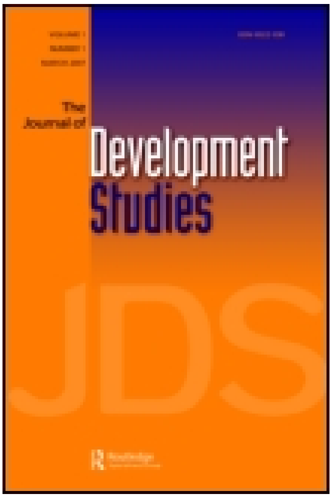

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Natural Disasters, Human Development and Poverty at the Municipal Level in Mexico

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ABSTRACT *This article analyses the effects of natural disasters on human development and poverty levels at the municipal level in Mexico. Using several sources, we build a panel of data in order to uncover if different natural shocks can affect social indicators. After controlling for geographic and natural characteristics which can make municipalities more hazard prone, as well as for other institutional, socio-economic and demographic pre-shock characteristics, in addition to using fixed effects, we find that general shocks, especially from floods and droughts, lead to significant drops in both types of indicator.*

1. Introduction

Significant social and economic consequences of major recent natural disasters in different parts of the world have reiterated the need to place disaster concerns higher on the global poverty agenda. In parallel, there seem to be evidence that global climate change would lead to wide-ranging shifts in climatic variables, possibly increasing the recurrence and virulence of climatic hazards in vast parts of the world (IPCC, 2007).

Hazards are potentially damaging physical events or phenomenon that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation (International Strategy for Disaster Reduction (ISDR), 2007). The probability of occurrence of hazards is associated with a threat to welfare until they materialise or vanish. If this threat becomes real and affects significantly life and property, then it is called a natural disaster (Hyndman and Hyndman, 2006).

While the occurrence of a natural hazard could be considered exogenous, its transformation into a disaster is not. Being exposed to a hazard per se can be welfare damaging: households due to risk-averse behaviour typically may adopt less than optimal income-generating activities to reduce this exposure, which in low-income contexts can translate into poverty, even if the hazard event never materialises. Simultaneously, if a contingency occurs, since the poor tend to lack adequate access to financial and social insurance institutions they probably end up using their few assets which could plunge them further into persistent deprivation. Therefore, the effect of

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hazards on poverty could be understood from two temporal angles with respect to the hazard itself: before it happens (ex ante) or once it occurs and becomes a disaster (ex post backward-looking assessment).

And yet, with a few exceptions (United Nations International Strategy for Disaster Reduction Secretariat (UNISDR), 2009), the foreseeable effects of geological or climatic hazard events on poverty have not translated into a systematic research agenda that illustrates their connection, in part because of the availability of related data. Major reviews on poverty dynamics have noted, for instance, that few studies account for this type of risk effect (Baulch and Hoddinott, 2000; Dercon and Shapiro, 2007).

The literature on the social and economic consequences of natural disasters is still scarce, since it is only in recent years that data has become more available for the analysis in this field. One strand of literature focuses on the effects of natural disasters on macro-economic indicators or country-level variables, including GDP, its growth, and inequality. The numerous studies differ in their techniques, data and findings. This literature is relevant in two respects: it provides some orders of magnitude to the effects of disasters, and it suggests channels through which their effects disseminate into the macro economy.

Some research in recent years has taken advantage of new data that has been linked to natural events. At the macro level economic growth results indicate a negative effect (Auffet, 2003; Strobl, 2011) or positive effect (Skidmore and Toya, 2002), such effects being clearer when analysed at the sectorial level as in Loayza et al. (2009). Other research, at village or household level, has focused on the effect on consumption, investment health and nutrition, and human capital (that is, Dercon et al., 2005; Alderman et al., 2006; Carter et al., 2007, among others). Specific effects have also been analysed and found to be important in local business as in Yamano et al. (2007), Thompson (2009) and Ewing et al. (2009).

When analysing which additional factors reduce or increase the effect of the disasters on macro indicators, Kahn (2005), Toya and Skidmore (2007) and Noy (2009) find that institutions, higher education and trade openness, as well as strong financial sector and smaller governments, are important factors in determining the effect that natural disasters have on development at the international level. However, the effect may differ according to levels of aggregation of economic sectors and for different disasters.

Loayza et al. (2009) tried to reconcile the seemingly contradictory results by estimating the medium-term effects of droughts, floods, earthquakes, and storms (separately and simultaneously) on economic growth using a model with three main sectors (agriculture, industry and services) and with the whole economy. They found that over a five-year period growth falls by 0.6 per cent after a drought, mainly affecting agriculture and industrial growth (falls by 1%). In contrast, overall growth rises by 1 per cent after a flood, to the extent that they are moderate, especially benefiting industrial economic sectors. Kellenberg and Mobarak (2008) find significant effects from diverse natural disasters on human lives, especially from floodings, landslides and windstorms, using a panel of countries, as such events, they argue, are more related to behavioural choices.

