

Breckner, Miriam; Englmaier, Florian; Stowasser, Till; Sunde, Uwe

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Economic Development and Resilience to Natural Catastrophes – Insurance Penetration and Institutions*

Miriam Breckner

Florian Englmaier

Till Stowasser

Uwe Sunde

February 12, 2016

This paper provides new evidence on the negative effect of natural catastrophes on economic development. The findings indicate that private insurance markets accommodate the negative effects of natural catastrophes in developed countries, whereas they do not seem to be effective in developing countries. This pattern explains the heterogenous effects of natural disasters on income that have been found in previous studies. The results suggest that insurance and a stable, well-institutionalized environment complement each other in mediating the negative disaster shock. The analysis is based on novel data on natural disasters and global insurance penetration rates and contributes to the ongoing debate about the implications of natural catastrophes for development.

JEL-classification: Q54, Q56, O13

Keywords: Natural disasters, Insurance, Institutions, Development

*Miriam Breckner, Florian Englmaier, Till Stowasser, Uwe Sunde: LMU Munich, Department of Economics. Corresponding author: Miriam Breckner, email: miriam.breckner@econ.lmu.de. We are grateful MunichRe NatCat Service for granting access to data on natural catastrophes and insurance penetration.

1. Introduction

The common perception regarding the key determinants of economic development is that good institutions foster development while natural catastrophes constitute one of the key impediments to development. However, a glance at the empirical literature reveals an unresolved controversy about whether natural catastrophes indeed have significant and persistent negative or positive effects on income, and under which circumstances these effects unfold. As is discussed in more detail below, the existing evidence reveals a surprisingly heterogeneous picture of the development consequences of natural catastrophes, with institutions being one of the main determinants of the sign of the effect. Most of the existing literature presents reduced form effects, with little evidence for the channels and mechanisms that influence the effect of natural catastrophes on economic development.

This paper contributes to the debate by providing new evidence on the effect of natural catastrophes on economic development, and in particular on the determinants of the sign of this effect. The analysis uses a novel and comprehensive data set of natural catastrophes as well as a measure of the damages caused by the catastrophes. In contrast to most of the existing literature, this data has global coverage on the insured and uninsured losses, thus allowing for an estimate of the economic consequences of natural catastrophes by distinguishing the extensive and intensive margin and the respective channels. The results suggest that the effect of natural catastrophes depends on the access to insurance in the form of private insurance or public disaster relief. Going beyond the reduced form evidence in the existing literature, the findings demonstrate that private insurance penetration and a stable, well-institutionalized environment complement each other in accommodating the negative effects of natural catastrophes. The robustness of the results is documented by replications with other data sets that have been used in the literature. This implies that market forces and public institutional infrastructure are both essential in providing economies with resilience against natural catastrophes.

This paper makes several contributions to the existing literature, which has shown that the impact of natural disasters on income depends on the type and severity of natural disasters, as well as on the economic and institutional environment. In particular, almost all studies using cross-country panel data find negative effects of natural disasters on income in the short-run, in particular in developing countries and for severe disasters (Noy, 2009; Hochrainer, 2009; Raddatz, 2009; Loayza, Olaberrı̄ı̄cea, Rigolini, and Christiaensen, 2012; Fomby, Ikedab, and Loayza, 2013), whereas there is some evidence that suggests a positive effect on income in developed economies, see, e.g. Noy

(2009). While the literature lacks a coherent explanation for this finding, some suggest that this effect is mechanical as reconstruction investment is part of GDP while the loss due to destruction of capital and structure is not (von Peter, Dahlen, and Saxena, 2012). Some recent studies provide evidence that access to finance can raise a country’s resilience to natural hazards, with international openness, and advanced financial markets being attenuating factors that operate towards economic recovery in the aftermath of a natural disaster (Noy, 2009; McDermott, Barry, and Tol, 2013; Felbermayr and Groeschl, 2014). Noy (2009) also suggests that higher levels of government spending belong to the list, whereas higher foreign exchange reserves appear to worsen the disaster impact. Our study adds to this a novel measure of insurance market development that has not been available for scientific purposes before. This measure reflects insurance market penetration based on micro level data and allows for a much more precise measurement of the role of insurance for resilience to natural catastrophes. von Peter, Dahlen, and Saxena (2012) present the first evidence that links the effect of natural disasters to insurance markets and show that, when treating uninsured and insured losses separately, uninsured disaster-related losses lead to income declines whereas there is no negative effect for insured losses. While we have access to the same data, which allows us to replicate their results, this paper broadens the focus by considering insurance market penetration as control and as a further mitigating factor. A distinct strand of the literature suggests that particular institutional attributes are relevant for mitigating the economic consequences of natural disasters, with countries with more stable and more democratic regimes appearing to be more capable to withstand the disaster shock (Noy, 2009; Cavallo, Galiani, Noy, and Pantano, 2013; Felbermayr and Groeschl, 2014). Our paper provides an important link between the functioning of insurance markets in attenuating the effects of catastrophes and the institutional environment.

Moreover, with the exception of Felbermayr and Groeschl (2014), who introduce a new dataset to the literature, Geo-Met, which yields measures of physical attributes of the disaster (e.g. Richter scale for earthquakes or windspeed for storms) and draws on geophysical and meteorological information only, almost all published studies employ the publicly available Em-Dat database for disasters. In addition to, and complementing this data, we employ the NatCat database provided by MunichRe, which constitutes the most comprehensive data set for disaster-related losses, including information on whether the losses were insured. To our knowledge, the only other study that has used these data in the context of macroeconomic resilience to natural disasters is by von Peter, Dahlen, and Saxena (2012).¹

¹Table 6 in the Appendix provides an overview of the related literature.

The remainder of the paper is structured as follows. Section 2 describes the data and the empirical framework. Section 3 presents the main results and some robustness. Section 4 concludes.

2. Data and Empirical Framework

2.1. Data

We construct a panel data set with yearly data for 129 countries for the period 1980 to 2014.² Data on natural catastrophes is provided by the NatCat SERVICE of the global insurance- and reinsurance group MunichRe. The data set contains information on the incidence of natural catastrophes of different types (geophysical, hydrological, climatological or meteorological).³ ⁴ The data also includes measures of the intensity of these catastrophes in terms of direct monetary losses and the number of fatalities, and provides information on different kinds of infrastructure assets affected. Of particular relevance for our analysis is the classification of disasters into severity categories 0-4, which are defined according to fatality- and monetary loss thresholds.⁵

The main advantage of the NatCat data over alternative data sets on natural catastrophes such as the publicly available Em-Dat data set which is employed in almost all published studies, is their comprehensiveness as well as the assessment of losses caused by the catastrophe. These loss data are of very high quality as they are essential for an accurate tracking of reinsurance liabilities and an adequate risk pricing of contracts by MunichRe, which is the largest reinsurance company worldwide.⁶ The calculation of disaster-related losses is based on replacement and repair costs and draws on various sources, including the insurance industry, scientific reports, weather services, news agencies, NGOs and GOs. According to their own assessment, NatCat Service provides the most comprehensive natural catastrophe loss database in the world (NatCatService, 30.08.2014). The loss data distinguish between insured losses and economic (overall)

²Due to missing observations for some countries, the panel is not balanced.

³Geophysical events involve earthquakes (and tsunamis), volcanic eruptions and (dry) mass movements such as rockfalls or landslides. Hydrological events involve floods and (wet) mass movements such as avalanches. Climatological events are defined as extreme temperatures (e.g. heat waves, cold waves, wildfires). Meteorological events are storms such as hurricanes.

⁴(Wirtz, Kron, Ližew, and Steuer, 2014) provide an extensive description of data bases on natural disasters with a special focus on NatCat data.

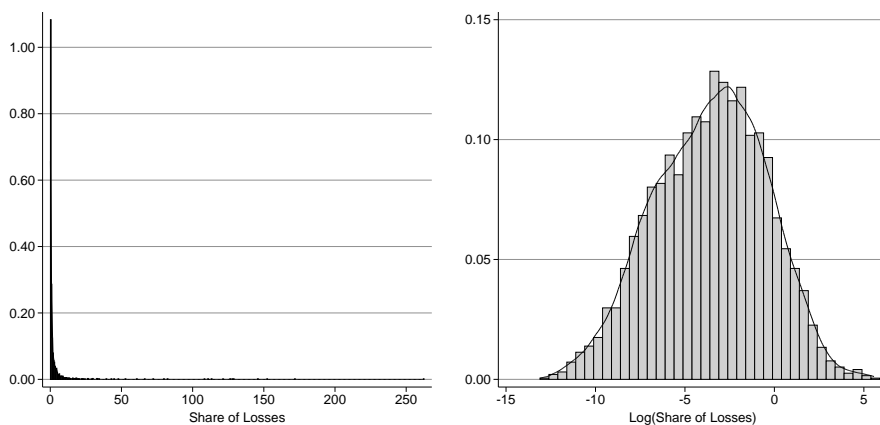
⁵For instance, in order to be classified into category 4 in a high-income economy, a disaster must have caused either 2.5 billion\$ or 1000 fatalities. For classification, losses are normalized by a normalization factor (current income to income in the respective year) which accounts for inflation and the increase in values.

⁶Source: Standard & Poors, see <http://de.statista.com/statistik/daten/studie/188545>.

losses. The accuracy of loss data and the distinction between overall and insured losses makes the NatCat data unique for the purpose of this study. For instance, the smallest loss registered in the NatCat database amounts to 4450 US\$, while disasters need to meet specific severity criteria before they are entered into alternative data bases, such as the Em-Dat database.⁷

In the empirical analysis, we employ two different specifications to capture natural catastrophes. First, we code a binary measure for natural disasters which is 1 if a severe disaster (category 4) occurred in country i , year t , and 0 otherwise. This measure only exploits the extensive margin of a natural catastrophe occurrence. Because the majority of events is related to relatively small losses that have ambiguous effects on income, we code catastrophes to be severe events (category 4). Second, as a measure of catastrophe intensity, we use the sum of direct losses caused by natural disasters in country i , year t , normalized by the level of GDP (of the preceding year). This measure exploits the intensive margin of disaster occurrence and makes use of the availability of high accuracy loss data. Losses are normalized by GDP to set the catastrophe intensity in relation to the country size. The weighted loss measure (losses per GDP) exhibits an outlier problem, where in some rare cases losses can amount to twice the level of GDP in extremely small countries. In particular, some small island states are affected in this respect. In order to accommodate this problem, and to allow for a straightforward interpretation, the log of the weighted loss is taken, which yields a rather normal distribution (see Figure 1). We also only consider shares of losses exceeding 0.1 percent in the baseline analysis to rule out that extremely small losses influence the estimated coefficients that can clearly not affect aggregate income.

