The Economics of Natural Disasters in a Developing Country: The Case of Vietnam

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Abstract

We examine impact of natural disasters on annual output and output growth in Vietnam. Using provincial data for primary and secondary industries in Vietnam, we employ the Blundell-Bond System GMM procedure to estimate the impact of disasters on the macro-economy. Results show that more lethal disasters result in lower output growth but that more costly disasters (in terms of destroyed capital) actually appear to boost the economy in the short-run. This result is consistent with the 'creative destruction' hypothesis that we outline. However we find that disasters have different macroeconomic impact in different geographical regions; and these differences are potentially related to the ability to generate transfers from the central government.

Keywords: Vietnam, natural disasters, growth, exogenous shocks

JEL codes: O40, Q54

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1. Introduction

Natural disasters have always resulted in significant economic and human loss. Major recent catastrophic events — such as the December 2004 tsunami in the Indian Ocean, the Pakistani Kashmir earthquake of October 2005 and cyclone Nargis that hit Myanmar in May 2008 — have brought the human and material cost of these disasters to the forefront of public attention worldwide, and especially in Asia. Natural disasters now also figure prominently in numerous policy debates, especially in relation to global warming and the attendant changes in the patterns of climatic events that are predicted to accompany it (IPCC, 2007).[1, 2]

Research in both the social and natural sciences has been devoted to increasing our ability to predict disasters, prepare for them and mitigate their direct costs. Curiously, few economists participate in this research; though one existing strand of economic research on the topic focuses on disasters *ex ante*; it examines how societies can better prepare themselves to the onset of disasters and what determines the direct damage they cause. In contrast, we focus on the natural disasters' *ex post* impact on the macro-economy. We measure and estimate the costs of these natural-economic in terms of forgone production, using a comprehensive provincial panel dataset for Vietnam. We critically examine several hypotheses regarding the determinants of these costs, and compare the economic costs of disasters across different

[1] Changing sea, land and air temperatures, rising sea levels, changing patterns of rain and snow and an unstable climate are all likely catalysts of future weather-related events. For now, there is apparently no evidence that geo-physical disasters may also be affected by global warming.

[2] The United Nation's *Integrated Regional Information Network* notes, "While the number of lives lost has declined in the past 20 years - 800,000 people died from natural disasters in the 1990s, compared with 2 million in the 1970s — the number of people affected has risen. Over the past decade, the total affected by natural disasters has tripled to 2 billion." (IRIN, 2005).

geographical areas.

Several recent studies have found a positive correlation between the frequency of natural disasters and long run economic growth and have interpreted that as evidence that disasters provide opportunities for reconstructing the capital stock to make it more productive – we term this the 'creative destruction' hypothesis.[3] We examine this hypothesis not by examining the long-run growth (since it is likely dependent on many unobservables) but rather whether the destruction indeed generates a period of renewed economic activity and investment in the short-run. We further define what conditions make these dynamics more likely.

We use a regional panel dataset rather than an international panel so that our results will not be muddied by doubts that other national events or macroeconomic dynamics (exchange rate fluctuations, terms of trade shocks, financial crises, etc.) may be biasing our results. We focus on Vietnam for several reasons: Vietnam experiences frequent weather-related natural disasters; not unlike other coastal nations like the Philippines and Cambodia. The largest disaster in the 20th century in Vietnam, in terms of the number of people killed, was a storm in 1964 that killed about 7,000 people while the top 10 disasters killed a cumulative

[3] Much of the literature calls these dynamics 'creative destruction;' but this concept deviates significantly from the Schumpeterian concept (see Schumpeter, 2008). In fact, a more accurate term for the Schumpeterian dynamics of innovation that destroys obsolete firms would be 'destructive creation.' We choose to use the term 'creative destruction' but emphasize its distinctness from the Schumpeterian connotation. Skidmore and Toya (2002) is the most widely cited work in this literature that supports the creative destruction view; though some recent work disputes their findings (Cuaresma et al., 2008 and Noy and Nualsri, 2008).

16,000 people.[4] The frequency of disasters and the absence of very large events make results more robust and less susceptible to the impact of outliers. Furthermore, while disasters in Vietnam occur more frequently in the Central Coast area, they occur throughout the country, and thus enable identification of impacts using a regional panel data. Vietnam is useful as a case study for investigation into the economic consequences of disasters in developing countries as Vietnam is also a rapidly developing emerging market, with both a viable agricultural sector and a rapidly increasing manufacturing sector. As such, the identified economic impact will be of relevance to countries at various stages of industrialization.