Mexico is not an exception for the suffering from the impact of natural events. Being in a geographical position that seems to develop natural events translating into some damages to population, and also a middle income country with high levels of poverty and inequality, makes Mexico an interesting field for the analysis of how shocks from natural disasters affect social indicators such as human development and poverty at the local level. This article contributes to the literature on the effect of natural disasters on poverty in analysing how different local shocks from natural disasters affect local social indicators such as the poverty levels and human development in municipalities in Mexico.

The article draws on a unique poverty panel dataset of municipalities in Mexico, connected with a database of natural disasters available also at the municipal level. We then bring data from other public sources to account for natural, geographic, socio-demographic and economic characteristics of municipalities, as well as for some institutional capacities to cope with disasters. After calculating in a regression framework the difference in welfare changes between affected and nonaffected municipalities, our estimates show that natural disaster shocks reduce human development and increase poverty in those areas.

Overall this article contributes to the existing literature on natural disasters in two ways. First, it assembles multiple databases (poverty maps, disaster data, census data and municipal socio-demographic and institutional panel data) at the municipal level to assess the effect of natural disasters on poverty and human development. This is a welcome development within the literature on natural disasters given the frequency of calculating and using output measures to assess disasters' effects. Furthermore, there is a glaring omission under existing literature on what policies (beyond household level) could help to redress the effect of these shocks. Empirically, we focus directly on the effects of natural disasters on human development and poverty, as well as resources, which could be fundamental prior to and during the recovery process.

The article is structured as follows. In section 2 we present the data and an overview of the variables considered for the present analysis, as well as the methodology used. Section 3 presents the results. Finally some conclusions and considerations are presented.

2. Methodology, Data Sources and Variables

Methodology

As explained earlier, hazards are threatening events that only become disasters if they find unprotected people and assets in their way. Provided one can control for vulnerability (that is, those characteristics that make a natural hazard turn into a disaster), one can treat disasters as an exogenous shock to social welfare indicators at sub-national level allowing for comparisons between treatment and control groups. With at least two periods of data, we can know what happened to poverty before and after the disaster and therefore calculate the effect of such disasters within a regression framework through a difference in difference specification and random effects model as in the following form:

$$Y_{mt} = \alpha_0 + \alpha_1 T_m + \alpha_2 A_t + \alpha_3 T_m A_t + \alpha_4 X_{mt} + \varepsilon_m + u_{mt} \tag{1}$$

Where Y denotes the outcome of interest for municipality m at year t. T denotes a dummy for areas considered treatment (that is, municipalities with incidence of a natural event), A is a year dummy taking the value of 1 for the 2005 (after) and cero for 2000, X is a vector of municipal characteristics (geographical, natural, socio-economic, institutional and financial). The term α_3 measures the effect of a natural disaster on the outcome variable Y.

We are including in X different sets of pre-shock variables which may render some municipalities more vulnerable to a natural hazard than others, or making the municipality more prone to a natural disaster. In this respect, we will interact the treatment dummy with these pre-shock covariates to control for existing observable variations between treatment and control groups that may determine the effect while reducing possible selection bias in the sample. Equation (1) then becomes:

$$Y_{mt} = \alpha_0 + \alpha_1 T_m + \alpha_2 A_t + \alpha_3 T_m A_t + \alpha_4 X_{mt} + \alpha_4 X_{mt} T_m + \varepsilon_m + u_{mt} \tag{2}$$

In addition, it may be argued that despite controlling for pre-shock variables there would be some unobservable characteristics that may affect the magnitude of the effect, therefore we will include a fixed effect model at the municipal level in the following form:

$$Y_{mt} = \alpha_m + \alpha_1 T_m + \alpha_2 A_t + \alpha_3 T_m A_t + \alpha_4 X_{mt} + \alpha_4 X_{mt} T_m + u_{mt} \tag{3}$$

Where Y is the level of the welfare indicator chosen (poverty incidence, poverty depth, poverty severity, human development) in municipality m at time t, and α_m is a municipal fixed effect.