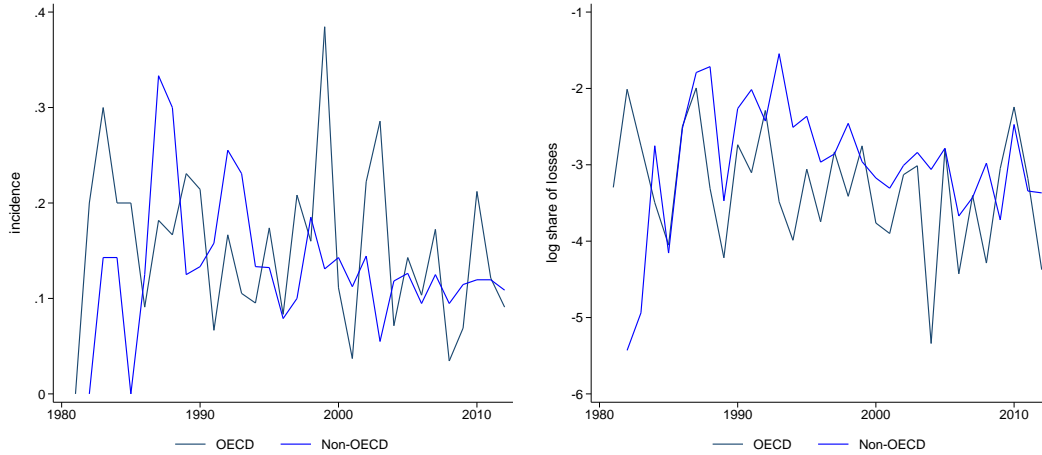
Figure 1: Histogram and Kernel Density Plot of Loss Measure



⁷For instance, for a disaster to be entered into the Em-Dat database at least one of the following criteria must be fulfilled: Ten or more people reported killed, hundred or more people reported affected, declaration of a state of emergency or a call for international assistance.

Figure 2 describes the evolution of the two disaster measures over time. Here, the sample is split between developed (OECD) and developing (non-OECD) countries. Two insights arise from the figures. First, employing these specification there is no systematic time trend in disaster occurrence. Second, there is no systematic difference in the occurrence pattern between the two groups of countries.

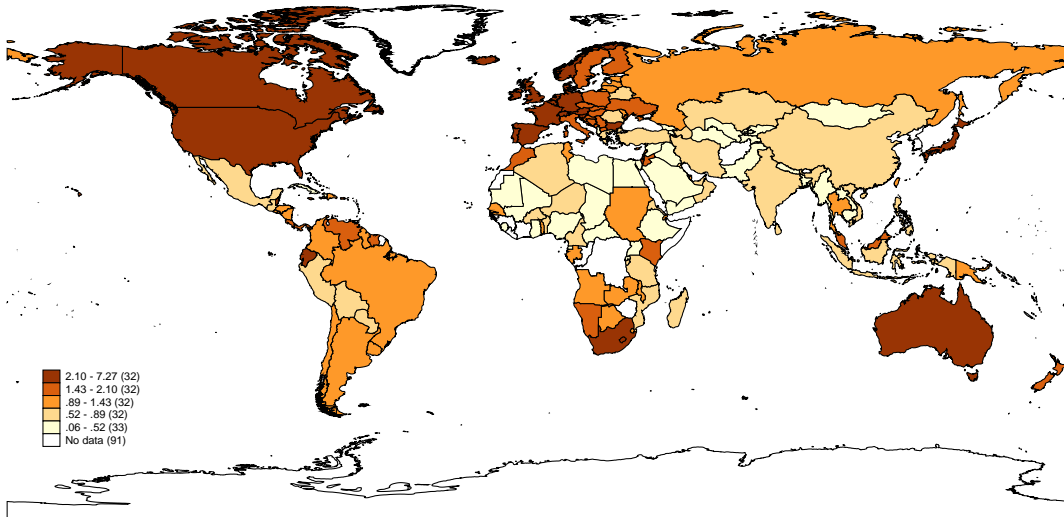
Figure 2: Yearly average of disasters by specification for OECD and non-OECD



The second main innovation in this paper concerns the availability of data on the development of insurance markets. In particular, the Economic Research Department of MunichRe provided us with unique data on national insurance market penetration for a worldwide panel. To our knowledge, this is the first time these data are available for research purposes. The availability of this data allows us to investigate whether access to insurance markets can help mitigating the consequences of natural catastrophes on economic development. The main measure we employ is the insurance penetration rate, which is defined as the annual sum of insurance premia paid in a country divided by the country's GDP. We focus on insurance premia excluding health- and life insurance. This leaves us with property- and casualty insurance, which we consider as best proxy for insurance coverage in the case of natural catastrophes. The availability of other insurance measures is used in further robustness checks. In addition to the investigation of insurance penetration as a mitigating factor, the availability of this measure enables us to account for the concern that the effect of natural disasters on income might be upward biased if better developed insurance markets correlate with both, the occurrence of disasters and the level of development, as suggested by Felbermayr and Groeschl (2014), by including the insurance penetration rate as control variable. Figure 3 shows a map of the average insurance penetration across countries over the observation period 1980-2014.

Data on aggregate and per capita GDP, as well as on population is obtained from

Figure 3: Average of the Insurance Penetration Rate, 1980-2014



the Worldbank's Development Indicators (WDI). Data on the capital stock and human capital in terms of a human capital index is taken from the Penn World Tables 8.0 (Feenstra, Inklaar, and Timmer, 2015). The human capital index draws on the database of Barro and Lee (2013) and reflects a function of the average years of schooling for the population aged 15 or older.

Data on institutions draws on several sources. First, we employ a new measure of the quality of political institutions, which is provided by Kuncic (2014). Kuncic (2014) comprise different concepts of measuring the well-functioning of political institutions and build a new aggregate index. This provides us with a measure of the higher order attributes which is the latent quality of political institutions. The institutional measures yield a sample of 197 countries for the period 1990 to 2010. Second, we employ the polity2 index from the polity4 database. This measure solely focuses on institutionalized democracy. Codings of the competitiveness of political participation, the openness and competitiveness of executive recruitment, and constraints on the chief executive yield an additive twenty one point scale (-10-10) moving from complete autocracy to full democracy. Further, for measuring the fiscal capacity of governments we use the aggregate tax revenue, which includes all transfers for public purposes to the central government. This measure is taken from the Worldbank's World Development Indicators (WDI).

Table 1 contains summary statistics of the main variables used in the empirical analysis.

Table 1: Summary Statistics - Estimation Sample

| | N | Min | Max | Mean | SD |
|---------------------------------|-------|-------|-------|-------|------|
| Disaster(Indicator) | 2,572 | 0.00 | 1.00 | 0.13 | 0.34 |
| Disaster(Log Loss) | 2,562 | -2.30 | 4.41 | -0.20 | 0.70 |
| Insurance Penetration Rate | 2,572 | 0.00 | 32.05 | 1.49 | 1.33 |
| log GDP per capita | 2,572 | -1.94 | 4.46 | 1.40 | 1.60 |
| log Capital stock | 2,572 | 7.03 | 17.61 | 12.30 | 1.98 |
| log Population | 2,572 | 12.20 | 21.02 | 16.30 | 1.65 |
| log Human capital index | 2,572 | 0.12 | 1.29 | 0.87 | 0.25 |
| Disaster(Indicator) Events only | 341 | 1.00 | 1.00 | 1.00 | 0.00 |
| Disaster(Log Loss) Events only | 721 | -2.30 | 4.41 | -0.72 | 1.18 |

2.2. Empirical Strategy

To investigate the effect of natural disasters on income we estimate the following empirical model:

$$\ln Y_{i,t} = \alpha + \beta \ln Y_{i,t-1} + \gamma DIS_{i,t} + \mu X_{i,t-1} + \nu_i + \nu_t + \nu_{i \times T} + \epsilon_{it}, \quad (1)$$

where the dependent variable $\ln Y_{i,t}$ is the log of per capita income in country i and year t . One lag of the dependent variable is included to capture convergence effects. The coefficient of primary interest is γ , which captures the impact of natural disasters on income. The variable $DIS_{i,t}$ represents the incidence of a natural catastrophe in country i and year t . Catastrophes are measured in two ways as described in more detail in the previous section, with a binary indicator that takes value 1 in a disaster year, and 0 otherwise capturing the extensive margin, and as a second measures the log of the weighted sum of overall (monetary) disaster-related losses that occurred within the disaster year as measure of the intensive margin of disaster occurrence. The vector X denotes a set of control variables and contains the capital stock, total population and human capital.⁸ All control variables enter in lags to avoid endogeneity due to a simultaneous impact of a disaster on dependent- and explanatory variables. The specification includes country fixed effects ν_i to account for time-invariant country characteristics and a full set of time (year) dummies ν_t to capture common time trends. In addition, the specification includes country-specific linear time trends $\nu_{i \times T}$ to account for unobserved country-specific factors that are varying systematically over time. Generally,

⁸The specification thus reflects the factors of production in a human capital augmented Solow growth model (Mankiw, Romer, and Weil, 1992).

country specific linear time trends capture the diverse evolution of incomes over time and facilitate an accurate estimation of disaster shocks to differential income paths.⁹ Standard errors are clustered at the country level and robust to heteroskedasticity.¹⁰

Combining a fixed effects estimator with a lag of the endogenous variable on the right hand side of the equation leads to biased estimates (Nickell, 1981). The bias results from a mechanical correlation between the transformed error term and the lagged dependent variable. The asymptotic order of bias is $1/T$ and thus declines with the length of the panel. Judson and Owen (1999) show that for an average number of $T=30$ (as in the above estimation framework with $T=34$) the Nickell bias is moderate and thus does not constitute a major concern. Hence, the baseline estimations will abstract from the dynamic panel problem.

Another potential concern is that the measure natural catastrophes is endogenous to economic development and insurance market development (Felbermayr and Groeschl, 2014). The reason is that the amount of monetary losses caused by a natural disaster might correlate with the (insurance market-) development status of a country. Moreover, (insurance market-) development might correlate with the distribution of disasters in the data set, if the insurance industry is a major source of information for compilation.¹¹ According to McDermott, Barry, and Tol (2013) this concern is reduced by employing a dichotomous measure for natural disasters as is done in our specification. Moreover, the potential selection bias is accounted for by the inclusion of country fixed effects into the regression. However, to fully address this issue it is necessary to include an interaction term between disasters and insurance market development into the regression to absorb the omitted effect at the moment that the disaster strikes. In the course of investigating the mediating effect of insurance markets by including an interaction term into the regression we therefore implicitly alleviate this concern. To investigate the mediating effect of insurance markets we estimate the following empirical model:

$$\ln Y_{i,t} = \alpha + \beta \ln Y_{i,t-1} + \gamma DIS_{i,t} + \delta DIS_{i,t} * INS_{i,t-1} + \mu X_{i,t-1} + \nu_i + \nu_t + \nu_{i \times T} + \epsilon_{it}, \quad (2)$$

where an interaction term between the natural disaster and the insurance market pen-

⁹In particular, the inclusion of country-specific linear time trends ensures that no unobserved country-specific trends drive the results. For instance one might think of improvements in disaster data quality or reporting that have been especially strong in transition economies.

¹⁰This is necessary as for instance measurement precision might be correlated with the amount of losses.