Table 1 presents descriptive statistics on the disaster variables we use (for source and exact description see data section). The table presents, for the main eight Vietnamese geographical regions, the number of disasters and their frequency, the average deaths per disaster (as % of provincial population), the number of people affected (% of provincial population) and the physical damage (as % of provincial output). It is apparent that the coastal areas experience more frequent and harmful disasters. By most measures, the coastal disasters (storms) are on average 2-3 times more damaging than disasters elsewhere; especially when compared to the Northern regions (the Red River Delta, the Northeast and Northwest). Overall, there are 732 disaster observations in our dataset.

In the following section, we describe the existing literature and highlight our contribution to it. We follow with a discussion of the data, methodology, and findings of this

[4] In terms of the number of people affected, the largest event was a 1980 storm that affected more than 9 million people. In terms of direct damages, the costliest storm occurred in 2006 and destroyed US$ 624 million in property.

paper; and conclude by pointing out some policy implications of our findings.

2. The economics of natural disasters in previous research

2.1 Output growth and disasters

Economic research on natural disasters is only in its infancy with very few papers examining any facet of disaster phenomena. Two exceptions of well developed research strands are worth noting. There is a significant body of micro-development research which examines the ways in which mostly rural households prepare and deal with sudden unexpected income shocks and the households' ability to insure against them (e.g., Townsend, 1994; Paxson, 1989; and Udry, 1994). The second existing strand examines specific disaster events - such as hurricane Mitch in Honduras, the Kobe earthquake in Japan, and estimates some of the specific costs and consequences of those individual events (e.g., Benson and Clay, 2004; Coffman and Noy, 2009; Halliday, 2006; Horwich, 2000; Narayan, 2001; Selcuk and Yeldan, 2001; and Vos et al., 1999).

The first strand may not be directly related to our investigation as it focuses on the reaction of households in the mostly rural Least Developed Countries (LDCs) to changes in rainfall and draughts. The second strand is more directly relevant to our work. However, Vietnam—a rapid industrializer in its early stage of development—has a high exposure to storm events, and these pose a different set of issues regarding disaster vulnerabilities and their aftermath. These storms, unlike geo-physical disasters (earthquakes, volcanic eruptions and the tsunamies they both may generate), are fairly frequent and expected, even if their magnitude

can sometime be unusual. Vietnam's consistent exposure to disasters may generate different macroeconomic dynamics surrounding them when compared to countries that only experience infrequent but very large geo-physical events.

Our work on the Vietnamese economic vulnerability to natural disasters is different since we avoid the difficulty of identifying the impact of a single event in a case study. Our findings may provide indication for general conclusions that otherwise can only be derived with a meta-analysis relying on a large number of such single-event studies.

As far as we know, there are only very few papers that examine any macroeconomic facet of natural disasters using a multiple-events framework. These are briefly discussed below, though none of them attempts to answer the questions we pursue hereafter for the case of a single developing country such as Vietnam. The first recent attempt to empirically describe macro-aspects of natural disasters is Albala-Bertrand (1993). In this seminal monograph, Albala-Bertrand develops an analytical model of disaster occurrence and reaction and collects data on a set of disaster events: 28 disasters in 26 countries during 1960-1979. Based on before-after statistical analysis, he finds that GDP increases, inflation does not change, capital formation increases, agricultural and construction output increase, the twin deficits increase (the trade deficit sharply), reserves increase, but no discernible impact on the exchange rate is observed. The patterns of onset and recovery observable in this dataset are then described with a special emphasis on the political economy aspects of the events themselves. Rasmussen (2004) conducts a similar tabulation of the data for Caribbean Islands. Tol and Leek (1999) survey the literature as far back as the 1960s, and argue that the positive effect on GDP can readily be

explained since disasters destroy the capital stock, while the GDP measure focuses on the flow of new production. They emphasize the incentives for saving for and investing in disaster mitigation and recovery efforts.