Estimating regressions with fixed municipal effects constitutes a robustness test for our main results. Further robustness checks are performed with varying control groups and samples sizes as explained below. We now turn to the sets of variables created for analysis, their sources and basic statistics.[1]

Data and Variables

To test whether a natural disaster affects poverty on municipality, one requires information on three fronts: (1) natural hazards, ideally from units of measurement associated with the phenomenon in turn – rainfall for drought and floods, temperature for frosts, earthquake magnitude and so forth; or alternatively from a disasters database that lead into hazard categories; (2) existing household, community and extra-community characteristics that account for both exposure and coping capacity to mitigate any effect; and (3) welfare outcomes, that crudely speaking result from the interaction of the first two and can span from money-metrics to human development indicators. We have data for 2,454 municipalities, from which several experienced natural disasters between 2000 and 2005.

Information on (1) the incidence of natural hazard events at municipal level was extracted from the DesInventar database (see the Online Appendix for a description of this database). Although DesInventar records disasters (a disaster triggers the inclusion into the hazard category; more simply, hurricanes in uninhabited areas are not recorded for example), it constitutes the only nationwide dataset on hazard events at municipal level in Mexico. For analytical purposes disasters are taken from those geological and climatic events and divided into five hazard categories: floods, frost, droughts, rains and other events.[2] The amount of information at our disposal on municipal characteristics (on geographic, socio-economic, demographic and public preventive and coping mechanisms, among others) still allow us to analyse disaster effects on poverty, mending potential endogeneity troubles contained on the exposure of municipalities to hazards and the coping mechanisms.[3] Comments on benefits and drawbacks using this kind of databases can be found in Wisner et al. (2004).

Most data for components (2) and (3) was elicited from the 2000 Census, the 2005 Count of Population and Housing, and surveys. We use as dependent variables the Human Development Index (HDI), as published by the UNDP, and income poverty levels in three officially defined alternative measures of poverty: food-based poverty, capabilities-based poverty and assets-based poverty (which are equivalent to extreme poverty, poverty and moderate poverty) as published by the National Council for Evaluation of Social Development Policy in Mexico (CONEVAL, 2008), both for 2000 and 2005 at the municipal level. A household is considered food poor if its member's income falls below the lowest income necessary to afford a minimum basket of food. A household is considered to be in capabilities-based poverty if its members cannot afford to cover their basic expenses on food, health and education, according to an officially defined basket. Finally, a household is considered to be in assets-based poverty if its members cannot cover their expenses of food, health, education, dressing, home and public transportation.

We control for characteristics (collectively named Geography and Nature) that may make some areas more prone to natural events, including measures of latitude, altitude, surface length, percentage of arid and semiarid areas within the municipality, deforestation rates, and maximum and minimum average temperatures and rainfall. Data under this category is from 2000 or one or two previous years, and were collected from several public sources including the National Water Commission (CONAGUA in Spanish), and the National Institute of Statistics and Geography (INEGI in Spanish).

We also account for emergency preparedness and hazard mitigation practices within the municipality (collectively named Institutional/Local Capacity). This includes variables that may improve the response capacity of local governments prior to hazard events and once turned into disasters. The first group comprises variables such as the existence of risk maps, civil defence units and contingency plans, as well financial capacity such as the share of local own earnings to total local earning (tax resources) and the share of federal transfers received divided by total local earning (federal resources). This set of variables was collected from the 2000 National Survey of Municipal Governments applied by the National Institute of Social Development (INDESOL). The availability of coping funds is proxied by a dummy that captures whether the municipality received financial resources for disaster relief and reconstruction after a natural disaster occurred. The Natural Disasters Fund (FONDEN in Spanish), the government agency in charge of allocating such funds, declares which events are catastrophic, triggering disbursements of the fund.[4]

We constructed a number of pre-shock (2000) municipal-level variables that may affect the resilience of the municipal population to natural hazards, that is, the capacity to recover from shocks. This includes the share of individuals or households with the following characteristic within the municipality: rural population; migration intensity; population working in different economic sectors (primary, secondary and tertiary); population with social security; indigenous population; demographic composition of population; and degree of inequality within the municipality measured through the Gini index. This data was gathered from the National Population Census in 2000 (INEGI) and the UNDP. In addition we will consider in the model state level effects. Summary statistics are presented in Table 1 with their corresponding source.

One potential issue to be aware is the possibility that some migration may be occurring due to natural shocks in affected areas. Some comments have arisen in the sense that selective migration may occur, with the better off leaving, and those with lower welfare remaining in affected areas, potentially biasing the results. In this respect, previous studies such as Belansen and Polacheck (2009) find an increase in earnings of about 4.5 per cent for those remaining, while in neighbouring counties decrease in same percentage, assuming that may happen because a fraction of workers may move, although from data is not possible to know it directly. DeSilva et al. (2010) find a reduction of 0.7 per cent in wages for low skilled industries compared to high skilled in Houston after receiving displaced from hurricane Katrina, although such effect is only significant when interacting with sales per firm in the area. Strobl (2011) finds a positive effect from hurricanes on outward and inward migration of taxpayers in the US coasts.