¹¹On the other hand one might argue that disasters in poorer countries cause more fatalities (Kahn, 2005) and therefore will be more extensively covered in the databases. A robustness check is thus to validate the results using the publicly available Em-Dat data, which uses different selection criteria to sort events into their data set than the NatCat data.

etration rate $DIS_{i,t} * INS_{i,t-1}$ is added to equation (1). The insurance penetration rate enters as lag such that it is not affected by the disaster shock and is included in the vector X . The coefficient of interest is δ , which measures the mediating effect of insurance markets on the effects that natural disasters have on income.

3. Main Results

3.1. Baseline Effect of Natural Disasters

The main results regarding the effect of natural catastrophes on economic development are presented in Table 2. Columns (1)-(3) show the results when focusing attention on the extensive margin, in terms of the incidence of a category 4 natural catastrophe in a given year. Two findings are relevant. First, on average the incidence of a natural catastrophe appears to be detrimental for development by reducing GDP per capita by more than half a percent, as indicated by the results in Column (1). Second, there appears to be pronounced heterogeneity in the effect, depending on the level of development. In particular, while the effect is negative it is not statistically significant in OECD countries as shown in Column (2), whereas the effect is larger in size and statistically significant negative in non-OECD countries, displayed in Column (3). This replicates the broad picture revealed by the existing literature, but it leaves open whether the negative effect is affected by the size of disaster-related losses (the intensive margin). Moreover, it leaves open the reasons for why developed countries are apparently more resilient to the occurrence of natural catastrophes than less developed countries.

Columns (4)-(6) address the question regarding the intensive margin by presenting results for an extended specification that includes both measures, the measure for disaster incidence and the disaster-related losses. The results of this specification show that the severity of the natural catastrophe, rather than the mere occurrence, matters for the economic consequences. Regarding the sub-samples, the extended specification yields qualitatively very similar results to the baseline specification with the disaster indicator.

Overall, these results suggest a negative effect of natural disasters on GDP per capita based on novel disaster data and different disaster specifications, in line with Noy (2009) and Felbermayr and Groeschl (2014). Existing research has pointed to the fact that the impact of natural disasters on income depends on different features of the socio-economic environment (e.g., trade openness, financial openness), as well as the quality of institutions (e.g., democratic institutions, political stability), see Noy (2009), McDermott, Barry, and Tol (2013), Fomby, Ikedab, and Loayza (2013) and Loayza, Olaberrijoa, Rigolini, and Christiaensen (2012) whose results also suggest a higher

vulnerability of less developed economies due to worse institutions and less developed capital markets.

Table 2: The Effect of Natural Catastrophes on Development

| | (1) | (2) | (3) | (4) | (5) | (6) |
|----------------------------------|---------------------|-------------------|---------------------|----------------------|---------------------|---------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| Dep. var.: log GDP per capita | | | | | | |
| Disaster dummy (cat4) | -0.619** (0.267) | -0.277 (0.206) | -0.776** (0.363) | | | |
| Disaster dummy (all events) | | | | -0.553** (0.241) | -0.552** (0.232) | -0.533* (0.288) |
| log share of losses (all events) | | | | -0.394*** (0.141) | -0.245 (0.148) | -0.424** (0.169) |
| Controls | yes | yes | yes | yes | yes | yes |
| Year fixed effects | yes | yes | yes | yes | yes | yes |
| Country fixed effects | yes | yes | yes | yes | yes | yes |
| Country specific trends | yes | yes | yes | yes | yes | yes |
| Observations | 3844 | 868 | 2976 | 3822 | 868 | 2954 |
| Number of countries | 129 | 33 | 104 | 129 | 33 | 104 |
| R-squared | 0.961 | 0.992 | 0.956 | 0.963 | 0.992 | 0.958 |

Notes: Controls comprise log population, log capital stock and log human capital. Huber-White robust standard errors clustered at country-level are reported in brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively. Coefficients and standard errors are multiplied by 100.

3.2. Effects of Insurance Markets

In order to investigate in more detail why developing countries suffer more from natural disasters, we first explore whether better developed insurance markets help to mitigate the negative effect of natural disasters in OECD countries. Insurance penetration has not played a great role as one of the potential reasons for the apparent heterogeneity in the effects of natural catastrophes in the literature so far. Thus, as a first step, we investigate the development of the insurance market as potential reason for the heterogeneity of different effects in the different samples.

Table 3 presents the results from estimating an empirical specification that includes an interaction term between the insurance penetration rate and the respective disaster measure (incidence, loss). The table follows the same structure as Table 2. Columns (1)-(3) show the results for specification using disaster incidence, while columns (4)-(6) show the results for the specification that also accounts for the intensive margin in terms of overall losses. By itself, insurance penetration does not appear to be related to economic development above and beyond the lagged controls from a standard development accounting framework. Regarding the effect of natural catastrophes, the negative coefficient for the entire sample is slightly larger than in the baseline specification, and

significant. This is true for the full sample as well as the two sub-samples. In OECD countries, the coefficient of the main effect of natural disasters is significant and even larger than for the sample of non-OECD countries. At the same time, the results provide evidence for a significant positive interaction between insurance penetration and disasters in the full sample. This effect is mainly driven by the OECD sample, however, and not significant in the non-OECD countries. Thus, at least in the OECD sample, the negative effect of the occurrence of a natural catastrophe is mitigated by higher insurance penetration.

The results are similar when considering the extended specification that also includes the measure of catastrophe severity in terms of losses. Again, higher losses imply more negative development effects, but insurance penetration dampens this effect significantly, at least in developed economies. Hence, ignoring the role of insurance markets appears to confound negative effects of natural catastrophes with the mitigation due to higher insurance penetration, which leads estimates of the average effect to be insignificant in the OECD sample. Overall, the findings suggest that natural disasters have a negative effect on income in both samples, but that insurance markets attenuate the income decline in OECD countries.

Figures 4 and 5 depict the total effect of the occurrence of a natural catastrophe and the associated damages, respectively, on GDP per capita. As long as insurance penetration is below a certain threshold, natural catastrophes have an unambiguously negative effect on income per capita. In OECD countries, this effect is mitigated with increasing access to insurance, in terms of higher insurance penetration, and, with average penetration the effect is already insignificant. The same is true when considering losses. In non-OECD countries, however, the mitigating effect of insurance penetration is substantially weaker. In particular, even at average insurance penetration levels (or at average levels exhibited by OECD countries) the effect of the occurrence of a natural catastrophe is negative. This raises the question why insurance markets appear not to abate the consequences of natural catastrophes in non-OECD countries.

Table 3: The Mitigating Effect of Insurance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|----------------------|----------------------|---------------------|----------------------|--------------------|---------------------|
| Dep. var.: log GDP per capita | All | OECD | non-OECD | All | OECD | non-OECD |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.290** (0.124) | 0.349** (0.151) | 0.148 (0.143) | | | |
| Disaster dummy (cat4) | -0.870*** (0.326) | -1.057** (0.436) | -0.810** (0.350) | | | |
| Ins. penetration rate (t-1) | 0.179 (0.123) | -0.498 (0.405) | 0.141 (0.138) | 0.0853 (0.164) | -0.415 (0.338) | 0.0512 (0.181) |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | 0.104 (0.109) | 0.103 (0.0956) | 0.103 (0.131) |
| Disaster dummy (all events) | | -0.351** (0.172) | | -0.421 (0.258) | | -0.335 (0.206) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | 0.0800* (0.0469) | | 0.446*** (0.152) | 0.0349 (0.0350) | |
| log share of losses (all events) | | -0.400*** (0.152) | | -1.218*** (0.430) | | -0.363** (0.158) |
| Controls | yes | yes | yes | yes | yes | yes |
| Year fixed effects | yes | yes | yes | yes | yes | yes |
| Country fixed effects | yes | yes | yes | yes | yes | yes |
| Country specific trends | yes | yes | yes | yes | yes | yes |
| Observations | 2572 | 677 | 1895 | 2562 | 677 | 1885 |
| Number of countries | 126 | 33 | 101 | 126 | 33 | 101 |
| R-squared | 0.977 | 0.991 | 0.975 | 0.980 | 0.991 | 0.979 |

Notes: Controls comprise log population, log capital stock and log human capital. Huber-White robust standard errors clustered at country-level are reported in brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively. Coefficients and standard errors are multiplied by 100.

Figure 4: Effect of Natural Disasters (Occurrence) on GDP per capita

$$(\beta_2 + \beta_3 * InsurancePenetration(\%))$$

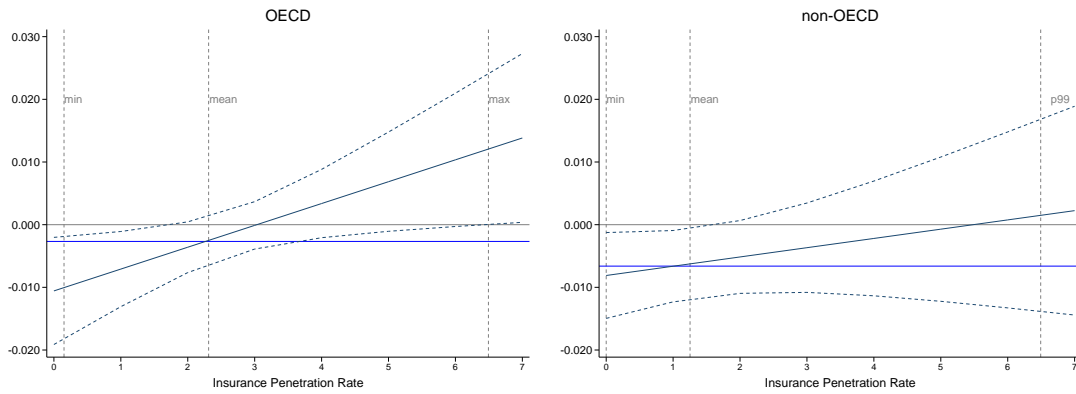
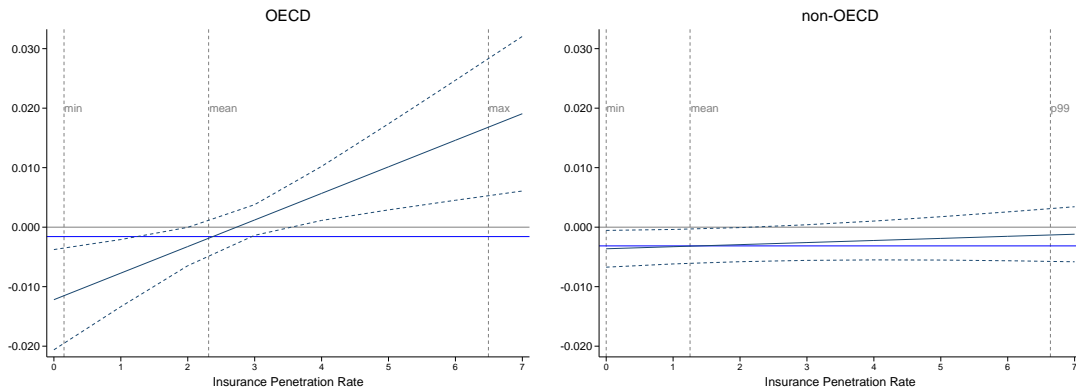


Figure 5: Effect of Natural Disasters (Losses) on GDP per capita

$$(\beta_2 + \beta_3 * InsurancePenetration(\%))$$



Notes: Graphs including 95% confidence interval calculated via the delta method. Light blue line indicates point estimates of table 2, i.e. ignoring insurance.