Skidmore and Toya (2002) and Noy and Nualsri (2007) examine the long-run impact of natural disasters on growth. The former use the frequency of natural disasters for the 1960-1990 period for each country normalized by land size in a cross-sectional dataset while the latter use a panel of country—5-years observations as in the extensive literature that followed the work by Barro (1997). Both these papers investigate the long-run trends (averaged across countries) in contrast with our aim of describing the short-run dynamics of the macro-economy following disasters for a specific developing country.[5] Long-run analysis raises questions of endogeneity in disaster impact that are, to a large extent, not relevant for the short-run.

We are aware of only two papers that have attempted to investigate the short-run dynamics of output following disasters in a broad cross-country dataset, and no papers that have attempted to do that for a specific country using national or sub-national regional/sectoral data. Raddatz (2007) investigates the external sources of short-run output volatility in low income developing countries. Using a VAR empirical methodology, the paper analyses the contribution of various external shocks, natural disasters among them, in explaining output

[5] Skidmore and Toya (2002) and Noy and Nualsri (2008) also reach diametrically opposing conclusions with the former identifying expansionary and the latter contractionary disaster effects.

fluctuations. Raddatz's (2007) concludes that natural disasters do have an adverse short-run impact on output dynamics.[6]

Noy (2009) also finds an adverse short-run effect and describes some of the structural and institutional details that make this negative effect worse. In particular, he concludes that countries with a higher literacy rate, better institutions, higher per capita income, higher degree of openness to trade, higher levels of government spending, more foreign exchange reserves, and higher levels of domestic credit, but with less-open capital accounts are better able to withstand the initial disaster shock and prevent further spillovers. Given these findings, Vietnam is an especially interesting case with its low per capita income but high literacy rate, rapidly increasing trade openness, and a high degree of government economic involvement. Our paper, based on regional Vietnamese data enables us to examine some of these suggested links based on the observed differences between regions.

Several papers investigate the institutional and structural determinants of initial disaster costs (Anbarci et al., 2005; Kahn, 2004; Raschky, 2008; and Skidmore and Toya, 2007) or of the subsequent impact on the economy (Noy, 2009 and Cavallo et al., 2009). To the best of our knowledge, however, no work has attempted to neither address any of these issues nor answer any of the questions we pose using data from the sub-national level or with a focus on a particular country.

[6] Yet, Raddatz (2007) concludes that only a small fraction of the output volatility in a typical low income country is explained by external adverse shocks (which include disasters).

2.2 Other macroeconomic impacts of disasters

As in most previous research, we focus here on the impact of disasters on growth and production. However, other impacts of disasters have also been under-investigated. Most importantly, especially when the disasters are likely to generate significant inter-regional transfers, is a more precise account of their fiscal impact. On the expenditure side, the disaster reconstruction costs to the public may be very different than the original magnitude of destruction of capital that occurred.[7] On the other side of the fiscal ledger, the impact of disasters on tax and other revenue sources has also seldom been quantitatively examined. A cross-country investigation of these effects, as in Noy and Nualsri (2008), yields some useful predictions, but to a large extent, the disasters' impacts on revenue and spending depend on the country-specific macroeconomic dynamics occurring following the disaster shock, and the unique structure of revenue sources (income taxes, consumption taxes, custom dues, etc.) and large expenditures. Obtaining accurate estimates of the likely fiscal costs of a disaster is useful in enabling better cost-benefit evaluation of various mitigation programs. These should also assist foreign aid organizations and international multilateral institutions in planning and preparing their programs. Another motivation to estimate the fiscal cost is to better enable governments to directly insure against disaster losses, indirectly through the issuance of catastrophic bonds (CAT bonds), or through precautionary saving. The only attempt we know of estimating the likely fiscal insurance needs of a government has been calculated for Belize

[7] See Fengler et al. (2008) for a discussion of this possibility.

(Borensztein et al., 2008); though whether these estimates for Belize apply to Vietnam, for example, is an unexplored question.

3. Data and methodology

3.1 Data

The data on natural disasters and their impacts for 64 provinces in Vietnam are available from the OFDA/CRED International Disaster database for the period from 1953 to 2008. However, data on output values for primary industry (including agricultural, forestry, and fishery) are only available for the period from 1995 to 2006. Hence, this is our estimation period. There are several provinces that were merged together before 1995 and then split again sometime after 1995, so we have to sum up data for these provinces and thus have data for 61 provinces to estimate.