In this regard, we did some checks with the available information that could hint something about, being aware that are just indicative. First, data for migration at the municipal level is only available from the population census in 2000 and 2010, although the questions change, and the information for the article is only available for 2000 and 2005. We used information on the population for municipalities, and ran a regression to check if there is a reduction in population after the natural shocks compared to municipalities with no shocks, and the results shows no significant evidence In this sense also, Rodriguez-Oreggia (2011), for example, analysed the effect of hurricanes on attrition for the labour surveys in metropolitan areas, also finding no significant effects. According to Macías (2010), migration in Mexico is due to pre-existent factors in localities, and not due to natural shocks. Models presented in the next section control for the share of individuals living in the same area after the last census. We acknowledge that specific models for migration and fertility should be applied to identify the impact of natural disasters on that issue, but that is beyond the scope of this article and data existing in Mexico.

3. Results

Disaster and Poverty

We estimated Equations (2) and (3) to assess the effect of natural disasters on human development and poverty. Using a sample that comprises all municipalities, Table 2 presents the results from natural disasters in general as treatment category, with those municipalities that experienced no disasters in the period of analysis as the control group. Estimations are presented with the panel structure using random and fixed effects at the municipal level, and standard errors are clustered at the municipal level.[5]

Table 1. Descriptive statistics

	Mean	Std. dev.	Min	Max	Source
Dependent					
Human Development Index*	0.7079	0.0758	0.3915	0.9165	PNUD (2008)
Food poverty incidence*	0.4438	0.2423	0.0160	0.9680	CONEVAL (2008)
Capacities poverty incidence*	0.5141	0.2427	0.0280	0.9810	CONEVAL (2008)
Assets poverty incidence*	0.6828	0.2119	0.0920	0.9950	CONEVAL (2008)
Natural disasters occurrence					
Any event[b]	0.4234	0.4942	0	1	DesInventar (2008)
Flood[b]	0.2326	0.4226	0	1	DesInventar (2008)
Frost[b]	0.0835	0.2768	0	1	DesInventar (2008)
Drought[b]	0.0831	0.2761	0	1	DesInventar (2008)
Rains[b]	0.0811	0.2730	0	1	DesInventar (2008)
Others[b]	0.1716	0.3771	0	1	DesInventar (2008)
Geography and nature					
Altitude*	1304	819	2	2924	INEGI (2006)
Latitude*	198388	33461	143827	322993	INEGI (2006)
Length*	985658	43623	865878	1166813	INEGI (2006)
Arid surface*	6.49	17.04	0.00	97.50	CNA (2007)
Semi-arid surface*	16.38	20.22	0.00	72.50	CNA (2007)
Deforestation rate*	−18.27	17.89	−62.57	−0.56	Davis (1997)
Minimum temperature*	7.25	5.74	0.00	24.00	CNA (2007)
Maximum temperature*	27.46	2.90	16.00	30.00	CNA (2007)
Minimum rain*	15.76	10.17	1.50	57.40	CNA (2007)
Maximum rain*	175.78	51.93	8.00	315.50	CNA (2007)
Socio-economic					
Rural municipalities**	0.8350	0.3713	0.0000	1.0000	INEGI (2001)
Economic dependency rate*	0.8333	0.1693	0.3945	2.3700	INEGI (2001)
Population with social security**	0.2148	0.1824	0.0000	0.8055	INEGI (2001)
Population living in the same state 5 years before**	0.9677	0.0252	0.6714	1.0000	INEGI (2001)
Indigenous population**	0.0379	0.0993	0.0000	0.7682	INEGI (2001)
Gini coefficient*	0.4044	0.0556	0.1955	0.5978	PNUD (2008)
Employed at primary sector**[a]	0.1284	0.0781	0.0005	0.5533	INEGI (2001)
Employed at secondary sector**[a]	0.0705	0.0458	0.0000	0.3461	INEGI (2001)
Employed at tertiary sector**[a]	0.0968	0.0618	0.0023	0.4098	INEGI (2001)
Coping funds and covariates					
With FONDEN resources 2000–2005**	0.8014	0.3990	0.0000	1.0000	CENAPRED (2008)
Same political party at municipal and state level when hazard occur	0.0348	0.1833	0	1	INAFED (2008)
Same political party at municipal and federal level when hazard occur	0.0168	0.1285	0	1	INAFED (2008)
Institutional/local capacity					
NGO for consultation or courses	0.2645	0.4412	0	1	INEGI (2003)
Seminar attendance	0.1716	0.3771	0	1	INEGI (2003)
No NGO	0.3014	0.4590	0	1	INEGI (2003)
Associated services	0.2158	0.4115	0	1	INEGI (2003)
Municipal regulations	0.2121	0.4089	0	1	INEGI (2003)
Municipal development plan	0.7211	0.4485	0	1	INEGI (2003)
Civil defence unit	0.5733	0.4947	0	1	INEGI (2003)
Civil defence programme	0.4607	0.4986	0	1	INEGI (2003)
Natural contingency in the 1990s	0.5909	0.4918	0	1	INEGI (2003)
Hazard map	0.3055	0.4607	0	1	INEGI (2003)
Tax resources**	6.4960	8.1633	0	90	INEGI (2003)
Federal resources**	40.9682	19.8749	0	100	INEGI (2003)