3.3. Robustness

In the following, we will report on the robustness of these findings to the use of alternative measures and estimation approaches, before investigating in more depth what are the mechanisms behind the results. The tables with the respective results are contained in the Appendix.

The first step of the robustness analysis explores the sensitivity of the results with respect to alternative measures. The findings are robust to the use of alternative measures of losses and a restriction to large disasters.¹² Likewise, the results also hold when accounting for the ratio of insured losses over all losses as an alternative measure for the insurance penetration rate.¹³ This measure might even be a more accurate

¹²See Table 7 in the Appendix.

¹³See Table 9 in the Appendix.

measure for insurance coverage regarding the destructed assets. In this context, it is also interesting to notice that, when using the ratio of insured losses over all losses as dependent variable, the occurrence of natural catastrophes appears, if anything, to be more frequent when insured losses are a higher share of overall losses, contrary to what one would expect if there were an adverse effect on access to insurance in the context of natural catastrophes (as suggested by some of the discussion in the literature mentioned before). Moreover, there is no relation of the penetration rate and the share of insured over total losses.¹⁴ The results are not confined to the use of the Nat-Cat data on natural catastrophes and also replicate when using the Em-Dat data.¹⁵ Finally, the results hold when using data on insurance penetration provided by the OECD.¹⁶

In a second step, we investigate the robustness of the results when adding additional interaction terms with natural catastrophe occurrence to rule out that insurance penetration picks up other factors, such as the level of development. It turns out that the effect does not emerge when estimating the model with an interaction of natural catastrophes with income.¹⁷ However, when including also the interaction between natural catastrophes with insurance penetration, the effect is essentially as in the baseline specification.¹⁸ Adding additional controls, such as institutional quality, domestic credit, trade openness or government expenditures leaves the results unchanged.¹⁹ At the same time, the positive interaction between natural catastrophes and insurance penetration remains unaffected by adding interaction terms of catastrophes with these additional controls.²⁰

3.4. Channels: The Role of Institutions

Having documented a significant role of insurance in moderating the adverse effects of natural catastrophes on economic development, at least in the developed countries, we now turn to the question about the reasons for the apparent heterogeneity in this mitigation. In particular, the previous results suggest that it is not merely the level of development per se that is responsible for the finding that the negative effects of natural catastrophes are diminished by access to insurance in developed countries, but not in less developed countries.²¹ This suggests that it might be another factor that is related with the level of development. Felbermayr and Groeschl (2014) find that a

¹⁴See Tables 10 and 11 in the Appendix.

¹⁵See Table A.1.5 in the Appendix.

¹⁶See Table A.1.6 in the Appendix.

¹⁷See Table 14 in the Appendix.

¹⁸See Table 15 in the Appendix.

¹⁹See Table 16 in the Appendix.

²⁰See Tables 17, 18, 19, 20, and 21 in the Appendix.

²¹Including an interaction term of the disaster with income does not change the result

prime candidate is higher quality of institutions by showing that higher institutional quality mediates the negative consequences of natural disasters. In the following we show that institutional quality also unfolds an indirect effectiveness through the channel of functioning insurance markets. To investigate this hypothesis, we estimate the model for an additional sample split by institutional quality. Tables 4 and 5 report the corresponding estimation results when splitting the full sample by institutional quality (in terms of political institutions). Table 4 reports results employing the loss specification, while table 5 reports respective results employing the indicator specification. Column 1-3 report results for sample splits according to the polity 2 index. Column 1 and 2 split the sample at the median of country averages of the polity2 measure. Column 3 contains countries that have an average value above the median, but do belong to the OECD sample. Columns 4-6 show results for a sample split according to a measure of absolute quality of political institutions by Kuncic (2014). Columns 4 and 5 split the sample at the median of country averages of the quality measure. Column 6 contains countries that have an average value above the median, but do belong to the OECD sample.

Two findings are relevant here. First, insurance markets appear to have a mediating effect in countries with high quality of institutions. The coefficient on the interaction term is more pronounced and significant in column (2) and (4). Second, this complementarity unfolds irrespectively of the development status. We observe that access to insurance markets helps to mitigate the disaster shock in countries that have good institutions but are part of the non-OECD sample. The findings indicate that insurance penetration indeed only works as a mitigating factor for the adverse effects of natural catastrophes on economic development in environments with institutional quality above the median, irrespectively of the development status. This suggests an additional subtlety related to the earlier results, namely that the failure of finding the mitigating effect of insurance in non-OECD countries might be related to the lower institutional quality in that sub-sample.

Table 4: The Mitigating Effect of Insurance by Institutional Quality

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|----------------------|----------------------|---------------------|----------------------|---------------------|----------------------|
| Dep. var.: log GDP per capita | <median | >median | >median non-OECD | <median | >median | >median non-OECD |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | 0.109 (0.158) | 0.0583 (0.123) | -0.0546 (0.0937) | 0.733** (0.298) | -0.0290 (0.0917) | 0.0188 (0.115) |
| Disaster dummy (all events) | -0.595*** (0.184) | -0.207 (0.277) | -0.104 (0.306) | -0.588*** (0.211) | -0.343 (0.227) | -0.498** (0.240) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | 0.0230 (0.0279) | 0.321*** (0.0772) | 0.0604* (0.0304) | -0.104 (0.276) | 0.0838* (0.0469) | 0.0576* (0.0295) |
| log share of losses (all events) | -0.331* (0.168) | -0.922*** (0.266) | -0.384* (0.217) | -0.295 (0.295) | -0.446** (0.177) | -0.496*** (0.174) |
| Ins. penetration rate (t-1) | 0.152 (0.126) | 0.0614 (0.181) | 0.244* (0.139) | 0.0462 (1.110) | 0.251** (0.124) | 0.247** (0.111) |
| Controls | yes | yes | yes | yes | yes | yes |
| Year fixed effects | yes | yes | yes | yes | yes | yes |
| Country fixed effects | yes | yes | yes | yes | yes | yes |
| Country specific trends | yes | yes | yes | yes | yes | yes |
| Observations | 1293 | 1251 | 917 | 1245 | 1214 | 879 |
| Number of countries | 68 | 57 | 49 | 65 | 56 | 48 |
| R squared | 0.978 | 0.986 | 0.982 | 0.981 | 0.985 | 0.978 |

Notes: Column 1-3 report results for sample splits according to the polity 2 index. Column 1 and 2 split the sample at the median of country averages of the polity2 measure. Column 3 contains countries that have an average value above the median, but do belong to the non-OECD sample. Columns 4-6 show results for a sample split according to a measure of absolute quality of political institutions by Kuncic (2014). Columns 4 and 5 split the sample at the median of country averages of the quality measure. Column 6 contains countries that have an average value above the median, but do belong to the non-OECD sample. Controls comprise log population, log capital stock and log human capital. Huber-White Robust standard errors clustered at country-level are reported in brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively. Coefficients and standard errors are multiplied by 100.

Table 5: The Mitigating Effect of Insurance by Institutional Quality

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---------------------|-------------------|---------------------|-------------------|----------------------|----------------------|
| | <median | >median | >median non-OECD | <median | >median | >median non-OECD |
| Dep. var.: log GDP per capita | | | | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.221 (0.136) | 0.499 (0.322) | 0.220* (0.110) | 0.374 (0.471) | 0.367*** (0.105) | 0.273** (0.104) |
| Disaster dummy (cat4) | -0.838** (0.325) | -1.495 (0.906) | -0.944** (0.461) | -0.857 (0.568) | -1.121*** (0.379) | -1.387*** (0.398) |
| Ins. penetration rate (t-1) | 0.270* (0.160) | 0.0774 (0.134) | 0.252* (0.129) | 0.653 (1.237) | 0.237*** (0.0887) | 0.270*** (0.0933) |
| Controls | yes | yes | yes | yes | yes | yes |
| Year fixed effects | yes | yes | yes | yes | yes | yes |
| Country fixed effects | yes | yes | yes | yes | yes | yes |
| Country specific trends | yes | yes | yes | yes | yes | yes |
| Observations | 1301 | 1253 | 937 | 1253 | 1216 | 881 |
| Number of countries | 68 | 57 | 50 | 65 | 56 | 48 |
| r2 | 0.972 | 0.986 | 0.981 | 0.975 | 0.985 | 0.978 |

Notes: Column 1-3 report results for sample splits according to the polity 2 index. Column 1 and 2 split the sample at the median of country averages of the polity2 measure. Column 3 contains countries that have an average value above the median, but do belong to the non-OECD sample. Columns 4-6 show results for a sample split according to a measure of absolute quality of political institutions by Kuncic (2014). Columns 4 and 5 split the sample at the median of country averages of the quality measure. Column 6 contains countries that have an average value above the median, but do belong to the non-OECD sample. Controls comprise log population, log capital stock and log human capital. Huber-White Robust standard errors clustered at country-level are reported in brackets. ***, **, * indicate significance at 1-, 5-, and 10-% level, respectively. Coefficients and standard errors are multiplied by 100.

4. Concluding Remarks

A number of studies have tackled the macroeconomic consequences of natural disasters. While the main part of the literature finds that natural disasters are harmful for income per capita in the short-run, some studies suggest that natural disasters may improve the macroeconomic performance. This paper contributes to the debate by providing new evidence on the economic effects of natural catastrophes, and in particular on how insurance markets influence the effects of natural disasters on income. We show that insurance markets mitigate the negative disaster shock in developed economies. Neglecting insurance markets may result in an insignificant negative or even positive effect of disasters on income per capita. However, when adding insurance, the results show a strong negative baseline effect of natural disasters on income, which is mitigated by insurance markets.

Further, this paper provides the first evidence for an interaction between access to insurance and institutional quality in mitigating the adverse economic effects of natural catastrophes. The results show that the failure of finding the mitigating effect of insurance in developing countries might be related to the lower institutional quality in that sub-sample. This findings implies that insurance and a stable, well-institutionalized environment complement each other in mediating the negative disaster shock.