As in Noy (2009), we use three reported measures of the magnitude of the disaster to form the damage measures (*DM*): (1) The number of people killed (*KIL*); (2) the number of people affected (*AFF*); and (3) the amount of direct damage (*DAM*). We weigh our measure based on the month in which the disaster occurred. The disaster measures (*DMS*) are calculated based on the cost measure (*DM*) and the onset month (*OM*):

$$DMS = DM(12 - OM)/12 \quad (1)$$

Data for *KIL* and *AFF* are then divided by the provincial population to obtain per capita measure, *KILP* and *AFFP*. Data for *DAM* are divided by provincial output values to obtain the ratio of damage to output, *DAMO*.

Since disaster damages affect the following-year output in reverse order, for example, disasters occurred in January of a particular year will probably have the least effect on the following-year output whereas those occurred in December will most likely have the most short-run effect, we weigh the lagged values of disaster measures (*DMSL*) using the onset month as the weight:

$$DMSL = DM*OM\ /12 \qquad (2)$$

Provincial data for other variables, including output values, domestic trade, school-enrollments as a proxy for education, freight traffic as a proxy for infrastructure, and numbers of medical staffs as a proxy for health care, are available from the Vietnam's Statistical Yearbooks (VSY) by the General Statistics Office of Vietnam (GSOV) from 1995 to 2006. To construct the variable output (OUT) we sum up the output values for primary sector and the output values for the secondary sector (called "industry" sector in VSY), which includes mining and quarrying, manufacturing, electricity, water, and gas supply. These output values are in 1994 constant Vietnamese Dong. Data on investment and actual foreign investment are only available for economic sectors as shown in Vu (2008). Since they are not available for individual provinces, they are accounted for by our time-fixed effects, and we do not use these in our estimations.

The domestic trade values are in current Vietnamese Dong. We convert them to the 1994 constant price using the consumer price index provided by the General Statistics Office. For school enrollments, we sum up primary, secondary, vocational, and technical schools and college enrollments and divide them by population to obtain a proxy for education. We also

divide the number of medical staff by population to obtain proxies for available health care. Data on domestic trade are divided by the output values and are expressed a percentage of output. Data on freight traffic is also divided by population to obtain a proxy for infrastructure. Information about the variables and their sources is summarized in appendix A. The tables in Appendix B provide more detailed information about the disaster variables and their temporal distribution.

3.2 Methodology

We estimate the equation

$$Y_{i,t} = \alpha_i^1 + \alpha_t^2 + \beta Y_{i,t-1} + \gamma DMS_{i,t} + \chi DMS_{i,t-1} + \phi X_{i,t-1} + \varepsilon_{i,t} \quad (3)$$

where *Y* is alternatively annual output or the annual output growth rate, *i* is a provincial index, and *t* the time index. α_i^1 and α_t^2 are the region and time fixed-effects, $DMS_{i,}$ is our measure for disaster magnitude, estimated separately for each type of damage (either *KILP*, *AFFP*, or *DAMO*), and $X_{i,t-1}$ are the lagged control variables as described in the previous section.

We employ the Blundell-Bond System GMM procedure as described in Blundell and Bond (1998) and Bond (2002) to control for the presence of lagged dependent variable in the estimated panel. The Blundell-Bond procedure is a refined application of the Arellano and Bond (1991) and the Arellano and Bover (1995) procedures. Arellano and Bond (1991) developed the difference-GMM estimator for dynamic panels. The method takes into account

that lagged dependent variables are predetermined but not exogenous: although they are independent of current disturbances, they might be influenced by past ones. Differencing the lagged dependent variables or taking deviations from the mean will eliminate the fixed effects. Nonetheless, the difference GMM produces biased coefficient estimates and unreliable tests when an endogenous variable is close to a random walk. In this case, past values provide little information about future changes, so the untransformed lags are weak instruments for transformed variables.

To solve this problem, Blundell and Bond (1998) develop a modified procedure introduced in Arellano and Bover (1995). In this approach, they add the difference of the instrumental variable (IVs) to make them exogenous to the fixed effects. In order to build this while retaining the original Arellano-Bonds for the transformed equation, they design a *system* GMM estimator while left-multiplying the original data by a transformation matrix, $Z_{+}^{*} = \begin{bmatrix} Z^{*} \\ I \end{bmatrix}$, where *Z** is the differenced matrix. Hence for individual i, the new data set is

$$X_{i+}^{*} = \begin{bmatrix} X_{i}^{*} \\ X_{i} \end{bmatrix}, \quad Y_{i+}^{*} = \begin{bmatrix} Y_{i}^{*} \\ Y_{i} \end{bmatrix}. \tag{4}$$

When an endogenous variable is close to a random walk, past changes are more predictive of current levels than past levels are of current changes, so the new instruments add extra controls to the original ones for models with lagged dependent variables. Hence, the Blundell-Bond (1998) approach effectively controls for autocorrelation and heteroskedasticity, provides consistent coefficient estimates, and performs more reliable Arellano-Bond tests for

autocorrelations and Sargent test for over-identifying restrictions than the original Arellano-Bond (1991).