Notes: *Average, **proportion. [a]Relative to total population. [b]Between 2000 and 2005. Data for year 2000 except coping.

As Table 2 shows, the occurrence of a natural disaster in the period 2000–2005 reduced the Human Development Index by about −0.0068 on average. This represents about 1 per cent drop (0.98 or 0.97% using random or fixed effects, respectively) in such index. For those municipalities affected by a natural hazard over the reviewed period this would be equivalent to losing on average two years of human development gains over the same period. This is a substantial reversal in development for an average municipality.

As for poverty, the occurrence of natural disasters during 2000–2005 increased food poverty, or extreme poverty, by about 3.7 per cent, capacities poverty by 3 per cent and assets poverty by 1.5 per cent. The effect from specific types of disasters could well vary and, for that reason, we disaggregate the natural shocks into different natural shocks as presented in Table 3.

In order to know the marginal effect from a specific variable given the shock from a natural disaster, in the Online Appendix we present the interactions of the treatment dummy with the control variables. The coefficients present the marginal effect from such controls. Most of them are not significant, although some are. For example, the use of federal resources against natural disasters effects (FONDEN) seems to have a positive effect on poverty, even though this variable may respond more to political factors for allocating such funds rather than to palliate adverse effects. Attending seminars related to public administration, as well as having a municipal development plan, have a negative effect on poverty when using all the sample. The political controls, same party as governor or president, are mostly relevant in both samples. The share of population with social security is highly relevant in reducing poverty with both samples for those localities with a disaster. The share of indigenous population, as well as employment in the tertiary sector and the Gini coefficient are only relevant using all sample of municipalities.[6]

Table 2. Effect of a natural disaster on social municipal indicators

	All municipalities in sample		Municipalities without previous disaster	
Social indicator	(1) Random effects	(2) Fixed effects	(3) Random effects	(4) Fixed effects
Human Development Index	−0.00688***	−0.00684***	−0.00392**	−0.00371**
	(0.00108)	(0.00108)	(0.00181)	(0.00179)
R^2	0.8447	0.756	0.8082	0.786
N	4,836	4,836	2,370	2,370
Food poverty (severe)	0.0367***	0.0371***	0.0225***	0.0222***
	(0.00495)	(0.00493)	(0.00873)	(0.00860)
R^2	0.8116	0.472	0.0181	0.549
N	4,884	4,884	2,404	2,404
Capacities poverty	0.0300***	0.0305***	0.0206**	0.0199**
	(0.00485)	(0.00483)	(0.00842)	(0.00828)
R^2	0.8209	0.427	0.7881	0.508
N	4,884	4,884	2,404	2,404
Assets poverty	0.0154***	0.0160***	0.0147**	0.0135**
	(0.00431)	(0.00427)	(0.00693)	(0.00679)
R^2	0.8150	0.210	0.7753	0.318
N	4,884	4,884	2,404	2,404
Natural disasters occurrence	yes	yes	yes	yes
Geography and nature	yes	yes	yes	yes
Socio-economic	yes	yes	yes	yes
Coping funds	yes	yes	yes	yes
Institutional/local capacity	yes	yes	yes	yes
Inequality	yes	yes	yes	yes

Notes: ***$p < 0.01$, **$p < 0.05$. Robust standard errors clustered at the municipal level in parentheses. All regressions are also controlled for state fixed effects and interaction of the treatment dummy with local declaratories when using random effects.