References

- ALBALA-BERTRAND, J. M. (1993): “Natural disaster situations and growth: A macroeconomic model for sudden disaster impacts,” *World Development*, 21(9), 1417–1434.
- BARRO, R., AND J.-W. LEE (2013): “A new data set of educational attainment in the world, 1950-2010,” *Journal of Development Economics*, 104, 184–198.
- CAVALLO, E., S. GALIANI, I. NOY, AND J. PANTANO (2013): “Catastrophic natural disasters and economic growth,” *Review of Economics and Statistics*, 95(5), 1549–1561.
- FEENSTRA, R. C., R. INKLAAR, AND M. P. TIMMER (2015): “The Next Generation of the Penn World Table,” *American Economic Review*, *forthcoming*.
- FELBERMAYR, G., AND J. GROESCHL (2014): “Naturally negative: The growth effects of natural disasters,” *Journal of Development Economics*, 111, 92–106.
- FOMBY, T., Y. IKEDAB, AND N. V. LOAYZA (2013): “The growth aftermath of natural disasters,” *Journal of applied Econometrics*, 28, 412–434.
- HOCHRAINER, S. (2009): “Assessing the macroeconomic impacts of natural disasters. Are there any?,” *World Bank Policy Research Working Paper*, 4968.
- JUDSON, R. A., AND A. L. OWEN (1999): “Estimating dynamic panel data models: a guide for macroeconomists,” *Economic Letters*, 65, 9–15.
- KAHN, M. E. (2005): “The death toll from natural disasters: The role of income, geography, and institutions,” *The Review of Economics and Statistics*, 87(2), 271–284.
- KUNCIC, A. (2014): “Institutional quality dataset,” *Journal of Institutional Economics*.
- LOAYZA, N., E. OLABERRĪĀ, J. RIGOLINI, AND L. CHRISTIAENSEN (2012): “Natural disasters and growth: Going beyond the averages,” *World Development*, 40(7), 1317–1336.
- MANKIW, N. G., D. ROMER, AND D. N. WEIL (1992): “A contribution to the empirics of economic growth,” *Quarterly Journal of Economics*, 107(2), 407–437.
- MCDERMOTT, T. K., F. BARRY, AND R. S. TOL (2013): “Disasters and development: Natural disasters, credit constraints, and economic growth,” *Oxford Economic Papers*, November, 1–24.

- NATCATSERVICE (30.08.2014): “<http://www.munichre.com/natcatservice>,” .
- NICKELL, S. (1981): “Biases in dynamic models with fixed effects,” *Econometrica*, 49(6), 1417–1426.
- NOY, I. (2009): “The macroeconomic consequences of disasters,” *Journal of Development Economics*, 88, 221–231.
- RADDATZ, C. (2007): “Are external shocks responsible for instability of output in low-income countries,” *Journal of Development Economics*, 84, 155–187.
- (2009): “The wrath of god: Macroeconomic costs of natural disasters,” *World Bank Policy Research Working Paper Series*, 5039.
- SKIDMORE, M., AND H. TOYA (2002): “Do natural disasters promote long-run growth?,” *Economic Inquiry*, 40(4), 664–687.
- VON PETER, G., S. V. DAHLEN, AND S. SAXENA (2012): “Unmitigated disasters? New evidence on the macroeconomic cost of natural catastrophes,” *BIS Working Papers*, 394.
- WIRTZ, A., W. KRON, P. LÜCKE, AND M. STEUER (2014): “The need for data: natural disasters and the challenges of database management,” *Natural Hazards*, 70(1), 135–157.

A. Appendix: Additional Tables

Table 6: Empirical studies on the indirect effects of natural disasters

| Study | Dependent variable | Factors influencing the effect on GDP | Method | Main result / Effect of ND on GDP | Sample |
|---|---|---|--|---|---|
| Albala-Bertrand (1993), WD | GDP growth (annual) | None | Simple theoretical framework + Cross-country estimation of long-term averages | Neutral or positive effect | Latin America |
| Cavallo, Galiani, Noy, and Pantano (2013), REST | GDP level (annual) | Political Stability (+) | Combine information from comparative case studies obtained with a synthetic control methodology, developed in Abadie et al. (2010) | Negative effect only for very large disasters which are followed by political revolution | World |
| Felbermayr and Groeschl (2014), JDE | GDP growth (annual) 4 lags of disaster impact | International openness (+) Democratic institutions (+) Financial openness (+) | FE - Panel study with interaction terms | Introduce new "GeoMet" database Negative effect | World |
| Fomby, Ikedab, and Loayza (2013), JAE | GDP growth (annual) | Development status(+) Disaster type Disaster severity(-) | VARX, applied to a panel of time series data. | Positive effect of floods Negative effect of storms and droughts Mixed evidence on earthquakes | World Developing |
| Hochrainer (2009), WBPRP | GDP growth (annual) | Aid, remittances(+) Disaster severity(-) | ARIMA, applied to a panel of time series data | Negative effect | World |
| Loayza, Olaberri, Rigolini, and Christiaensen (2012), WD | GDP growth (5-year avg.) | Development status(+) Economic Sectors | Dynamic GMM panel estimator | Negative effect of severe disasters Positive effect of moderate disasters in some sectors Positive effect of floods Negative effect of droughts No effect of earthquakes and storms | World Developing |
| McDermott, Barry, and Tol (2013), OEP | GDP growth (annual) GDP growth (5-year avg.) 10 lags of disaster impact | Financial market development(+) | Simple theoretical framework + FE Panel regression | Negative effect | World Developing |
| Noy (2009), JDE | GDP growth (annual) | Development status(+) Country size(+) Literacy rate(+) Institutional strength(+) Openness to trade(+) Domestic credit(+) Government spending(+) | Hausman-Taylor Estimator for panel with interaction terms | Overall negative effect and in developing countries Positive effect in OECD | World OECD Developing Big Econ. Small Econ. |
| Raddatz (2009), WBPRP | GDP growth (annual) | Development status(+) Country size(+) | Panel autoregressive distributed lags (PARDL) model | Negative effect of climatic disasters | World |
| Raddatz (2007), JDE | GDP level (annual) | None | VAR, applied to a panel of time-series data | Negative effect of climatic disasters No effect of geological disasters | Developing |
| Skidmore and Toya (2002), EI | GDP growth (cross-country with 20 years averages) | None | Cross-country estimation of long-term averages | Positive effect of climatic disasters | World |
| von Peter, Dahlen, and Saxena (2012), BIS WP | GDP growth (annual) 4 lags of disaster impact | Insurance markets(+) Development status(+) | FE Panel regression: Amount of insured losses and uninsured losses as two separate 'events' in regression | The uninsured part of disaster losses cause the adverse indirect effect output, while the impact of insured losses is inconsequential. | World Developing Developed Small Econ. |

A.1. Robustness

A.1.1. Alternative Measure of Losses

Table 7: Share of losses, including dummy for very large disasters (>15% of GDP)

| | (1) | (2) | (3) |
|--|-----------------------|------------------------|------------------------|
| | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.830*** (31.45) | 0.891*** (22.33) | 0.791*** (29.35) |
| Ins. penetration rate (t-1) | 0.00164 (1.34) | -0.00375 (-1.06) | 0.00138 (1.01) |
| log capital stock (t-1) | -0.0545 (-1.55) | -0.236*** (-3.70) | -0.0236 (-0.64) |
| log population (t-1) | -0.207** (-2.04) | 0.0539 (0.21) | -0.0648 (-0.69) |
| log human capital (t-1) | 0.0244 (0.26) | 0.0590 (0.85) | 0.0246 (0.23) |
| Disaster Dummy (>15) NATCAT | 0.104 (1.43) | | |
| Share of Losses NATCAT | -0.00218** (-2.23) | -0.0198*** (-5.62) | -0.00171* (-1.82) |
| Disaster Dummy (>15) NATCAT*Share of Losses NATCAT | -0.000683 (-0.42) | 0.0194*** (4.09) | 0.00742*** (7.23) |
| Disaster Dummy (>15) NATCAT*Ins. penetration rate (t-1) | -0.0846* (-1.83) | | 0.266*** (16.62) |
| Share of Losses NATCAT*Ins. penetration rate (t-1) | 0.000262 (0.62) | 0.00813*** (5.34) | 0.0000102 (0.02) |
| Disaster Dummy (>15) NATCAT*Share of Losses NATCAT*Ins. penetration rate (t-1) | 0.00294** (2.29) | -0.00790*** (-3.38) | -0.0106*** (-13.05) |
| Disaster dummy (all events) | -0.000537 (-0.24) | 0.0158** (2.24) | -0.00168 (-0.73) |
| Disaster dummy (all events)*Ins. penetration rate (t-1) | 0.000382 (0.45) | -0.00733** (-2.68) | 0.00153 (1.43) |
| Constant | -13.09*** (-5.52) | -12.28*** (-4.00) | -13.85*** (-4.48) |
| r2 | 0.980 | 0.991 | 0.979 |
| countryFE | yes | yes | yes |
| countryTrends | yes | yes | yes |
| yearFE | yes | yes | yes |
| N | 2562 | 677 | 1885 |

Notes: There are only 3 observation within the non-OECD sample (Belize 2000, Belize 2001, Honduras 1998) and 2 observations in the OECD sample (Chile 2010, New Zealand 2011) for which the 15 percent criterion holds. As the interaction effect between these disasters and insurance yields more variation (degrees of freedom) than the indicator itself, the coefficient on the interaction between these large disasters can be estimated while the baseline effect is omitted.

A.1.2. Sample Split by Insurance

Table 8: The Effect of Natural Catastrophes on Development by Insurance Penetration

| | (1) | (2) | (3) | (4) |
|----------------------------------|----------------------|----------------------|-----------------------|------------------------|
| | Low Insurance | High Insurance | Low Insurance | High Insurance |
| log GDP p.c.(t-1) | 0.791*** (17.20) | 0.879*** (36.44) | 0.808*** (25.33) | 0.879*** (36.53) |
| log capital stock (t-1) | -0.0973** (-2.21) | -0.0419 (-1.64) | -0.109** (-2.59) | -0.0422 (-1.64) |
| log population (t-1) | 0.117 (1.19) | -0.241*** (-3.10) | 0.165** (2.03) | -0.242*** (-3.13) |
| log human capital (t-1) | -0.119 (-0.85) | 0.0384 (0.57) | -0.156 (-1.00) | 0.0396 (0.59) |
| Disaster dummy (cat4) | -0.00522 (-1.24) | -0.00456 (-1.53) | | |
| Disaster dummy (all events) | | | -0.00840** (-2.25) | -0.00390 (-1.57) |
| log share of losses (all events) | | | -0.00368 (-1.65) | -0.00361*** (-2.75) |
| Constant | -13.44*** (-3.11) | -8.116*** (-4.11) | -13.39*** (-3.27) | -8.133*** (-4.12) |
| r2 | 0.956 | 0.982 | 0.960 | 0.982 |
| countryFE | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes |
| N | 1908 | 1861 | 1888 | 1859 |
| C | 64 | 62 | 64 | 62 |

A.1.3. Alternative Insurance Penetration Measure

Table 9: Alternative measure for disaster insurance: Average of the ratio insured losses/overall losses of all disasters that occurred 1980-2014