We employ the two-step estimation procedure for small sample. For the number of lags to include, we use the Akaike (1973) Information Criterion (AIC) and Schwarz (1978) Bayesian Information Criterion (BIC); for both, only the first lagged value of each variable is significant. We also carry out the modified Hausman endogeneity test to pinpoint the endogenous variables that need instrumental variables in the procedure for each regression.[8]

The system-GMM methodology we use is intended to overcome the problems posed by the inclusion of a lagged dependent variable in a panel set-up with some endogeneity. Yet, in order to derive causal inferences on the effect of the disaster variables on our macroeconomic measures of interest (mainly GDP growth), we generally require further assumptions.

We see no a priori reason to argue that these disaster measures will face any reverse causality from the output growth variable (i.e., growth will Granger cause future disasters); we thus assume (weak) exogeneity of the disaster measures. This assumption is also adopted by the four other papers that use a disaster measure as an independent variable, albeit in very different specifications (Noy, 2009; Raddatz, 2007; Ramcharan, 2007; and Skidmore and Toya, 2002).

4. Estimation Results

[8] Results available from the authors upon request.

Table 2 shows regression results for the model with dependent variable as annual output. The independent variables include lagged output (the dynamic panel structure) and current and lagged values of damage-measure variables (all with suffix *L*). Since we use lagged and contemporaneous disaster variables, a special interpretation is needed. The next column after each specification lists the sum of the two disaster coefficient and provides the p-value of this sum. Our estimates for the total effect of a disaster, however, can be interpreted as a lower bound, since in calculating the total impact of a disaster we ignore the dynamic panel component (the lagged dependent variable on the RHS). Nevertheless, the coefficients for these lagged dependent variables are fairly small, so our results do not misstate the actual disaster cost.

The results of the original coefficient estimates for *KILP*, *AFFP*, and *DAMO*, are reported in Columns (2.1a), (2.2a), and (2.3a) respectively, whereas the sums of the two coefficients for each variable *KILP*, *AFFP*, and *DAMO* are report in all the corresponding (b) columns, respectively. From this table, the impacts of the number of people killed (*KILP)* and the number of people affected (*AFFP*) on annual output are negative whereas the impact of the amount of direct damages (*DAMO*) on annual output is not significantly significant.

Next, we estimate the model with dependent variable as annual output growth, we first regress annual output growth on each of the variable for disaster damage: *KILP, AFFP, DAMO,* education, trade, and infrastructure. Table 3 reports the results. It shows that the impact of the number of people killed and the number of people affected on annual output growth are not statistically significant. Nevertheless, the impact of the amount of direct damage is positive and significant. These imply that the negative economic effects of natural disasters in

Vietnam, if there are any, are short lived. This might further imply the resilient characteristics of a developing economy. [9]

Since many growth models add initial output value as an independent variable, we also repeat the exercise for the model in Table 3 with initial output values as an additional control variable. Table 4 reports the results. The signs and significances of the disaster damages on output growths are the same as previously reported in table 3.

Because the impact of the amount of direct damage on output growth is positive and significant, we want to see if regions with higher frequencies of disasters enjoy more output growth than regions with low frequencies of disasters. We use the Red River Delta region, which has the lowest frequency of disasters, as the base group. Although floods occur frequently there, only the ones with significant damages are reported by the OFDA/CRED International Disaster Database. Hence, this region still has the lowest frequency among all regions in Vietnam. We generate seven slope dummies for the other seven regions and regress output growth on the amount of direct damage with all control variables added, including the initial output values. Table 5 reports results of the benchmark variables.[10] The base group takes on the coefficient of the direct damage (*DAMO*), which shows the effect of *DAMO* on the output growth of the Red River Delta region.

