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Applied Econometrics: Empirical Project

Do economies respond with neoclassical growth dynamics to natural disasters? Evidence from panel data on the effect of natural disasters on growth

Abstract:

We analyze the dynamic growth effects of natural disasters using a panel IV fixed effects model and we analyze whether these effects are in line with what neoclassical growth models predict for the cases where natural disasters hit an economy. We find the impact effect of disasters on per capita GDP growth can be explained by including a quadratic term of monetary damage over GDP, which suggests there is evidence of neoclassical growth dynamics at least for relatively small disasters. However, results are inconclusive for larger disasters.

1. Introduction

Natural disasters pose a growing threat to all kinds of societies. The Katrina Hurricane, the Asiatic tsunami in 2004 or the earthquake hitting Haiti in 2010 are recent examples of how devastating these events can be and how all kinds of countries can be hit by these hazards. In the light of a growing risk in the occurrence of natural catastrophes (UNISDR, 2017), the question about how economies respond to natural disasters has been gaining attention in the last years.

In this paper, we contribute to the literature of the effects of disasters on growth by specifically analyzing natural disasters in the eyes of a standard neoclassical growth model, such as the Solow-Swan model –henceforth simply the Solow model. We specifically address the question as to whether economies respond with neoclassical growth dynamics to natural disasters. After a disaster hits a country, do we see immediate catch up dynamics to the old steady state, as neoclassical growth models predict? How long does it take for economies to catch up? Do savings, investment or human capital explain the catch up patterns? Using data from the GeoMet database and the Penn-World Table, we isolate the exogenous impact effect of natural disasters on growth using a panel IV fixed effects model to estimate the standard growth regressions used in growth literature. We find evidence in favor of the neoclassical growth model at least for small disasters. Specifically, we find that monetary damage over GDP explains growth of GDP per capita once we include linear and quadratic terms of the former in a standard growth regression. We also find our results are robust when we use certain disaster-specific intensity measures and to the inclusion of Solow-related interaction variables. We also find higher saving rates cause countries to reduce the negative marginal impact effect of large natural disasters on growth.

This paper is organized as follows: in section 2, we present the conceptual framework of the question we seek to answer. Section 3 presents the data used in this paper. The justification of the econometric model used is presented in section 4, whereas the results obtained are presented in section 5. Finally, section 6 concludes.

2. Conceptual Framework

Neoclassical growth models have been the cornerstone models upon which modern economic growth theory has been built. For this paper, it suffices to expose a sketch of the Solow model to gain an overview of the events these models predict when a country is hit by a natural disaster.

The Solow model assumes a standard Cobb-Douglas production function with constant returns to scale to capital and labor and decreasing returns to one of these factors. In labor augmenting terms and dividing the production function by A_tL_t, production per effective worker takes the following form:

$$y_t = f_t(k_t) = k_t^{\alpha} \qquad (1)$$

where A_t is the technology parameter, L_t is the labor force, $k_t \equiv \frac{K_t}{A_tL_t}$ and $\alpha \in (0,1)$.

It is also assumed both labor force and the technology parameter grow at constant rates g and n, respectively. Here we assume $g=0$ to simplify the exposition.

Finally, assuming an exogenous and constant saving rate, savings per effective worker are given by $sy_t = sk_t^{\alpha}$, which yields the following law of motion of capital per effective worker:

$$\dot{k}_t = sk_t^{\alpha} - (n+\delta)\, k_t \qquad (2)$$

where $\dot{k}_t = \frac{\partial k_t}{\partial t}$.

The Solow model predicts that countries will converge to a steady state level of capital per worker– and hence output per worker- given there are decreasing returns to capital accumulation. Mathematically, this can be seen by setting (2) equal to 0 and solving for k_t.

When applied to natural disasters, the Solow model predicts that, controlling for the level of population, per capita income growth should fall following the impact of a natural disaster as capital is destroyed; on the contrary, it should rise in the subsequent periods following the recovery of the economy, as the amount saved by households exceeds the depreciation of old capital. Furthermore, the speed of convergence to the old steady state should eventually fade due to decreasing returns to scale to capital accumulation. Figure 1 illustrates the kind of dynamics the Solow model predicts for the impact of a natural disaster on GDP per capita, assuming $g=0$. Other neoclassical growth models, such as the Ramsey-Cass-Koopmans model, predict similar results: growth is inversely related to the initial level of GDP per capita, so countries hit by natural disasters that dampen GDP per capita on impact should grow faster in the subsequent periods after the shock.

3. Data

To estimate our model, we use data from the following two main sources.

Firstly, we use the same dataset as used in Felbermayr and Gröschl (2014), whose creators refer to as GeoMet[1]. This is a panel of 108 countries over the period 1979-2010 containing data on natural disasters occurrence, intensity, damage, etc. From the GeoMet we use (1) monetary damage over GDP: the amount of damage, in US thousand $, over property, crops and livestock caused by a given natural disaster over GDP; (2) sum of disaster indexes: this index is constructed as the mean-normalized sum of the largest earthquake within a year (as measured by the Richter Scale), the largest volcanic eruption (as measured by the VEI[2] index), largest storm/tornado (as measured by the maximum wind speed and wind gust registered in a given month within a year), the largest floods and droughts (as measured by the maximum standard deviation of monthly rain amount with respect to the monthly sample average) and maximum extreme temperature events within a year (as measured by the percentage difference in temperature between one month and the long run average temperature in the sample) and (3) count of disasters in a given year weighted by land area[3]. The GeoMet database also contains control variables used in our model, like (4) annual inflation, (5) polity index[4], (6) trade openness of the economy, (7) current account balance as a share of GDP, (8) real interest rates, (9) annual percentage increase in gross capital formation and (10) percentage of net inflows of foreign direct investment over GDP. Finally, we also obtain other disaster-related data like (11) the maximum

[1] For a more detailed information on how this dataset was created, the reader should refer to the original paper by Felbermayr and Gröschl (2014).
[2] VEI stands for Volcanic Explosivity Index.
[3] Disasters are defined as large if at least 1000 people are killed; or cause, at least, 1 billion US dollar monetary damage (deflated with US dollars from WDI) plus 100,000 people or more are affected.
[4] This index is elaborated by the Polity IV project.

