erosion in social norms as to a lopsided distribution of the division of labor in housework and child care between men and women. Shatnawi and Fishback (2018) indicate that World War II caused a substantial increase in the wartime demand and post-war demand for female workers in manufacturing compared with the setting in 1941.

This study considers the immediate or short-term impact of natural disasters on women's empowerment. The question on the medium-term or long-term impact of natural disasters on women's empowerment is still open. To deepen the insight into the association between natural disasters and women's empowerment, future research should address this issue.

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## APPENDIX

TABLE 1. CORRELATIONS AMONG 8 VARIABLES ON WOMEN'S EMPOWERMENT

	Visits	Daily needs	Large purchases	Contraception	Their own health	Child schooling	Child health
Visits	1						
Daily purchases	0.885***	1					
Large purchases	0.652***	0.600***	1				
Contraception	0.961***	0.889***	0.664***	1			
Their own health	0.797***	0.746***	0.652***	0.804***	1		
Child schooling	0.824***	0.749***	0.674***	0.830***	0.947***	1	
Child health	0.707***	0.651***	0.753***	0.718***	0.825***	0.842***	1

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

TABLE 2. DESCRIPTIVE STATISTICS ON DEPENDENT VARIABLES

Index of women's empowerment	0.061	2.500	-6.063	1.944
Number of women's empowerment	5.997	3.079	0	8
<b>Women's empowerment on</b>				
Visits	0.793	0.405	0	1
Daily purchases	0.804	0.397	0	1
Large purchases	0.768	0.422	0	1
Contraception	0.650	0.477	0	1
Their own health	0.802	0.398	0	1
Child schooling	0.738	0.440	0	1
Child health	0.752	0.432	0	1
Having a baby	0.689	0.463	0	1

TABLE 3. DESCRIPTIVE STATISTICS ON INDEPENDENT VARIABLES

	Mean	Std. Dev	Min	Max
Number of natural disasters	6.442	5.346	0	21
Household size	4.476	1.745	1	13
Number of household members of working age	2.942	1.534	0	9
Number of girls aged less than 5	0.086	0.302	0	2
Number of girls aged 5 to 15	0.335	0.638	0	5
Number of females aged 15 to 60	1.546	0.955	0	6
Number of females aged over 60	0.297	0.471	0	3
Dummy variable for bank for social policy	0.545	0.498	0	1
Dummy variable for bank for agriculture and rural development	0.262	0.440	0	1
Dummy variable for having irrigation facilities	0.906	0.292	0	1
Dummy variable for good quality of main irrigation canals	0.250	0.433	0	1
Dummy variable for good quality of tertiary canal	0.136	0.343	0	1
Dummy variable for good quality of public well	0.027	0.161	0	1
Dummy variable for good quality of dike	0.091	0.288	0	1

TABLE 4: ROBUSTNESS CHECKS ON THE IMPACT OF NATURAL DISASTERS ON WOMEN'S EMPOWERMENT

	Coefficients	Standard errors	N	adj. $R^2$
<b>Panel A. index and number of women's empowerment</b>				
Index of women's empowerment	0.037**	-0.017	3810	0.014
Number of women's empowerment	0.049**	-0.022	3810	0.069
<b>Panel B. women's empowerment on household activities</b>				
Visits	0.004	-0.003	3810	0.093
Daily purchases	0.004	-0.003	3810	0.092
Large purchases	0.003	-0.003	3810	0.063
Contraception	0.008**	-0.003	3810	0.025
Their own health	0.005*	-0.003	3810	0.089
<b>Panel C. women's empowerment on their own children</b>				
Child schooling	0.010***	-0.003	3810	0.045
Child health	0.009***	-0.003	3810	0.049
Having a child	0.006*	-0.003	3810	0.03

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ . Standard errors in parentheses. The regressions control for characteristics of households such as: household size, education of household head, number of household members of active age (15-55/66), number of girls aged less than 5, number of females aged 15 to 60, number of females aged 60 above, and characteristics of communes such as: dummy variable for bank for social policy, dummy variable for bank for agriculture and rural development, dummy variable for having irrigation facilities, dummy variable for good quality of main irrigation canals, dummy variable for good quality of tertiary canal, dummy variable for good quality of public well, dummy variable for good quality of dike. The regressions also control for household-level fixed-effects and year fixed-effects. Standard errors are clustered at the commune level.