[9] This results regarding the impact of different disaster measures, and especially the potentially positive impact, is in line with the cross-country comparative finding, reported in Noy (2009), that countries that are able that mobilize resources for disaster reconstruction more quickly generally enjoy less adverse outcomes following disasters. A centralized economy, with an authoritarian government, large saving rates, and little openness in the capital account, is clearly able to generate more resources for reconstruction.

[10] For results for the other control variables, please contact the authors.

The differences in coefficients of other groups relative to the base group are reported in Column 5.1. A positive sign implies a region enjoys higher output growth than the base region and vice versa. Coefficients of the other groups are calculated by sum up coefficient of each group to the coefficient of the base group. Tests are performed to see if they are significantly greater or smaller than zero. Column 5.2 reports these calculated coefficient and p-values for their significances. Column 5.3 then reports sum of the lagged value and the current value for all regions and their respective p-values.

The results show that most of the regions with higher frequencies of disasters do not enjoy higher output growth than the base region; though given the positive and statistically significant coefficient for the base region, that does not mean that the other regions do not exhibit the same creative destruction dynamics Nevertheless, the effect of *DAMO* on output growth in the two least developed regions, the Northwest and the Central Highlands, is not statistically different from zero. Only the Southeast, which ranks fourth in high frequency and which has a higher level of development than all the other regions, has a coefficient that is significantly greater than that of the base region. This finding provides tentative support both to the creative destruction hypothesis that speculates that regions that have more access to reconstruction funds will grow faster following a disaster (see Noy, 2009, for more on the determinants of access to reconstruction funds). This finding also appears to support the observation, by Cuaresma at al. (2008), that only regions with high levels of development can enjoy capital upgrading after the occurrence of a natural disaster.

5. Caveats and Conclusions

Using provincial data for primary and secondary industries in Vietnam, this paper estimated the impact of disasters on the macro-economy. Our results show that more lethal disasters, in terms of lives lost and lives affected, result in lower output growth but that more costly disasters (in terms of destroyed capital) actually appear to boost the economy in the short-run. This result is consistent with the creative destruction hypothesis that we outlined earlier. We find further support for this hypothesis by examining the differing macroeconomic impacts of disasters in different geographical regions within the country. These differences appear to be determined by the degree of access to reconstruction funds both from the private sector and from the central government, where richer and less remote regions exhibit faster growth following a disaster.

Like any empirical research, better data has the potential of shedding more light on the results we find and on the channels of transmission we speculate about. In particular, the lack of provincial data on investment and foreign direct investment may be hindering a precise identification of the channels of transmission. It is possible that regions that have more access to foreign knowledge (as proxied by FDI) are more resilient, for example, or that the channel of transmission we identify is actually not related to increased levels of investment but rather to the necessity to re-build inventories. Whenever data on these variables become available, for Vietnam, or for other economies in similar circumstances, new estimations will be called for.

Appendix Table A – Data Sources

Variable	Definition	Source
DAMO	Damage from disaster as % of output	EM-DAT* and VSY**
AFFP	Number of people affected by disaster (% of population)	EM-DAT and VSY
KILP	Number of people killed by disaster (% of population)	EM-DAT and VSY
OUT	Output values (1994 Dong)	VSY
OUTG	Growth of output	VSY
INOUT	Initial output values	VSY
INFRA	freight traffic as infrastructure (million km per person)	VSY
TRADE	domestic trade (% of output)	VSY
EDUC	School enrollment rate (% of population)	VSY
HEALTH	Health care (number of medical staff per person)	VSY

* EM-DAT: The OFDA/CRED International Disaster Database at www.em-dat.net - Université Catholique Louvain.
** VSY: Vietnam's Statistical Yearbooks, General Statistics Office of Vietnam, 1995-2006.