Richter scale registered in a given year for a particular country, (12) the maximum wind speed and wind gust (13) other disaster indexes (sum of indexes weighted by land area, sum of indexes weighted by the inverse of the standard deviation of the index for a particular country over all the years, etc.). Secondly, we use the Penn World Table to obtain yearly country-level data on (1) real GDP per capita, (2) population levels, (3) real consumption (public and private), and (4) human capital. We also use data on real GDP to define a proxy of the saving rate as $(Real\ GDP_t\text{-}Real\ Consumption_t)/Real\ GDP_t$. Summary statistics of the main variables used are provided in table 1.

4. Econometric Model

The Solow model has served as a theoretical basis for an extensive empirical literature that has tried to test the mechanisms at work behind the growth of countries and regions. A popular approach to relate the Solow model to the data is by using growth regressions. This methodology was pioneered by Barro (1991) and is also extensively used in the literature on the effects of natural disasters on growth such as Skidmore and Toya (2002), Noy (2009) or Felbermayr and Gröschl (2014). We follow a similar approach to these last papers and consider the following benchmark model:

$$\Delta\ ln\ y_{i,t} = (1-\rho)\ ln\ y_{i,t-1} + \gamma D_{i,t-h} + \theta\Delta\ ln\ pop_t + \beta X_{i,t-1} + \alpha_i + \alpha_t + \varepsilon_{i,t} \qquad (3)$$

where $\Delta\ ln\ y_{i,t}$ is the growth rate of per capita GDP in year t; $ln\ y_{i,t-1}$ is the lagged value of $y_{i,t}$; $D_{i,t-h}$ is disaster intensity measure at date t-h, with h={0, 1, 2, 3, 4, 5} and $\Delta\ ln\ pop_t$ is controlling for the population growth in year t. For other controls, contained in the vector $X_{i,t-1}$ we use an almost identical approach as the one used by Felbermayr and Gröschl (2014) and just add the saving rate and a human capital index to include interactions of these with our disaster intensity measure later on. Therefore, $X_{i,t-1}$ contains Solow-related variables like the saving rate, gross capital formation, net inflows of foreign direct investment, the real interest rate and a human capital index. This vector also contains inflation, current account balance and measures of openness and quality of institutions. Note that we use the lagged values of these variables to control for the characteristics of a country before the disaster hits. Finally, we also account for country and time invariant characteristics for each observation, contained in α_i and α_t, respectively.

Similar versions of this model have been estimated in several papers that study the effect of natural disasters on growth. Each paper uses different variables to measure the intensity of the natural disaster, though. For instance, Noy (2009) uses the number of people killed and affected and the amount of direct monetary damage, whereas Felbermayr and Gröschl (2014) use various disaster indexes constructed directly from meteorological and geophysical data. Here we use a new hybrid approach and we instrument the amount of monetary damage over GDP using two disaster indexes.

First, we use monetary damage over GDP as the disaster intensity measure because we want to study the response of economies to a capital destruction caused by a natural disaster. The amount of monetary damage over GDP thus seems the most plausible candidate to proxy for how much capital is destroyed after a disaster hits a country. Secondly, the instrumentation of monetary damage over GDP responds to our concern that this variable may be endogenous. It seems reasonable to expect that the total monetary damage will be larger in richer countries or regions, where there is more to destroy (see Guha-Sapir et al., 2016). Although we can try to control for the richness of a country by using damage over GDP, estimating the model using a fixed effects estimator or by controlling for the lagged level of GDP, there may still be issues of endogeneity arising, for instance, from country-specific economic cycles –which are neither time nor country invariant. For the purpose of this study, which is to evaluate whether economies respond with neoclassical growth dynamics to natural disasters, this kind of endogeneity may invalidate our results as the response of a natural disaster of a country that is growing due to a technological shock[5] contained in the error term is different from a country that is depressed for exactly the opposite reason.

[5] We have in mind the kind of technological shocks that appear in the literature of business cycles, as in Prescott (1986).

Given these considerations, we estimate our model by instrumenting monetary damage over GDP with two disaster indexes contained in GeoMet: the sum of all meteorological/geophysical indexes of disasters and the count of total disasters that occurred in a given year weighted by land area. It seems natural to hold these instruments are valid once we account for fixed effects and for population growth[6]: the larger the intensity of disasters, measured by its meteorological/geophysical intensity or by the number of occurrences in a given year, the larger the monetary damage we should observe in that year. Furthermore, the meteorological/geophysical intensity of disasters or the number of occurrences should only affect the growth rate of output per capita via the monetary damage the natural disaster causes, once controlling for population growth and fixed effects. We should remark here that, although one may think there may be many unobservables that correlate with the instruments we use –for instance, unobserved consumer confidence, which dampens growth, may be lower after large disasters, which would make our instruments and consumer confidence appear correlated-, these unobservables will correlate with the instrument only via the instrumented variable. This does not endanger the validity of our instruments. Still, tests for relevance and exogeneity of the instruments are presented in the section below. Finally, we also include year dummies to account for time effects[7] and we use clustered errors to obtain consistent standard errors for the estimators.