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.878*** (31.35) | 0.933*** (28.71) | 0.856*** (28.85) | 0.888*** (43.86) | 0.933*** (29.29) | 0.866*** (41.13) |
| log capital stock (t-1) | -0.0789*** (-2.76) | -0.168*** (-4.65) | -0.0752*** (-2.48) | -0.0861*** (-3.04) | -0.165*** (-4.45) | -0.0820*** (-2.73) |
| log population (t-1) | 0.0619 (0.47) | -0.0356 (-0.23) | 0.165 (1.06) | 0.0801 (0.64) | -0.0373 (-0.24) | 0.185 (1.24) |
| log human capital (t-1) | 0.00316 (0.05) | 0.0829 (1.09) | 0.0166 (0.23) | -0.0239 (-0.36) | 0.0783 (1.02) | -0.0129 (-0.16) |
| Disaster dummy (cat4) | -0.00842** (-2.49) | -0.00923** (-2.47) | -0.00684 (-1.56) | | | |
| Disaster dummy (cat4)*Avg. (Insured losses/Overall losses) | 0.0279*** (2.62) | 0.0247** (2.46) | -0.0590 (-0.59) | | | |
| Disaster dummy (all events) | | | | -0.00604** (-2.14) | -0.0111*** (-3.02) | -0.00575* (-1.66) |
| Disaster dummy (all events)*Avg. (Insured losses/Overall losses) | | | | 0.0149 (1.06) | 0.0277** (2.49) | -0.00983 (-0.11) |
| log share of losses (all events) | | | | -0.00430** (-2.57) | -0.00862** (-2.65) | -0.00299 (-1.52) |
| log share of losses (all events)*Avg. (Insured losses/Overall losses) | | | | 0.00906 (1.14) | 0.0257** (2.72) | -0.0794 (-1.33) |
| Constant | -8.643*** (-3.10) | -8.700*** (-4.11) | -6.992* (-1.79) | -8.949*** (-3.36) | -8.484*** (-3.88) | -7.279*** (-2.01) |
| r2 | 0.961 | 0.992 | 0.956 | 0.963 | 0.992 | 0.958 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 3844 | 868 | 2976 | 3822 | 868 | 2954 |

A.1.4. Regress Insured/Overall Losses on Insurance Penetration Rate

Table 10: Regressing the ratio insured losses/overall losses on the insurance penetration rate. Dependent variable: Insured Losses/Overall Losses if Disaster of category 4 occurs, 0 otherwise

| | (1) | (2) | (3) |
|---|---------------------|---------------------|----------------------|
| | All | OECD | non-OECD |
| log GDP p.c.(t-1) | -0.0725 (-1.20) | -0.396** (-2.61) | 0.0583 (1.23) |
| Ins. penetration rate (t-1) | -0.00232 (-0.99) | 0.0241 (0.35) | -0.000897 (-0.56) |
| log capital stock (t-1) | 0.0184 (0.24) | -0.245 (-0.59) | -0.0582 (-0.75) |
| log population (t-1) | 0.353 (1.17) | 1.135 (0.80) | 0.492* (1.70) |
| log human capital (t-1) | 0.370 (0.83) | 2.249*** (3.02) | -0.231 (-0.87) |
| Disaster dummy (cat4) | 0.0213* (1.96) | -0.0108 (-0.19) | 0.0249** (2.44) |
| Disaster dummy (cat4)*Ins. penetration rate (t-1) | -0.00567 (-0.75) | 0.00373 (0.16) | 0.00138 (0.24) |
| Constant | 36.67*** (5.33) | 9.779 (0.40) | 5.038 (0.51) |
| r2 | 0.140 | 0.238 | 0.107 |
| countryFE | yes | yes | yes |
| countryTrends | yes | yes | yes |
| yearFE | yes | yes | yes |
| N | 2084 | 619 | 1465 |

Dependent variable: Insured Losses/Uninsured Losses if Disaster of category 4 occurs, 0 otherwise

Table 11: Regressing the ratio insured losses/overall losses on the insurance penetration rate. Dependent variable: Insured Losses/Overall Losses if Disaster of category 4 occurs, . otherwise

| | (1) | (2) | (3) |
|-----------------------------|--------------------|--------------------|--------------------|
| | All | OECD | non-OECD |
| log GDP p.c.(t-1) | -0.0570 (-0.34) | -1.242 (-0.74) | -0.0414 (-0.24) |
| Ins. penetration rate (t-1) | -0.0637 (-0.65) | -0.0466 (-0.20) | -0.0244 (-0.51) |
| log capital stock (t-1) | 0.159 (0.78) | -0.0172 (-0.01) | 0.0889 (0.47) |
| log population (t-1) | 0.946 (1.06) | 5.763 (1.07) | 0.374 (0.40) |
| log human capital (t-1) | 0.354 (0.38) | -0.334 (-0.16) | 0.722 (0.80) |
| Constant | 10.08 (0.35) | -64.90 (-1.08) | -31.81 (-1.24) |
| r2 | 0.408 | 0.715 | 0.378 |
| countryFE | yes | yes | yes |
| countryTrends | yes | yes | yes |
| yearFE | yes | yes | yes |
| N | 341 | 102 | 239 |

A.1.5. Replicating Baseline Results using Em-Dat Data

Table 12: Equivalent to table 7, using Em-Dat- instead of NatCat Data.

| | (1) All | (2) OECD | (3) non-OECD | (4) All | (5) OECD | (6) non-OECD |
|---|----------------------|-----------------------|----------------------|----------------------|----------------------|----------------------|
| log GDP p.c.(t-1) | 0.800*** (21.68) | 0.888*** (21.70) | 0.754*** (18.96) | 0.827*** (32.01) | 0.889*** (21.88) | 0.786*** (31.58) |
| Ins. penetration rate (t-1) | 0.00177 (1.48) | -0.00511 (-1.26) | 0.00132 (0.99) | 0.00215 (1.34) | -0.00761 (-1.56) | 0.00168 (0.97) |
| log capital stock (t-1) | -0.0359 (-0.88) | -0.232*** (-3.72) | -0.00193 (-0.05) | -0.0563 (-1.59) | -0.236*** (-3.84) | -0.0244 (-0.69) |
| log population (t-1) | -0.119 (-1.25) | 0.0370 (0.15) | -0.0762 (-1.10) | -0.0790 (-0.95) | 0.0546 (0.22) | -0.0352 (-0.65) |
| log human capital (t-1) | 0.0223 (0.23) | 0.0635 (0.91) | 0.0243 (0.22) | 0.0240 (0.25) | 0.0577 (0.83) | 0.0237 (0.23) |
| Disaster dummy (cat 4) EMDAT*Insurance Penetration (t-1) | 0.00500* (1.97) | 0.00665*** (3.41) | 0.00675 (0.88) | | | |
| Disaster dummy (cat4) EMDAT | -0.0128** (-2.51) | -0.0194*** (-4.26) | -0.0131* (-1.75) | | | |
| Disaster dummy (all events) EMDAT*Insurance Penetration (t-1) | | | | -0.000414 (-0.43) | 0.00815** (2.09) | -0.000421 (-0.47) |
| Disaster Dummy (all events) EMDAT | | | | 0.00150 (0.52) | -0.0192* (-1.88) | 0.00154 (0.49) |
| Log share of losses EMDAT*Insurance Penetration (t-1) | | | | 0.000363 (0.68) | 0.00489* (1.88) | 0.000274 (0.52) |
| log share of losses (all events) EMDAT | | | | -0.00232 (-1.50) | -0.0142** (-2.11) | -0.000775 (-0.49) |
| Constant | -12.37*** (-5.13) | -12.13*** (-3.99) | -14.49*** (-5.88) | -11.88*** (-5.22) | -12.27*** (-4.04) | -13.78*** (-5.97) |
| r2 | 0.977 | 0.991 | 0.975 | 0.980 | 0.991 | 0.979 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2627 | 677 | 1950 | 2617 | 677 | 1940 |

A.1.6. Replicating Baseline Results for OECD Sample using OECD Insurance Data

Table 13: Equivalent to column 2 and 5 in table 7, using OECD insurance data.

| | (1) | (2) |
|---|------------------------|-----------------------|
| | OECD | OECD |
| log GDP p.c.(t-1) | 0.927*** (25.88) | 0.928*** (26.85) |
| log capital stock (t-1) | -0.184*** (-4.24) | -0.183*** (-4.31) |
| log population (t-1) | -0.0395 (-0.24) | -0.0487 (-0.29) |
| log human capital (t-1) | 0.0871 (1.11) | 0.0880 (1.13) |
| Non-Life Ins. Penetration (t-1) OECD | -0.00509* (-1.84) | -0.00354 (-1.32) |
| Disaster dummy (cat4) | -0.00761*** (-2.82) | |
| Disaster dummy (cat4)*Non-Life Ins. Penetration (t-1) OECD | 0.00236*** (2.78) | |
| Disaster dummy (all events) | | -0.00938* (-1.77) |
| Disaster dummy (all events)*Non-Life Ins. Penetration (t-1) OECD | | 0.00185 (1.27) |
| log share of losses (all events) | | -0.0108*** (-3.00) |
| log share of losses (all events)*Non-Life Ins. Penetration (t-1) OECD | | 0.00303*** (3.26) |
| Constant | -9.841*** (-4.12) | -9.589*** (-4.09) |
| r2 | 0.991 | 0.992 |
| countryFE | yes | yes |
| countryTrends | yes | yes |
| yearFE | yes | yes |
| N | 769 | 769 |

A.1.7. Including the Interaction Term Disaster*Income

Table 14: Including interaction term with income

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|-----------------------|----------------------|-----------------------|----------------------|----------------------|----------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.801*** (20.89) | 0.889*** (22.01) | 0.756*** (17.67) | 0.829*** (31.83) | 0.890*** (21.68) | 0.790*** (30.11) |
| Ins. penetration rate (t-1) | 0.00165 (1.40) | -0.00499 (-1.22) | 0.00133 (1.00) | 0.00164 (1.41) | -0.00462 (-1.15) | 0.00135 (1.04) |
| log capital stock (t-1) | -0.0330 (-0.80) | -0.242*** (-3.88) | 0.00259 (0.06) | -0.0535 (-1.54) | -0.237*** (-3.83) | -0.0234 (-0.65) |
| log population (t-1) | -0.253** (-2.22) | 0.0591 (0.24) | -0.113 (-1.04) | -0.208** (-2.07) | 0.0540 (0.22) | -0.0665 (-0.72) |
| log human capital (t-1) | 0.0158 (0.17) | 0.0682 (0.99) | 0.0194 (0.18) | 0.0243 (0.26) | 0.0641 (0.92) | 0.0248 (0.24) |
| Disaster dummy (cat 4) NATCAT*log GDP p.c.(t-1) | 0.00192 (1.34) | 0.00311 (0.97) | 0.000424 (0.12) | | | |
| Disaster dummy (cat4) | -0.00688** (-2.10) | -0.0124 (-1.19) | -0.00673** (-2.06) | | | |
| Disaster dummy (all events) | | | | -0.00364 (-1.62) | -0.0162* (-1.72) | -0.00388* (-1.81) |
| Disaster dummy (all events)*log GDP p.c.(t-1) | | | | 0.000454 (0.35) | 0.00401 (1.30) | 0.00160 (0.72) |
| Log share of losses NATCAT*log GDP p.c.(t-1) | | | | 0.000461 (0.55) | 0.00610 (1.61) | -0.000105 (-0.06) |
| log share of losses (all events) | | | | -0.00314* (-1.86) | -0.0210 (-1.66) | -0.00293* (-1.69) |
| Constant | -13.69*** (-5.49) | -12.49*** (-4.08) | -14.76*** (-4.51) | -13.07*** (-5.54) | -12.08*** (-4.06) | -13.90*** (-4.55) |
| r2 | 0.977 | 0.991 | 0.975 | 0.980 | 0.991 | 0.979 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2572 | 677 | 1895 | 2562 | 677 | 1885 |