Appendix Table B.1 – Average Numbers of Disasters per Month: January through June

Region	January	February	March	April	May	Jun
Red River Delta	0.0185	0.0370	0.0555	0.0741	0.1111	0.0925
Northeast Area	0.0741	0.0555	0.0925	0.0185	0.1296	0.1111
Northwest Area	0.0925	0.0741	0.0741	0.0555	0.0370	0.1296
North Central Coast	0.0555	0.1111	0.0925	0.0741	0.1296	0.1481
South Central Coast	0.0741	0.0555	0.1481	0.1667	0.2462	0.2037
Central Highlands	0.0370	0.0741	0.1296	0.1111	0.1481	0.1296
Southeast Area	0.0370	0.0185	0.0741	0.925	0.1296	0.1481
Mekong River Delta	0.0185	0.0370	0.0370	0.0555	0.0741	0.1111

Appendix Table B.1 – Average Numbers of Disasters per Month: July through December

Region	July	August	September	October	November	December
Red River Delta	0.1296	0.1481	0.2222	0.2037	0.1825	0.1667
Northeast Area	0.1481	0.1667	0.1825	0.2407	0.2037	0.2222
Northwest Area	0.2222	0.1481	0.2407	0.2592	0.2407	0.1825
North Central Coast	0.1667	0.2037	0.2777	0.2592	0.2407	0.2592
South Central Coast	0.2777	0.3148	0.2462	0.3333	0.2592	0.2462
Central Highlands	0.2407	0.2037	0.2592	0.3142	0.2407	0.2037
Southeast Area	0.1481	0.1825	0.1667	0.2592	0.2407	0.1825
Mekong River Delta	0.1481	0.2037	0.2592	0.3142	0.2592	0. 2937

Source: EM-DAT: The OFDA/CRED International Disaster Database at www.em-dat.net - Université Catholique de Louvain – Belgium.

Table 1 – Descriptive Statistics for Disaster Variables

Region	Obs.[a]	Killed[b]	Affected[c]	Damage[d]	Annual obs.[e]
Red River Delta	63	0.11	44.25	3.08	1.34
Northeast	76	0.15	49.21	4.33	1.43
Northwest	56	0.13	45.32	5.13	1.62
North-Central Coast	125	0.29	127.54	11.85	2.21
South-Central Coast	108	0.28	114.73	10.04	3.65
Central Highlands	78	0.16	116.43	9.52	3.15
Southeast	78	0.21	98.34	8.68	2.06
Mekong Delta	68	0.19	84.86	7.54	1.87
TOTAL	732	0.20	75.52	5.58	

For detailed description of variables and sources, see data section.
[a] number of disaster observations per region.
[b] Number of people killed (mean per 10,000).
[c] Number of people affected (mean per 1,000).
[d] Damage (mean % of output).
[e] Number of events per year (mean).

Table 2. Effects of Disasters on Output
Dependent Variable: Annual Output

	(1)		(2)		(3)	
Variable	(5.1a)	(5.1b)	(5.2a)	(5.2b)	(5.3a)	(5.3b)
OUTL	.115***		.103***		.111***	
	(.000)		(.004)		(.003)	
KILP	-131.2***	-235.6***				
	(.007)	(.006)				
KILPL	-104.4					
	(.376)					
AFFP			-15.24**	-17.69**		
			(.015)	(.021)		
AFFPL			-2.45			
			(.107)			
DAMO					.022	.025
					(.527)	(.447)
DAMOL					.003	
					(.354)	
INFRA	138.5**		12.98		14.2**	
	(.032)		(.476)		(.021)	
TRADE	14.25**		16.35**		9.54**	
	(.008)		(.045)		(.047)	
EDUC	2.191**		1.692***		3.164**	
	(.041)		(.009)		(.036)	
HEALTH	2.812		3.132**		2.21**	
	(.142)		(.028)		(.041)	
Observations	546		546		546	
p-value for F-test	.000		.000		.000	
p- value for AR(1)	.243		.329		.392	
p-value for AR(2)	.671		.429		.725	
Chi^2-Sargan	.591		.690		.459	
Chi^2-Hansen	.286		.697		.742	

Notes: The associated p-values for coefficients are in parentheses. ***, **, * indicate the significant level at 1, 5, and 10 percent respectively, with p-values in parentheses. The p-value for AR(1) and p-value for AR(2) are from Arellano-Bond test for AR(1) and AR(2) in first differences and second differences, respectively.