5. Results

When we estimate versions of the baseline specification described above, we find evidence that economies suffering small disasters respond with neoclassical growth dynamics.

First of all, the first stage of the IV regression yields that both the sum of disaster indexes and the count of disasters significantly increase monetary damage. The F-test rejects no joint significance of

[6] Papers like Bakkensen and Barragey (2016) have documented that countries which, for their geographical position, suffer more natural disasters, also present higher (precautionary) saving rates. Given that the recovery of a country that usually suffers natural disasters may be different than that of a country that does not usually suffer them, we should account for fixed effects. Population/population growth should also be accounted for: disasters that destroy capital will likely cause deaths. As, by construction, GDP per capita depends on population, omitting this variable would bias our estimates.

[7] These may account for international economic cycles or the fact that climate change is associated to an increase in the risk of suffering natural disasters, as recognized by the UNISDR.

both instruments and both instruments are individually highly significant, from which we conclude that instruments are indeed relevant. Not surprisingly, all lagged controls have no significant effect on monetary damage. Furthermore, we find the coefficient on population growth is negative and significant, a result we may associate to the fact that monetary damage and population growth should be negatively correlated, as some natural disasters may cause both higher monetary damage and lower population growth. When we use other disaster indexes, such as the sum of disaster indexes weighted by land area or by the inverse of their standard deviation, these do not have a significant impact on monetary damage, so we do not incorporate these indexes in our analysis. Finally, it should be noted that we do not include time fixed effects in the first stage. Although results are not much sensitive to this approach, this is done to slightly reduce the standard error of our estimates. Details on the coefficients of the instruments in the first stage can be found in table 2. For further details on the first stage, the reader should refer to the script of this project.

For the second stage of the regression, when the baseline specification is run as described in (3), we find no significant impact of disasters on growth (see table 3). However, when we include a quadratic term for the instrumented monetary damage, the picture changes radically: we find a highly significant inverse U shaped impact effect of natural disasters on growth (see figures 2 and 3). The F-test associated to the linear and quadratic terms is also highly significant, suggesting these variables are jointly significant. More specifically, for small disasters –i.e. disasters which cause a monetary damage smaller than 0,62% of GDP- the effect of the disaster on growth is positive, whereas the effect turns negative for disasters that cause an amount of monetary damage larger than 0,62% of GDP. This suggests that countries that suffer small losses rapidly catch up to the old steady state level of output per capita[8], whereas countries suffering large losses see their annual per capita production figures reduced.

[8] Some authors (for instance Albala-Bertrand, 1993; Okuyama, 2003 or Benson and Clay, 2004) have suggested that the impact effect of disasters on growth could even be positive. They disagree on the forces behind this positive effect, though: Albala-Bertrand argues the economy grows as replaces old capital by new one. However, Benson and Clay (2004) argue this is due to a reconstruction-led Keynesian boom.

With regards to the lagged values of monetary damage, incorporated to capture medium-term growth dynamics after a disaster, none of the coefficients associated to these lagged values is significant[9]. It should also be remarked that the estimates for the control variables generally are in line with what one would expect from the growth literature.

As a robustness check, we estimate the benchmark model with the quadratic term by using each particular disaster's index as an instrument. We obtain the Richter scale and the maximum wind speed are relevant instruments and yield very similar parameter estimates in the second stage. In the case of earthquakes, this still holds if we restrict our sample to observations where the number of earthquakes for a given year is larger than zero (see table 4). For the other kind of disasters' indexes, we cannot reject the hypothesis that the effect of these indexes on monetary damage is different from zero, so we conclude these are not relevant indexes.

To check for the appropriateness of our econometric specification, we first perform a Sargan test of overidentifying restrictions to check for the exogeneity of the two instruments used in the main specification and obtain there is statistical evidence in favour of the hypothesis of exogeneity (see comments under table 3). Having this evidence, we then perform a Hausman test on the coefficient of monetary damage over GDP for the adequacy of instrumenting this variable. Table 5 confirms the coefficient of monetary damage is significantly different when using IV than when it is not used, which yields evidence in favour of the need to instrument monetary damage over GDP.

Finally, we also estimate (3) using a basic pooled OLS estimator without IV, a random effects estimator with IV and fixed effects estimator without IV. Results are all provided in table 3. Furthermore, the Hausman test for the hypothesis that the fixed effects estimator with IV is more appropriate than the random effects with IV yields evidence in favour of the fixed effects model (see comments under table 3).

[9] Unfortunately, we cannot repeat this exercise for observations with a monetary damage larger than 0,62% of GDP, as we do not have enough observations to estimate the model. This is a result of the right-skewed density of monetary damage over GDP (see figure 4).

We also run the benchmark model with the quadratic term, without lags of damage and with other lagged interactions of the linear and quadratic instrumented monetary damage with the relevant variables used in neoclassical growth models –i.e. human capital, annual growth of gross capital formation and the saving rate. We find that the slope of the parabola is reduced as the saving rate increases because the interaction of the linear monetary damage with the saving rate is significant[10]. The F test for the joint significance of this interaction and the linear term of monetary damage over GDP rejects the null at an almost 5% significance level. Results on the model plus interactions can be found in table 6. Figure 6 displays how, over the relevant range of monetary damage, countries with high saving rates before the disaster will experience less negative marginal impact effects of large disasters on growth as compared to countries with low saving rates before the disaster. This result suggests that two identical countries suffering a big disaster, one with a high saving rate and one with a low saving rate, will differ in how a marginal increase in the amount of monetary damage over GDP affects GDP per capita growth. For the high-saving rate country, a marginal increase in the amount of damage will have a less negative effect on growth than for the low-saving rate country. This result is in line with what a neoclassical endogenous savings models, like the Ramsey-Cass-Koopmans model, predict: countries that save more will quickly build up new capital, as compared to countries that save less.