Table 3. Effects of different natural disasters on social municipal indicators

	Human Development Index		Food poverty (severe)		Capacities poverty		Assets poverty	
	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects
Flood	−0.00271**	−0.00269**	0.0354***	0.0358***	0.0295***	0.0299***	0.0188***	0.0193***
	(0.00124)	(0.00123)	(0.00544)	(0.00538)	(0.00545)	(0.00539)	(0.00520)	(0.00512)
Frost	−0.00555***	−0.00556***	−0.00814	−0.00815	−0.00605	−0.00608	0.00108	0.00100
	(0.00204)	(0.00202)	(0.00847)	(0.00839)	(0.00833)	(0.00824)	(0.00763)	(0.00753)
Drought	−0.0101***	−0.0100***	0.0434***	0.0440***	0.0390***	0.0397***	0.0266***	0.0274***
	(0.00195)	(0.00193)	(0.00784)	(0.00774)	(0.00810)	(0.00798)	(0.00807)	(0.00790)
Rains	0.00641***	0.00640***	−0.000950	−0.00116	−0.00599	−0.00625	−0.0133*	−0.0137*
	(0.00189)	(0.00187)	(0.00785)	(0.00777)	(0.00793)	(0.00785)	(0.00760)	(0.00749)
Others	−0.00558***	−0.00557***	0.0232***	0.0234***	0.0200***	0.0202***	0.00705	0.00726
	(0.00132)	(0.00130)	(0.00576)	(0.00570)	(0.00572)	(0.00567)	(0.00528)	(0.00522)
Adjusted R^2	0.8457	0.7604	0.8151	0.4814	0.8233	0.4357	0.8166	0.2173
N	4,836	4,836	4,884	4,884	4,884	4,884	4,884	4,884
Natural disasters occurrence	yes	yes	yes	yes	yes	yes	yes	yes
Geography and nature	yes	yes	yes	yes	yes	yes	yes	yes
Socio-economic	yes	yes	yes	yes	yes	yes	yes	yes
Coping funds	yes	yes	yes	yes	yes	yes	yes	yes
Institutional/local capacity	yes	yes	yes	yes	yes	yes	yes	yes
Inequality	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All municipalities in sample. All regressions are also controlled for state fixed effects and interaction of the treatment dummy with local declaratories when using random effects. *Overall* R-squared is reported when using random effects; meanwhile *within* R-squared is reported when using fixed effects. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Robust standard errors clustered at the municipal level in parentheses.

Financial variables for the locality are also not significant (tax resources and federal resources). These results point to the need to improve local capacity indicators for coping better with natural shocks and reducing the impact from such shocks on social indicators.

Table 3 shows welfare effect disaggregated by type of disaster.[7] All events but rains reduce the HDI with statistical significance: floods (0.38%), frosts (0.78%), droughts (1.34%) and other disasters (0.78%). Interestingly, rains have a positive effect in such index (0.9 per cent), and this effect remains constant in further runs. This finding is not entirely surprising: Loayza et al. (2009) found, in a global sample, that countries that moderate floods and storms have a positive effect on growth of about the same magnitude as our analysis, across different economic sectors.

Floods, droughts and other disasters[8] also increase poverty. In the case of floods the effect ranges from 1.9 to 3.5 per cent for assets poverty, 2.9 per cent for capacities poverty and 3.5 per cent for food poverty. Droughts also increase poverty levels in a significant way: 4.3 per cent food poverty, 2.7 per cent assets poverty and 3.9 per cent capacities poverty. Other disasters also increase food and capacities poverty by 2.3 and 2 per cent, respectively, with no significant effect on assets poverty. Frost and rains are not significant.

In all the previous regression we have included a dummy indicating whether such municipality had been affected by a given disaster in the previous decade, but the coefficients, unreported here, are not significant, possibly indicating the prevalence of medium and short-term effects at the local level. In order to make a further check on this issue we will focus on restricting the sample to municipalities without previous disasters, then to those with only disasters in the period.

Robustness Checks

We performed checks on the robustness of the estimations obtained by restricting the sample first to those municipalities without reported disasters in the previous decade (1990s), with the comparison group being those municipalities without disasters previously reported and without disasters in the period under analysis. In this way, we are comparing localities that are affected in the period to localities that have not been affected even in previous periods of time, which is the closest we can get to a pure control group. These estimations are presented in Table 4. Second, we restrict the sample only to those municipalities suffering from any disaster in the period of analysis, and for this case, since only affected municipalities are in the sample, the comparison group will be municipalities under the category of 'other' disasters. In this case, we are trying to identify the effect, in a differentiated way, for those with treatment or disasters in the period of analysis. The results are presented in Table 4 for restricted sample without previous disasters.

In this exercise, both human development and poverty levels are adversely affected by disasters with statistical significance. Droughts reduce the Human Development Index by 2 per cent, and other disasters by 0.8 per cent, but rains tend also to increase the Index by 1 per cent. Droughts, floods, and other disasters tend also to increase poverty, though the first category without significance. Some effects are even larger than those found in Table 3, using the all-municipalities sample. Therefore, using as a control group a set of municipalities that have not been affected in any period for a natural disasters seems to present a larger effect on poverty and human development.