Table 3. Effects of Disasters on Output Growth. Model Without Initial Output
Dependent Variable: Annual Output Growth

	(1)		(2)		(3)	
Variable	(6.1a)	(6.1b)	(6.2a)	(6.2b)	(6.3a)	(6.3b)
OUTGL	.0533**		.0665***		.0867***	
	(.045)		(.008)		(.004)	
KILP	-.725	-.112				
	(.328)	(.463)				
KILPL	.613					
	(.657)					
AFFP			.0031	-.0055		
			(.687)	(.563)		
AFFPL			-.0086			
			(.463)			
DAMO					.0005**	.0003**
					(.031)	(.042)
DAMOL					-.0002	
					(.435)	
INFRA	.2243**		.6648**		.207**	
	(.029)		(.0254)		(.028)	
TRADE	.4692**		.5281**		.1546**	
	(.031)		(.041)		(.047)	
EDUC	.3342***		.3825**		.4973**	
	(.009)		(.045)		(.035)	
HEALTH	.6504**		.5625		.4102	
	(.034)		(.165)		(.854)	
Observations	486		486		486	
p-value for F-test	.000		.000		.000	
p- value for AR(1)	.143		.228		.213	
p-value for AR(2)	.798		.675		.786	
Chi^2-Sagan test	.465		.576		.755	
Chi^2-Hansen test	.453		.435		.645	

Notes: The associated p-values for coefficients are in parentheses. ***, **, * indicate the significant level at 1, 5, and 10 percent respectively, with p-values in parentheses. The p-value for AR(1) and p-value for AR(2) are from Arellano-Bond test for AR(1) and AR(2) in first differences and second differences, respectively.

Table 4. Effects of Disasters on Output Growth. Model with Initial Output
Dependent Variable: Annual Output Growth

	(1)		(2)		(3)	
Variable	(7.1a)	(7.1b)	(7.2a)	(7.2b)	(7.3a)	(7.3b)
OUTGL	.0561**		.0362**		.065***	
	(.040)		(.024)		(.009)	
KILP	-.467	-.102				
	(.647)	(.463)				
KILPL	.365					
	(.153)					
AFFP			-.0034	.044		
			(.681)	(.456)		
AFFPL			.0078			
			(.435)			
DAMO					.0006**	.0004**
					(.024)	(.029)
DAMOL					-.0002**	
					(.035)	
INFRA	.5942**		.4245**		.3647**	
	(.032)		(.029)		(.035)	
TRADE	.6546**		.4235		.4571**	
	(.045)		(.325)		(.043)	
EDUC	.4521**		.4346**		.6924***	
	(.034)		(.025)		(.015)	
HEALTH	.1228**		.1359**		.1028**	
	(.028)		(.032)		(.044)	
INOUT	-.0576**		-.1486***		-.0243**	
	(.046)		(.007)		(.037)	
Observations	482		482		482	
p-value for F-test	.000		.000		.000	
p- value for AR(1)	.114		.142		.124	
p-value for AR(2)	.539		.768		.647	
Chi^2-Sargan test	.758		.698		.912	
Chi^2-Hasen test	.576		.576		.605	

Notes: The same as in Table 5.

Table 5. Regional Effects of Disasters on Output Growth.
Dependent Variable: Annual Output Growth

Variable	8.1	8.2	8.3
DAMO	.124**		.181**
	(.042)		(.032)
DAMOL	.057**		
	(.028)		
Northeast Area	-.009	.115**	.187**
	(.486)	(.041)	(.045)
Northeast Area Lag	.015	.072**	
	(.362)	(.009)	
Northwest Area	-.113**	.011	.045
	(.039)	(.647)	(.574)
Northwest Area Lag	-.023	.034	
	(.364)	(.436)	
North Central. Coast	.009	.133**	1.73**
	(.435)	(.029)	(.046)
North Central. Coast Lag	-.017	.040*	
	(.475)	(.092)	
South Central Coast	-.022	.102**	.179**
	(.329)	(.034)	(.041)
South Central Coast Lag	.020	.077	
	(.589)	(.243)	
Central Highlands	-.113**	.011	.016
	(.032)	(.529)	(.387)
Central Highlands	-.052**	.005	
	(.031)	(.564)	
Southeast Area	.044**	.168**	.257**
	(.041)	(.031)	(.026)
Southeast Area Lag	.032**	.089***	
	(.036)	(.007)	
Mekong River Delta	.015	.129**	.170**
	(.634)	(.025)	(.033)
Mekong River Delta Lag	-.016	.041**	
	(.473)	(.041)	
Observations	482	482	482
p-value for F-test	.000	.000	.000
p- value for AR(1)	.132	.154	.124
p-value for AR(2)	.565	.376	.694
Chi^2-Sargan test	.747	.657	.579
Chi^2-Hasen test	.645	.584	.486

Notes: The same as in Table 5.

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