Table 15: Including two interaction terms, income and insurance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|------------------------|----------------------|-----------------------|-----------------------|----------------------|-----------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.801*** (20.88) | 0.889*** (21.96) | 0.757*** (17.67) | 0.828*** (32.37) | 0.888*** (22.11) | 0.790*** (30.61) |
| Ins. penetration rate (t-1) | 0.00176 (1.42) | -0.00496 (-1.23) | 0.00141 (1.02) | 0.00171 (1.00) | -0.00377 (-1.03) | 0.00102 (0.55) |
| log capital stock (t-1) | -0.0334 (-0.81) | -0.242*** (-3.83) | 0.00211 (0.05) | -0.0538 (-1.55) | -0.237*** (-3.79) | -0.0235 (-0.65) |
| log population (t-1) | -0.253** (-2.22) | 0.0603 (0.24) | -0.112 (-1.03) | -0.211** (-2.09) | 0.0482 (0.20) | -0.0723 (-0.78) |
| log human capital (t-1) | 0.0146 (0.15) | 0.0698 (1.00) | 0.0183 (0.17) | 0.0242 (0.26) | 0.0638 (0.93) | 0.0252 (0.24) |
| Disaster dummy (cat4) | -0.00871*** (-2.67) | -0.00746 (-0.66) | -0.00812** (-2.40) | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.00209 (1.60) | 0.00432** (2.22) | 0.00154 (1.10) | | | |
| Disaster dummy (cat 4) NATCAT*log GDP p.c.(t-1) | 0.000974 (0.57) | -0.00159 (-0.36) | -0.000177 (-0.05) | | | |
| Disaster dummy (all events) | | | | -0.00347** (-2.06) | -0.00419 (-1.66) | -0.00353* (-1.75) |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | 0.0000159 (0.01) | 0.000483 (0.22) | 0.000448 (0.34) |
| Disaster dummy (all events) NATCAT*log GDP p.c. (t-1) | | | | 0.000167 (1.08) | 0.000420 (0.27) | 0.00153 (0.62) |
| log share of losses (all events) | | | | -0.00391** (-2.36) | -0.0142 (-1.42) | -0.00350** (-2.09) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | | | 0.000773 (1.39) | 0.00409*** (3.68) | 0.000525 (1.36) |
| Log share of losses NATCAT*log GDP p.c.(t-1) | | | | 0.00000418 (0.01) | 0.000885 (0.31) | -0.000730 (-0.53) |
| Constant | -13.74*** (-5.51) | -12.53*** (-4.04) | -14.78*** (-4.51) | -13.11*** (-5.50) | -12.14*** (-4.00) | -14.03*** (-4.56) |
| r2 | 0.977 | 0.991 | 0.975 | 0.980 | 0.991 | 0.979 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2572 | 677 | 1895 | 2562 | 677 | 1885 |

A.1.8. Adding further control variables

Table 16: Adding polity2, domestic credit, trade openness and government expenditure as further controls

| | (1) All | (2) OECD | (3) non-OECD | (4) All | (5) OECD | (6) non-OECD |
|--|-------------------------|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| log GDP p.c. (t-1) | 0.788*** (29.74) | 0.872*** (19.22) | 0.756*** (24.24) | 0.787*** (29.90) | 0.873*** (19.42) | 0.755*** (24.23) |
| Ins. penetration rate (t-1) | 0.00224*** (2.63) | -0.00629 (-1.64) | 0.00210* (1.92) | 0.000702 (0.71) | -0.00490 (-1.50) | 0.000435 (0.38) |
| log capital stock (t-1) | -0.0503 (-1.46) | -0.185*** (-3.05) | -0.0229 (-0.57) | -0.0498 (-1.45) | -0.179*** (-2.89) | -0.0233 (-0.59) |
| log population (t-1) | -0.122* (-1.67) | -0.0132 (-0.05) | -0.0867 (-0.99) | -0.127* (-1.72) | -0.0188 (-0.08) | -0.0930 (-1.06) |
| log human capital (t-1) | 0.0235 (0.26) | -0.0867 (-1.01) | 0.0533 (0.45) | 0.0317 (0.35) | -0.0838 (-0.98) | 0.0584 (0.49) |
| Polity (t-1) | 0.000424 (0.83) | 0.00122 (0.15) | 0.000640 (1.13) | 0.000439 (0.85) | 0.000906 (0.11) | 0.000641 (1.13) |
| Domestic credit (t-1) | -0.000548*** (-6.15) | -0.000218** (-2.73) | -0.000542*** (-4.39) | -0.000544*** (-6.15) | -0.000230*** (-3.06) | -0.000532*** (-4.33) |
| Trade openness (t-1) | 0.000520*** (3.29) | 0.000580** (2.56) | 0.000405** (2.37) | 0.000521*** (3.31) | 0.000595** (2.69) | 0.000407** (2.38) |
| Government expenditure (t-1) | 0.00126 (1.39) | 0.00711** (2.33) | 0.000905 (1.03) | 0.00130 (1.43) | 0.00713** (2.36) | 0.000931 (1.06) |
| Disaster dummy (cat4) | -0.00820** (-2.40) | -0.0117** (-2.71) | -0.00806** (-2.20) | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.00246* (1.92) | 0.00371** (2.43) | 0.00155 (1.21) | | | |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | 0.00165 (1.25) | 0.000461 (0.61) | 0.00181 (1.11) |
| Disaster dummy (all events) | | | | -0.00390** (-2.29) | -0.00397 (-1.34) | -0.00386* (-1.89) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | | | 0.000719 (1.65) | 0.00424*** (2.91) | 0.000346 (1.11) |
| log share of losses (all events) | | | | -0.00372** (-2.41) | -0.0119*** (-2.80) | -0.00344** (-2.15) |
| Constant | -14.72*** (-6.94) | -13.80*** (-4.43) | -16.77*** (-5.22) | -14.65*** (-6.90) | -13.42*** (-4.33) | -16.87*** (-5.29) |
| r2 | 0.982 | 0.991 | 0.980 | 0.982 | 0.991 | 0.980 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2249 | 600 | 1649 | 2247 | 600 | 1647 |

A.1.9. Adding further interaction terms

Table 17: Including two interaction terms, polity2 and insurance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|-----------------------|----------------------|-----------------------|-----------------------|----------------------|----------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.834*** (30.54) | 0.880*** (18.18) | 0.795*** (28.61) | 0.833*** (30.65) | 0.880*** (18.17) | 0.795*** (28.67) |
| Ins. penetration rate (t-1) | 0.00151 (1.19) | -0.00473 (-1.19) | 0.000980 (0.70) | 0.00000842 (0.00) | -0.00243 (-0.64) | -0.000649 (-0.28) |
| log capital stock (t-1) | -0.0481 (-1.31) | -0.233*** (-3.39) | -0.0169 (-0.44) | -0.0561 (-1.57) | -0.231*** (-3.37) | -0.0266 (-0.71) |
| log population (t-1) | -0.207* (-1.96) | 0.00298 (0.01) | -0.0463 (-0.48) | -0.189* (-1.86) | 0.00151 (0.01) | -0.0298 (-0.32) |
| log human capital (t-1) | 0.0372 (0.35) | -0.00434 (-0.04) | 0.0677 (0.60) | 0.0355 (0.34) | -0.00326 (-0.03) | 0.0576 (0.52) |
| Polity (t-1) | 0.000629 (1.19) | 0.000951 (0.13) | 0.00108* (1.69) | 0.000498 (0.83) | 0.00140 (0.20) | 0.000881 (1.20) |
| Disaster dummy (cat4) | -0.00907** (-2.36) | -0.0150 (-0.90) | -0.00792** (-2.02) | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.00243** (2.06) | 0.00326* (1.75) | 0.00181 (1.49) | | | |
| Disaster dummy (cat 4) NATCAT*Polity (t-1) | 0.000260 (0.64) | 0.000460 (0.22) | 0.0000415 (0.10) | | | |
| Disaster dummy (all events) | | | | -0.00326** (-2.02) | -0.00413 (-1.53) | -0.00318* (-1.70) |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | 0.00173 (1.03) | -0.000983 (-0.51) | 0.00191 (1.04) |
| Disaster dummy (all events) NATCAT*Polity (t-1) | | | | -0.0000998 (-0.23) | 0.000382 (0.62) | -0.000117 (-0.22) |
| log share of losses (all events) | | | | -0.00362* (-1.95) | -0.0285* (-1.96) | -0.00327* (-1.76) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | | | 0.000805 (1.65) | 0.00353** (2.56) | 0.000313 (0.87) |
| Log share of losses NATCAT*Polity (t-1) | | | | -0.0000696 (-0.34) | 0.00191 (1.38) | -0.000113 (-0.51) |
| Constant | -12.25*** (-4.56) | -12.73*** (-3.94) | -11.71*** (-3.54) | -12.58*** (-4.78) | -12.51*** (-3.94) | -12.37*** (-3.88) |
| r2 | 0.979 | 0.990 | 0.977 | 0.981 | 0.991 | 0.980 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2440 | 643 | 1797 | 2433 | 643 | 1790 |

Table 18: Including two interaction terms, trade openness and insurance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|-----------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.792*** (20.98) | 0.881*** (21.69) | 0.750*** (17.45) | 0.821*** (32.30) | 0.880*** (21.69) | 0.784*** (28.89) |
| Ins. penetration rate (t-1) | 0.00134 (0.95) | -0.00471 (-1.17) | 0.00104 (0.68) | 0.00210 (1.44) | -0.00449 (-0.90) | 0.00164 (1.02) |
| log capital stock (t-1) | -0.0386 (-0.96) | -0.211*** (-3.07) | -0.0131 (-0.28) | -0.0533 (-1.49) | -0.206*** (-3.01) | -0.0305 (-0.74) |
| log population (t-1) | -0.262*** (-2.64) | 0.0200 (0.08) | -0.134 (-1.34) | -0.233** (-2.52) | 0.00676 (0.03) | -0.109 (-1.23) |
| log human capital (t-1) | 0.00640 (0.07) | 0.0578 (0.82) | -0.00356 (-0.03) | 0.0226 (0.26) | 0.0531 (0.77) | 0.0151 (0.15) |
| Trade openness (t-1) | 0.000529*** (3.26) | 0.000370* (1.77) | 0.000470*** (2.68) | 0.000414*** (2.98) | 0.000409** (2.31) | 0.000362** (2.39) |
| Disaster dummy (cat4) | -0.00924* (-1.81) | -0.0118** (-2.07) | -0.00922 (-1.53) | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.00261* (1.96) | 0.00351** (2.22) | 0.00136 (0.92) | | | |
| Disaster dummy (cat 4) NATCAT*Trade Openness (t-1) | 0.0000272 (0.53) | 0.0000183 (0.16) | 0.0000331 (0.56) | | | |
| Disaster dummy (all events) | | | | -0.00363** (-2.13) | -0.00434 (-1.54) | -0.00369* (-1.77) |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | -0.00104 (-1.38) | 0.00182 (0.53) | -0.000878 (-0.97) |
| Disaster dummy (all events) NATCAT*Trade Openness (t-1) | | | | 0.0000649** (2.56) | -0.0000156 (-0.18) | 0.0000632** (2.31) |
| log share of losses (all events) | | | | -0.00519** (-2.06) | -0.0132** (-2.55) | -0.00626* (-1.93) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | | | 0.000668 (1.57) | 0.00463*** (3.00) | 0.0000823 (0.19) |
| Log share of losses NATCAT*Trade Openness (t-1) | | | | 0.0000173 (0.76) | 0.00000981 (0.41) | 0.0000365 (1.11) |
| Constant | -13.89*** (-5.71) | -10.28*** (-2.99) | -16.84*** (-5.03) | -12.94*** (-5.72) | -9.869*** (-2.89) | -15.58*** (-5.13) |
| r2 | 0.978 | 0.991 | 0.977 | 0.981 | 0.991 | 0.980 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2555 | 677 | 1878 | 2547 | 677 | 1870 |