The other lagged interactions -i.e. monetary damage over GDP (linear and squared terms) with human capital and investment rate-, are not significant.

6. Conclusion

In this paper, we addressed the question as to whether economies responded with neoclassical growth dynamics to natural disasters. Precisely for the fact that we observe economies slightly growing –or not growing at all- after being hit by small disasters and falling after being hit by large ones, we

[10] Still, for reasonable values of the saving rate, the effect of monetary damage over GDP on growth is still concave.

conclude that, as neoclassical growth theories suggest, output per capita falls precisely at the moment of the impact and starts growing immediately afterwards. However, as economies are not followed in continuous time, but rather once a year, we cannot capture the full picture a neoclassical model would suggest for the case where a natural disaster hits an economy (figure 1). We instead observe some observations once they have already caught up to the old steady state and some other observations which still have not. From this, we conclude that, at least for small disasters, we see the catch up effect neoclassical growth theories predict. We also conclude this catch up effect is rather quick as lagged values of monetary damage over GDP do not explain growth at all. Still, further research lines may try to apply a similar approach as the one used in this paper but to observations followed quarterly to get a more detailed picture of how quick is the catch up effect. Besides that, the finding of a positive effect of small disasters on growth does not exactly comply with a standard neoclassical growth model, which would predict no effect on growth at all in case the convergence to the old steady state was achieved during the same year of the impact. In view of this result, we also conclude that natural disasters have a productivity/Keynesian boom effect through the destruction of capital.

Finally, although we conclude that economies respond with neoclassical growth dynamics to small disasters, this need not be true for all types of disasters: some economies may become stuck in traps after large disasters hit. We conclude that we cannot answer this question as we do not have enough observations to run our baseline regression on the largest disasters. A similar approach as the one used in this paper but applied to the most devastating disasters thus merits careful investigation.

Tables and Figures

Table 1 : Summary of the statistics disasters					
Variable	Observations	Mean	Standard deviation	Min	Max
Monetary damage	3208	0.141	1.354	0	62.066
Disaster index	3208	66.913	23.97	0.004	172.504
Disaster index weighted by inverse of sd and by land area	3208	0.032	0.171	6.63e-06	2.228
Maximum Richter scale	3208	3.936	2.342	0	8.8
Maximum volcanic explosivity index	3208	0.22	0.705	0	6
Maximum wind speed experienced	3208	60.812	22.322	0	165
Absolute difference of monthly precipitation over mean, from daily average (1979-2010)	3208	1.57	5.85	0	87.361
Drought (1 if 3 month in row below 50% of long run mean, or 5 months within year, 0 other)	3208	0.061	0.24	0	1
Positive difference in precipitation over mean, from daily averages (1979-2010)	3208	0.89	0.954	0	14.79

TABLE 1: *Note that the maximum monetary damage in the sample (62.006% of GDP) corresponds to the earthquake of Haiti in 2010. Figures 7 and 8 show the Kernel density estimates of the two main instruments, sum of disaster indexes and count of total disasters.*

Table 2: First stage regressions Dependent variable : Monetary damage			
	(1)	(2)	(3)
Disaster index	0.016*** (0.003)	-	-
All disaster in EM-DAT (count weighted by land area)	76.752*** (16.793)	-	-
Maximum Richter scale experienced	-	0.125*** (0.035)	-
Maximum wind speed experienced	-	-	0.018*** (0.003)
Number of observations	1,893	1,893	1,893
Fixed Effects	Yes	Yes	Yes

TABLE 2: *We use cluster-robust standard errors. We test the joint significance of the coefficients of model (1), we reject the null hypothesis, so both instruments are jointly relevant. The predicted values obtained from (1) are the ones used in all the general FE regressions. In the 3 models we control for lagged values of savings, gross direct investment, credit, openess, a political index, human capital, consumer price index, trade balance, foreing direct investment, interest rate and the contamporaneous value of population growth.*

Table 3 : Main specification Dependent variable : Growth rate of GDP (i,t)						
	Pooled OLS	2IV FE without quadratic term	FE without IV	2IV FE with lags	RE + 2IV	2IV FE
Monetary damage (exogenous) (i,t)	-0.0002 (0.002)	0.002 (0.003)	-0.001 (0.002)	0.026 (0.009)	0.013 (0.01)	0.023 (0.01)
Monetary damage squared (i,t)	-8.83e-06 (0.0003)	-	0.00002 (0.00003)	-0.015* (0.006)	-0.005 (0.003)	-0.018** (0.007)
Log GDP/Capita (i, t-1)	-0.011*** (0.003)	-0.122*** (0.02)	-0.085*** (0.016)	-0.125*** (0.02)	-0.012 (0.004)	-0.095*** (0.016)
Population growth (i, t)	-0.044 (0.68)	2.187** (0.536)	1.083 (0.74)	1.818*** (0.633)	0.284 (0.784)	1.12* (0.572)
Savings rate (i,t-1)	0.029** (0.013)	0.081* (0.042)	0.065*** (0.026)	0.088** (0.42)	0.031 (0.014)	0.077** (0.029)
Gross capital formation (i,t-1)	0.041*** (0.009)	0.018 (0.011)	0.027*** (0.008)	0.021** (0.011)	0.037 (0.009)	0.031*** (0.008)
Monetary damage (i,t-1)		0.009* (0.005)		0.006 (0.005)		
(i,t-2)		-0.003 (0.004)		-0.003 (0.005)		
(i,t-3)		0.001 (0.004)		0.001 (0.004)		
(i,t-4)		0.004 (0.004)		0.005 (0.004)		
(i,t-5)		-0.008 (0.005)		-0.007 (0.006)		
Number of observations	1,893	1,893	1,893	1,346	1,893	1,893
Fixed Effects	No	Yes	Yes	Yes	No	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes

TABLE 3: *We use cluster robust standard errors in all the FE or RE models and robust standard errors in the Pooled OLS. We test the joint significance of monetary damage over GDP and monetary damage over GDP squared in the FE +IV model, the p-value is 0.03 so the coefficients are jointly significant at the 5% level. We do a Hausman test of fixed effects vs random effects, computed using the last two models in the table, which are identical except for the FE and RE, the p-value of the test is 0. Therefore, the fixed effects model should be used. For the model of FE+ 2IV we perform a test of overidentifying restrictions to test the exogeneity of our instruments. The p-value of the test is 0.52 so we accept the null hypothesis of exogeneity of our instruments. We use for all the models the same controls as in table 2.*

Table 4 : Regressions for particular disasters Dependent variable : Growth rate of output, 1980-2010		
	Earthquakes	Hurricanes
Monetary Damage (i,t)	-0.002 (0.014)	0.021*** (0.006)
Monetary Damage squared (i,t)	-0.031*** (0.003)	-0.028 (0.003)
Log GDP/Capita (i, t-1)	-0.082*** (0.016)	-0.095*** (0.015)
Population Growth (i, t)	0.127 (0.554)	1.114** (0.471)
Savings Rate (i,t-1)	0.049* (0.027)	0.072*** (0.025)
Gross Capital Formation (i,t-1)	0.032*** (0.01)	0.032*** (0.008)
Number of observations	1,549	1,893
Fixed Effects	Yes	Yes
Time Effects	Yes	Yes

TABLE 4: *We use clustered-robust standard errors. Recall that the maximum Richter scale and the combined wind speed are used as instruments. Recall also that for earthquakes we filter for the observations where there is an earthquake to focus on what happens exactly when an earthquake happens. We use for both models the same controls as in table 2.*

Table 5 : Hausman test on potentially endogenous variables					
	Beta (OLS)	Beta (2SLS)	Var[Beta(OLS)]	Var[Beta(2SLS)]	Hausman
Monetary Damage	-0.001	0.017	0.000003	0.0001	1.945
Monetary Damage squared	0.00002	-0.014	0,000000001	0.00005	-2.5603

Table 6 : Model with interactions Dependent variable : Growth rate of GDP (i,t)	
Monetary damage (i,t)	-0.021 (0.022)
Monetary damage squared (i,t)	-0.014 (0.016)
Monetary damage (i,t) * Savings rate (i,t-1)	0.06** (0.025)
Monetary damage squared (i,t) * Savings rate (i,t-1)	0.025 (0.015)
Monetary damage (i,t) * Gross capital formation (i,t-1)	0.008 (0.02)
Monetary damage squared (i,t) * Gross capital formation (i,t-1)	-0.012 (0.017)
Monetary damage (i,t) * Human capital (i,t-1)	0.003 (0.008)
Monetary damage squared (i,t) * Human capital (i,t-1)	0.001 (0.008)
Gross capital formation (i,t-1)	0.029* (0.009)
Savings (i,t-1)	0.042** 0.023)
Human capital (i,t-1)	0.008 (0.024)
Number of observations	1,893
Fixed Effects	Yes
Time Effects	Yes

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TABLE 6: *We use clustered-robust standard errors. Monetary damage is instrumented as usual, (obtained from model 1 in table 2). We use the same controls as in table 2. The F test for joint significance of the linear term of monetary damage over GDP and the lagged saving rate interacted with the linear term of monetary damage over GDP has a p-value of 0,0615.*