A final check consisted of restricting the study sample to only those municipalities that suffered a disaster in the period under analysis. In this case, the control group are those municipalities which experienced disasters contained under the 'other' category. This model was applied only when we disaggregate by type of disaster.

Table 5 shows that, relative to those municipalities that experienced 'other' disasters, droughts and frosts reduce the Human Development Index by 1.27 and 0.66 per cent, respectively. For poverty levels, the main effects are coming from floods and droughts. Floods increase food poverty by about 3.2 per cent, capacities poverty by 2.7 per cent and asset poverty by 1.9 per cent, compared to those municipalities that suffered other type of disasters. Droughts have also a negative and significant effect on poverty: 4.2 per cent increase in food poverty, 3.8 per cent in

Table 4. Effects of different natural disasters on social municipal indicators restricted to municipalities without natural disaster in previous period

	Human Development Index		Food poverty (severe)		Capacities poverty		Assets poverty	
	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects
Flood	−0.00395	−0.00350	0.0459***	0.0462***	0.0402***	0.0399***	0.0274***	0.0260***
	(0.00250)	(0.00247)	(0.0112)	(0.0111)	(0.0106)	(0.0104)	(0.00864)	(0.00838)
Frost	0.00528	0.00526	−0.0747***	−0.0749***	−0.0615***	−0.0617***	−0.0233	−0.0236
	(0.00374)	(0.00367)	(0.0181)	(0.0178)	(0.0183)	(0.0180)	(0.0156)	(0.0153)
Drought	−0.0142***	−0.0143***	0.0306	0.0304	0.0223	0.0222	−0.000326	−0.000243
	(0.00492)	(0.00483)	(0.0205)	(0.0201)	(0.0209)	(0.0205)	(0.0185)	(0.0182)
Rains	0.00772*	0.00744*	−0.0262	−0.0265	−0.0283	−0.0283	−0.0271**	−0.0266**
	(0.00412)	(0.00403)	(0.0225)	(0.0221)	(0.0203)	(0.0199)	(0.0127)	(0.0125)
Others	−0.00589**	−0.00546**	0.0342***	0.0345***	0.0339***	0.0337***	0.0241**	0.0227**
	(0.00250)	(0.00246)	(0.0113)	(0.0111)	(0.0113)	(0.0110)	(0.01000)	(0.00970)
Adjusted R^2	0.8080	0.7879	0.7889	0.5607	0.7915	0.5183	0.7771	0.3238
N	2,370	2,370	2,404	2,404	2,404	2,404	2,404	2,404
Natural disasters occurrence	yes	yes	yes	yes	yes	yes	yes	yes
Geography and nature	yes	yes	yes	yes	yes	yes	yes	yes
Socio-economic	yes	yes	yes	yes	yes	yes	yes	yes
Coping funds	yes	yes	yes	yes	yes	yes	yes	yes
Institutional/local capacity	yes	yes	yes	yes	yes	yes	yes	yes
Inequality	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All regressions are also controlled for state fixed effects and interaction of the treatment dummy with local declaratories when using random effects. *Overall* R-squared is reported when using random effects; meanwhile *within* R-squared is reported when using fixed effects. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Robust standard errors clustered at the municipal level in parentheses.

Table 5. Effects of different natural disasters on social municipal indicators restricted to municipalities with natural disaster only

	Human Development Index		Food poverty (severe)		Capacities poverty		Assets poverty	
	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects	(1) Random effects	(2) Fixed effects
Flood	−0.000621	−0.000614	0.0326***	0.0327***	0.0278***	0.0280***	0.0193***	0.0195***
	(0.00153)	(0.00151)	(0.00675)	(0.00664)	(0.00677)	(0.00665)	(0.00636)	(0.00624)
Frost	−0.00478**	−0.00479**	−0.00777	−0.00791	−0.00529	−0.00546	0.00202	0.00180
	(0.00204)	(0.00200)	(0.00857)	(0.00844)	(0.00844)	(0.00831)	(0.00787)	(0.00772)
Drought	−0.00908***	−0.00905***	0.0425***	0.0430***	0.0386***	0.0392***	0.0271***	0.0277***
	(0.00200)	(0.00197)	(0.00816)	(0.00802)	(0.00840)	(0.00824)	(0.00834)	(0.00814)
Rains	0.00721***	0.00719***	−0.00145	−0.00176	−0.00606	−0.00643	−0.0128*	−0.0133*
	(0.00193)	(0.00190)	(0.00799)	(0.00787)	(0.00805)	(0.00792)	(0.00773)	(0.00757)
Adjusted R^2	0.8717	0.7606	0.8299	0.4612	0.8359	0.4134	0.8154	0.1866
N	2,062	2,062	2,068	2,068	2,068	2,068	2,068	2,068
Natural disasters occurrence	yes	yes	yes	yes	yes	yes	yes	yes
Geography and nature	yes	yes	yes	yes	yes	yes	yes	yes
Socio-economic	yes	yes	yes	yes	yes	yes	yes	yes
Coping funds	yes	yes	yes	yes	yes	yes	yes	yes
Institutional/local capacity	yes	yes	yes	yes	yes	yes	yes	yes
Inequality	yes	yes	yes	yes	yes	yes	yes	yes