Table 19: Including two interaction terms, government expenditure and insurance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|----------------------|----------------------|----------------------|------------------------|-----------------------|-----------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.786*** (18.49) | 0.888*** (22.00) | 0.742*** (15.45) | 0.820*** (31.21) | 0.890*** (22.30) | 0.782*** (28.05) |
| Ins. penetration rate (t-1) | 0.00220** (2.38) | -0.00807* (-1.93) | 0.00193* (1.77) | 0.00244** (2.24) | -0.00833** (-2.29) | 0.00227* (1.90) |
| log capital stock (t-1) | -0.0582 (-1.33) | -0.241*** (-4.05) | -0.0188 (-0.39) | -0.0836** (-2.37) | -0.237*** (-3.98) | -0.0498 (-1.32) |
| log population (t-1) | -0.226* (-1.91) | -0.0334 (-0.16) | -0.102 (-0.88) | -0.174* (-1.72) | -0.0423 (-0.20) | -0.0511 (-0.52) |
| log human capital (t-1) | -0.000642 (-0.01) | -0.0303 (-0.30) | -0.00159 (-0.01) | 0.0184 (0.17) | -0.0255 (-0.25) | 0.0157 (0.13) |
| Government expenditure (t-1) | 0.000736 (0.75) | 0.00660** (2.19) | 0.000541 (0.63) | 0.000882 (1.14) | 0.00704** (2.56) | 0.000644 (0.90) |
| Disaster dummy (cat4) | -0.0153** (-2.54) | -0.00625 (-1.14) | -0.0173** (-2.42) | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.00348*** (2.63) | 0.00448** (2.38) | 0.00233* (1.74) | | | |
| Disaster dummy (cat 4) NATCAT*Government Expenditure (t-1) | 0.000776 (1.45) | -0.000957 (-0.97) | 0.00101* (1.67) | | | |
| Disaster dummy (all events) | | | | -0.00520*** (-2.96) | -0.00347 (-1.27) | -0.00533** (-2.62) |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | -0.000621 (-0.77) | 0.00237 (1.06) | -0.000718 (-0.80) |
| Disaster dummy (all events) NATCAT*Government Expenditure (t-1) | | | | 0.000635** (2.28) | -0.000531 (-0.62) | 0.000647** (2.23) |
| log share of losses (all events) | | | | -0.0107*** (-2.99) | -0.0119 (-1.33) | -0.0120*** (-2.94) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | | | 0.000996* (1.74) | 0.00411** (2.61) | 0.000482 (1.40) |
| Log share of losses NATCAT*Government Expenditure (t-1) | | | | 0.000702** (2.44) | 0.000629 (0.08) | 0.000839** (2.53) |
| Constant | -16.02*** (-5.90) | -14.84*** (-5.63) | -17.17*** (-4.72) | -15.17*** (-5.96) | -14.43*** (-5.52) | -16.03*** (-4.85) |
| r2 | 0.976 | 0.991 | 0.974 | 0.980 | 0.991 | 0.978 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2407 | 634 | 1773 | 2399 | 634 | 1765 |

Table 20: Including two interaction terms, domestic credit and insurance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|-------------------------|-------------------------|-------------------------|-------------------------|------------------------|-------------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c.(t-1) | 0.814*** (30.50) | 0.892*** (21.62) | 0.770*** (26.97) | 0.814*** (30.57) | 0.891*** (21.87) | 0.770*** (27.29) |
| Ins. penetration rate (t-1) | 0.00225*** (2.29) | -0.00483 (-1.17) | 0.00224* (1.79) | 0.00223* (1.75) | -0.00501 (-1.35) | 0.00198 (1.34) |
| log capital stock (t-1) | -0.0323 (-0.98) | -0.241*** (-4.05) | 0.00553 (0.16) | -0.0311 (-0.94) | -0.233*** (-3.97) | 0.00705 (0.21) |
| log population (t-1) | -0.163* (-1.90) | 0.0758 (0.28) | -0.0995 (-1.15) | -0.168* (-1.93) | 0.0666 (0.25) | -0.104 (-1.19) |
| log human capital (t-1) | 0.0390 (0.47) | 0.0686 (1.02) | 0.0559 (0.55) | 0.0451 (0.54) | 0.0620 (0.96) | 0.0622 (0.59) |
| Domestic credit (t-1) | -0.000418*** (-3.51) | -0.0000305 (-0.27) | -0.000547*** (-4.71) | -0.000443*** (-3.92) | -0.0000294 (-0.22) | -0.000556*** (-4.82) |
| Disaster dummy (cat4) | -0.0109*** (-2.76) | -0.00736 (-1.64) | -0.0166** (-2.61) | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.00178 (1.42) | 0.00479*** (2.78) | 0.000793 (0.42) | | | |
| Disaster dummy (cat 4) NATCAT*Domestic Credit (t-1) | 0.0000452 (1.22) | -0.0000529** (-2.61) | 0.000184* (1.86) | | | |
| Disaster dummy (all events) | | | | -0.00392** (-2.33) | -0.00425 (-1.65) | -0.00389* (-1.94) |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | -0.0000603 (-0.06) | 0.00132 (0.60) | 0.000229 (0.21) |
| Disaster dummy (all events) NATCAT*Domestic Credit (t-1) | | | | 0.0000470 (1.27) | -0.00000956 (-0.20) | 0.0000455 (0.93) |
| log share of losses (all events) | | | | -0.00449** (-2.32) | -0.0141*** (-3.17) | -0.00415 (-1.66) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | | | 0.000594 (1.61) | 0.00437*** (3.05) | 0.000353 (1.15) |
| Log share of losses NATCAT*Domestic Credit (t-1) | | | | 0.0000147 (1.26) | 0.0000183 (1.59) | 0.0000214 (0.79) |
| Constant | -12.83*** (-6.06) | -12.49*** (-3.88) | -14.19*** (-4.79) | -12.63*** (-5.94) | -12.10*** (-3.86) | -14.10*** (-4.83) |
| r2 | 0.981 | 0.991 | 0.980 | 0.981 | 0.991 | 0.980 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2509 | 663 | 1846 | 2507 | 663 | 1844 |

Table 21: Including two interaction terms, financial openness and insurance

| | (1) | (2) | (3) | (4) | (5) | (6) |
|--|-----------------------|----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | All | OECD | non-OECD | All | OECD | non-OECD |
| log GDP p.c. (t-1) | 0.810*** (19.25) | 0.879*** (21.86) | 0.762*** (15.76) | 0.842*** (34.75) | 0.882*** (22.91) | 0.803*** (33.17) |
| Ins. penetration rate (t-1) | 0.00110 (0.82) | -0.00221 (-0.43) | 0.000793 (0.54) | 0.0000755 (0.04) | -0.00103 (-0.21) | -0.000275 (-0.113) |
| log capital stock (t-1) | -0.0356 (-0.90) | -0.236*** (-3.92) | 0.00201 (0.05) | -0.0518 (-1.53) | -0.234*** (-3.96) | -0.0189 (-0.55) |
| log population (t-1) | -0.256** (-2.30) | 0.128 (0.48) | -0.129 (-1.30) | -0.217** (-2.17) | 0.133 (0.51) | -0.0890 (-1.05) |
| log human capital (t-1) | 0.0141 (0.15) | 0.0669 (1.02) | 0.00538 (0.05) | 0.0265 (0.30) | 0.0570 (0.88) | 0.0186 (0.19) |
| Financial openness (t-1) | 0.00144 (0.75) | 0.00870*** (3.06) | -0.00166 (-0.80) | 0.000548 (0.22) | 0.00719** (2.73) | -0.00189 (-0.66) |
| Disaster dummy (cat4) | -0.00808** (-2.56) | -0.0102** (-2.64) | -0.00752** (-2.18) | | | |
| Disaster dummy (cat 4) NATCAT*Insurance Penetration (t-1) | 0.00263** (2.31) | 0.00367*** (2.78) | 0.00181 (1.33) | | | |
| Disaster dummy (cat 4) NATCAT*Financial Openness (t-1) | 0.000891 (0.72) | -0.000132 (-0.07) | 0.000840 (0.44) | | | |
| Disaster dummy (all events) | | | | -0.00317* (-1.89) | -0.00370 (-1.46) | -0.00298 (-1.51) |
| Disaster dummy (all events) NATCAT*Insurance Penetration (t-1) | | | | 0.00104 (0.88) | -0.0000164 (-0.01) | 0.00107 (0.80) |
| Disaster dummy (all events) NATCAT*Financial Openness (t-1) | | | | 0.00123 (0.64) | 0.00225 (1.18) | 0.000662 (0.28) |
| log share of losses (all events) | | | | -0.00330** (-2.12) | -0.0126*** (-2.82) | -0.00309* (-1.95) |
| Log share of losses NATCAT*Insurance Penetration (t-1) | | | | 0.000834 (1.53) | 0.00352*** (3.12) | 0.000347 (0.98) |
| Log share of losses NATCAT*Financial Openness (t-1) | | | | -0.000498 (-0.80) | 0.00151 (1.25) | -0.00106 (-1.04) |
| Constant | -13.38*** (-5.09) | -11.74*** (-3.93) | -15.28*** (-4.36) | -12.20*** (-5.24) | -11.48*** (-3.95) | -13.62*** (-4.52) |
| r2 | 0.978 | 0.991 | 0.976 | 0.981 | 0.991 | 0.980 |
| countryFE | yes | yes | yes | yes | yes | yes |
| countryTrends | yes | yes | yes | yes | yes | yes |
| yearFE | yes | yes | yes | yes | yes | yes |
| N | 2479 | 665 | 1814 | 2473 | 665 | 1808 |