Figure 1: Simulations of the dynamics of GDP per capita in the Solow Model

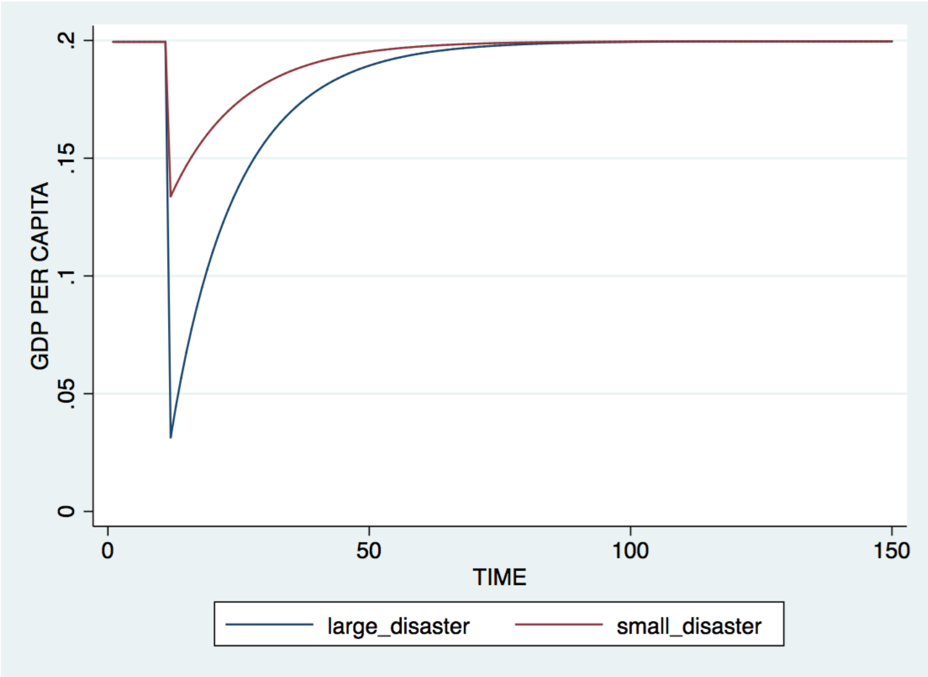


Figure 2: Estimated effect of Monetary Damage of GDP o growth rate, range 0-1% of GDP

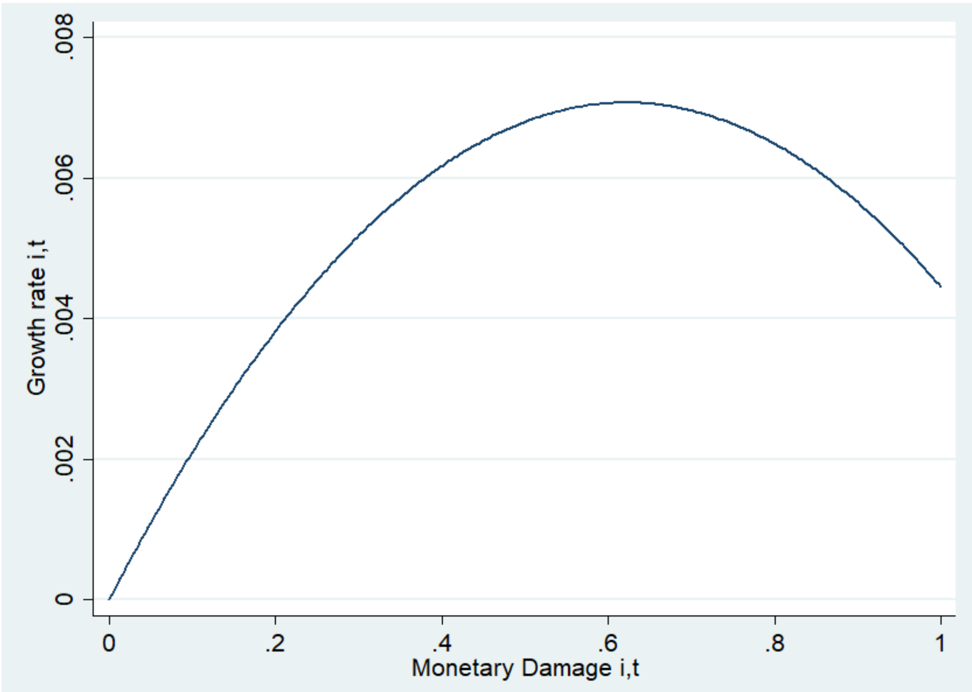


Figure 3: Estimated effect of Monetary Damage of GDP o growth rate, range 0-60% of GDP

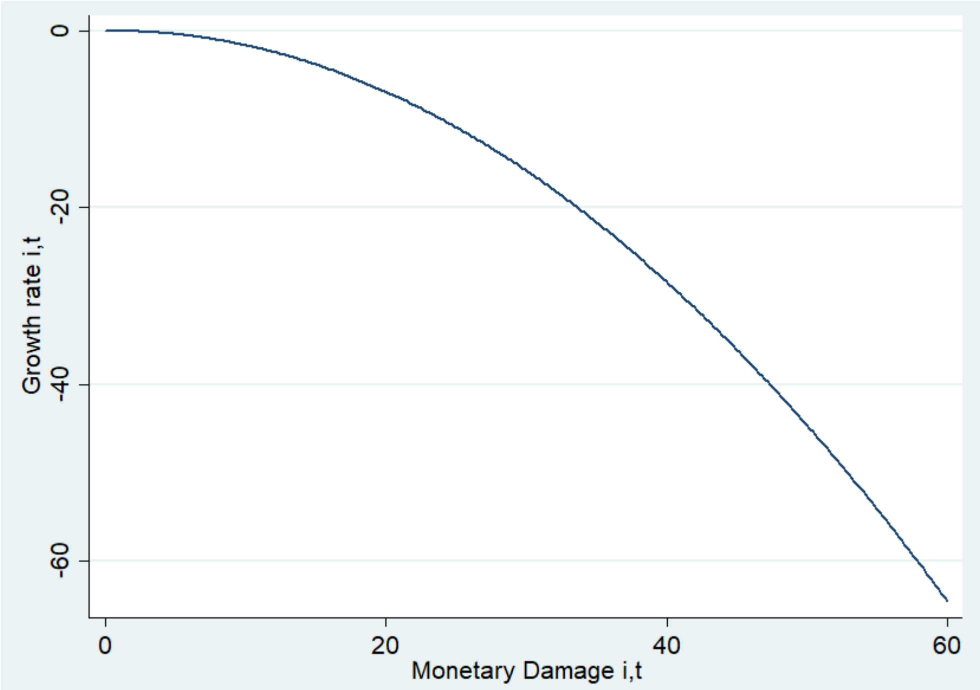


FIGURE 3: *This corresponds to the range of values of the GeoMet data, the biggest observation (60%) corresponds to the earthquake of Haiti in 2010.*