Notes: All regressions are also controlled for state fixed effects and interaction of the treatment dummy with local declaratories when using random effects. *Overall* R-squared is reported when using random effects; meanwhile *within* R-squared is reported when using fixed effects. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Robust standard errors clustered at the municipal level in parentheses.

capacities poverty and 2.6 per cent in asset poverty, again compared to those localities that experienced other types of disasters.

Conclusion

Natural disasters have gained prominence in recent times as they are becoming more recurrent. Notwithstanding the expected harm of these and many other hazards on poverty, an empirical agenda that illustrates their connection is still missing by and large, at least for Mexico. In this context, this article analyses the effect of natural disasters on human development (measured through the Human Development Index developed by UNDP) and poverty (measured under three different poverty lines: food, capacities and assets) during the 2000–2005 period, years for which data is available.

In a panel setting, we exploit the variation on the incidence of natural disasters across municipalities in Mexico using a difference-in-difference strategy within a regression framework. Having pre- and post-disaster welfare outcomes and covariates, we control for different sets of pre-shock variables that may influence the magnitude of the effect of natural disasters, including geographical and natural characteristics; socio-economic factors, institutional and local administrative capacity, as well as financial coping mechanisms and political covariates, and their interactions with the treatment dummies.

Our results show a significant and adverse effect of natural disasters on both human development and poverty. Poverty levels increased between 1.5 and 3.7 per cent, based on the measure considered. Similarly, for affected municipalities, the effect on the Human Development Index was similar to going back two years in human development over the same period analysed, on average. Disaggregating by type of event we found that floods and droughts had the most adverse effects compared to other hazards. Institutional factors suggest a big room for implementing more efficient public mechanisms to cope with the shock from disasters at the local level and for preventing ex ante the shocks.

An area for future research could be to determine whether these indicators catch up after a longer period of time. Previous literature suggests that an initial drop in economic growth could be followed by larger growth due to reconstruction inflows. Can we expect the same with poverty and human development? It would be interesting to document, for example, if some sectors benefited after an initial dip, but poverty did not, but, for that, availability of data for the long term will be required.

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Notes

1. These models measures the average effect from any specific shock, since the data is not suitable for better measures of intensity, as shown in the Online Appendix, we will focus on the model presented.
2. Other events comprise a set of events with lower frequency including: landslide, avalanche, eruption, hailstorm, surge, snowstorm, earthquake, electric storm, tornado, strong winds.
3. Although the DesInventar database has information on both casualties and economic losses, we decided not to rely on those parameters.
4. For this analysis we received from CENAPRED a base that only includes whether a municipality had a declared emergency and authorised the use of FONDEN, but not the specific amounts. In addition, FONDEN usually runs out

of funds given the prevalence of diverse events during a year, in addition to be subject to political voracity in order to have the money transferred, besides that local government are not exactly accountable for the use of such money for affected population (Borensztein et al., 2008). For other issues of FONDEN regarding the lack of complementarity between federation and states due to financial constrains see, for example, Saldaña-Zorrila (2007).

5. Ideally, one should use municipal fixed effects for separating the causes of changes within municipalities, but cannot be used if we want to analyse time invariant variables, such as the pre-shocks we included in the models. For a matter of comparison we present both estimations, fixed and random although the Hausman test for all the regressions in Tables 2, 3 and 4 are mostly not significant, except for Table 2 in assets poverty, where fixed effects are then preferred.
6. We only present in the Online Appendix the controls interacted for general disaster, due to considerations of space.
7. For this case, some municipalities can be accounted for different disasters (that is, if they suffered from a hurricane they are recording under floods and under storms), since the DesInventar records the disaggregated event.
8. Comprises: avalanche, eruption, hailstorm, surge, snowstorm, earthquake, electric storm, tornado, strong winds.

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