Figure 4: Kernel density of Monetary Damage over GDP

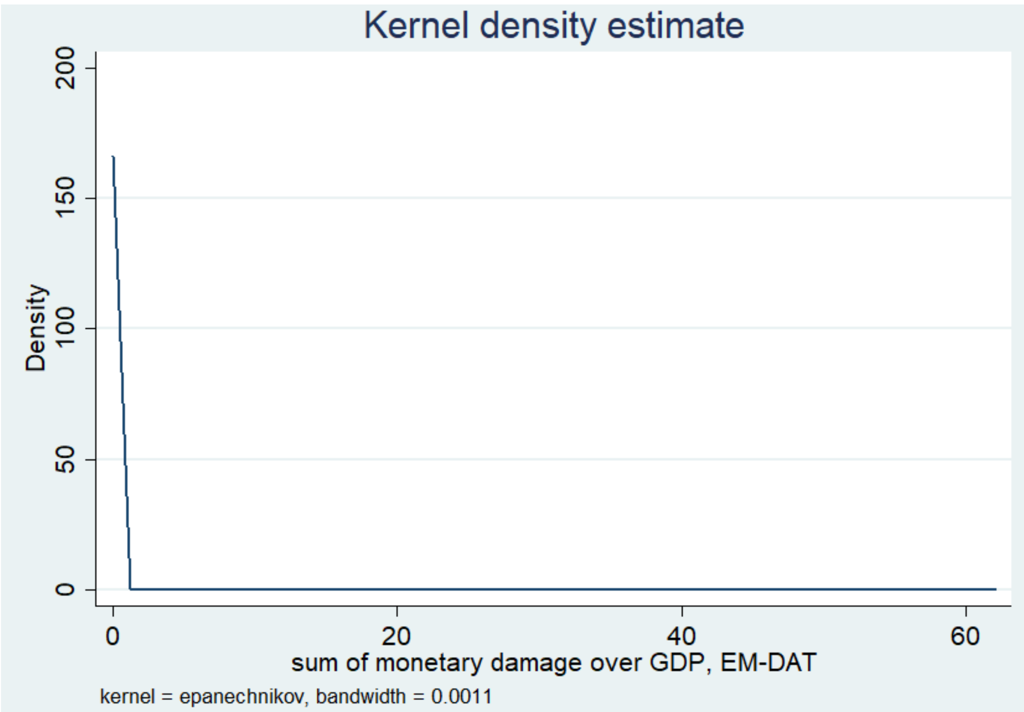


Figure 5: Estimated effects on growth conditional on different savings rate

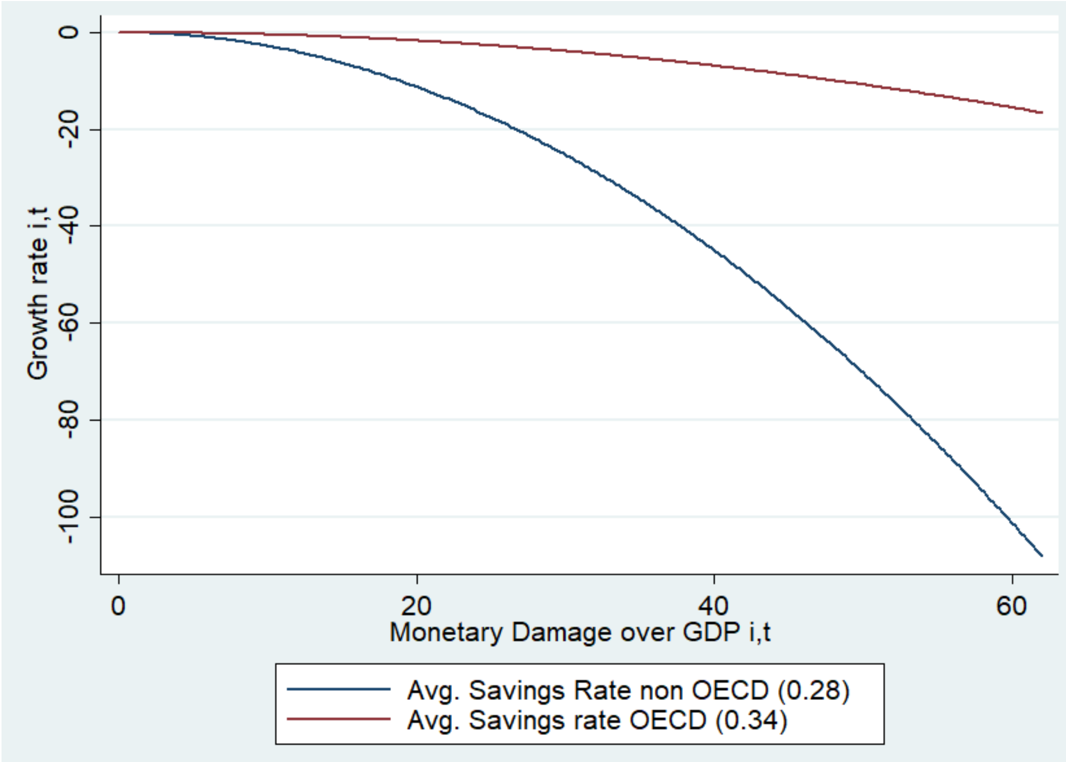


FIGURE 5*: Since the estimates are from a model in which monetary damage is interacted also with the annual rate of gross capital formation and average human capital with more interactions, we calculate the functional form of the parabola with the average values of the annual rate of gross capital formation and average human capital.*

Figure 6: Kernel Density of the sum of disaster indexes

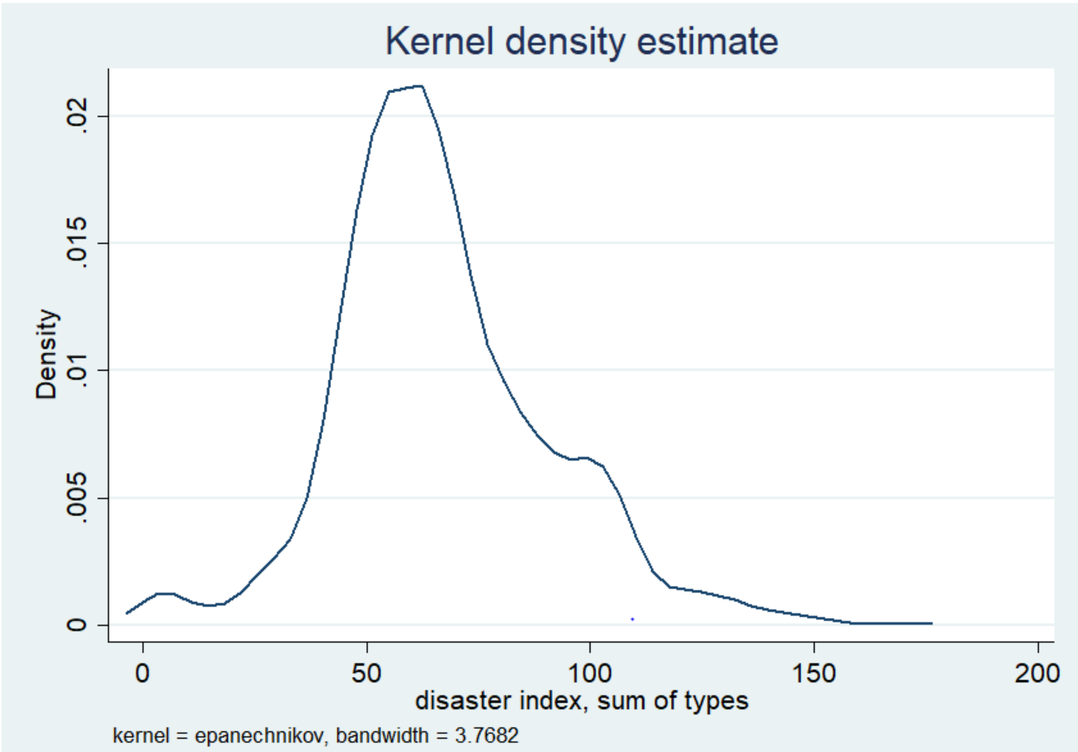
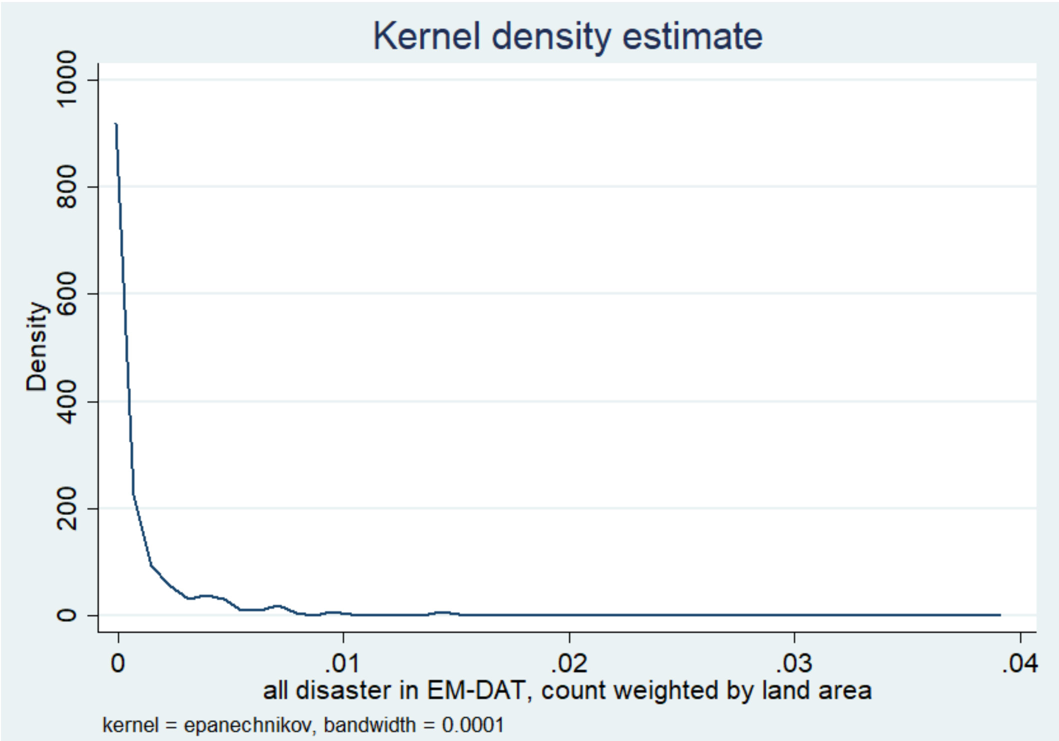


Figure 7: Kernel Density of the count of total disasters weighted by land area



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