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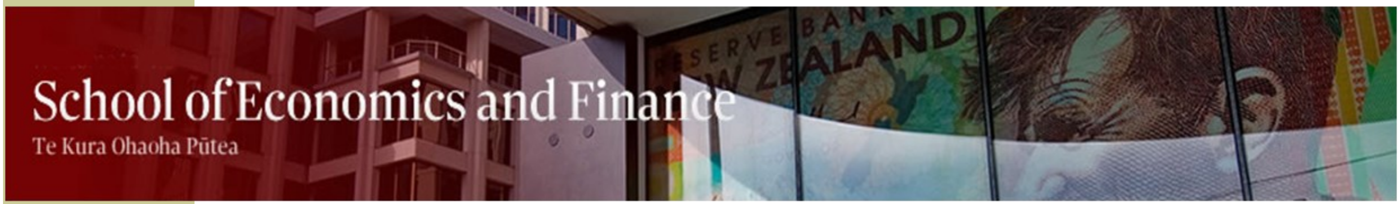

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Tam Bang Vu and Ilan Noy

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Natural Disasters and Firms in Vietnam

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Abstract

This paper investigates the consequences of natural disasters on firms in Vietnam over the period 2000 to 2008. We examine the impacts of natural disasters on firm investment and retail sales. We find evidence of adverse effects of disasters on retail sales accompanied by an increase in firm investment of very similar magnitude. There are important differences across geographical units, with the positive impact on investment unique to large cities and provinces with large urban concentrations. We find that more remote rural areas, especially in the North, experience declines in sales without the mitigating boost to investment in disasters' aftermath. We also show that the decline in sales is not apparently associated with declines in household incomes.

Key words: Vietnam, natural disasters, investment, retail sales, recovery.
JEL classification: O40, Q54

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Introduction

During the past decade, natural disasters have attracted increasing attention worldwide, particularly in East Asia in the wake of several recent catastrophic events: the Indian Ocean tsunami in 2004, cyclone Nargis and the Sichuan earthquake both in 2008, and the Tohoku earthquake-tsunami-nuclear disaster of 2011.[1] Increased public and policy awareness of this issue is also driven by the growing awareness of global climate change.[2]

The literature that assesses the economic consequences attributed to natural disasters either focuses on macroeconomic indicators such as GDP or trade flows, or on households income, wealth, and spending. We know of no papers that focus on the operations of firms in disasters' aftermath, and very few that distinguish impacts across different sub-national regions. Understanding the impact of disaster shocks on firms is clearly an essential piece of the puzzle if we were to more fully understand the general impact of external shocks on economic activity. It is plausible that the impact may be different across geographical regions, and we find that this difference is associated with access to central government resources in the disaster's aftermath. Here, we focus on Vietnam, which we view as an interesting case study for several reasons.

First, and foremost, Vietnam is highly exposed. Given its latitude and extensive coastline, the country, and especially the central coast, is very vulnerable to tropical storms[3] and the associated wind damage, as well as wave surges and storm-fed inland floods they generate; the latter typically associated with Vietnam's two large river systems (the Red River in the North and the very large

[1] On the region's vulnerability to disasters, see Noy (2013a).

[2] While the evidence regarding the impact of climate change on trends in disaster occurrence is at best inconclusive, there is little doubt that changing atmospheric conditions and weather patterns will lead to changes in the spatial distribution of disasters, and in particular the emergence of disasters (floods, storms, droughts and extreme temperatures) in areas that were previously considered less vulnerable. For more details, see IPCC (2012).

[3] Cyclones (severe tropical storms) are typically called typhoons in the Western Pacific.

Mekong delta in the South/as shown in figure 1). The country is also vulnerable to floods associated with the rainy season in the mountainous areas—especially the Central Highlands and the North-West. Table 1 provides some information about the spatial distribution of natural disasters across Vietnam's eight regions.

Second, typhoons and floods are largely predictable events, both their long-term likelihoods, and the very near-term predictions of their arrival. As such, they pose a different set of issues regarding disaster prevention and mitigation, and associated damages, than events that are still largely unpredictable, such as earthquakes, tsunamis and volcanic eruptions (see table 2 for information about the distribution of event-types across the Vietnamese regions). The specific adverse impacts we find are thus doubly surprising because of this predictability.[4]

Third, Vietnam—a lower-middle income country in its early stages of rapid development but with very high rates of literacy and public investment[5]—offers an interesting juxtaposition of relative poverty but a high ability to mobilize resources (human and otherwise) for both prevention/mitigation and for post-disaster recovery.

Fourth, the data available for Vietnam—both the provincial data on disasters from *Desinventar* and the province-level data on firms—enables us to employ a different strategy for identifying impacts than has previously been done – more on that in the literature review below.

Here, we examine the short-run impacts of natural disasters on firm investment and

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[4] Advances in scientific knowledge are bound to improve the predictability of geo-physical events (and that is clearly happening for volcanic eruptions), so that the findings regarding climatic events may hint at future limits of damage mitigation for post-geophysical-disasters as well.

[5] The World Bank estimates a US$ 1,595 gross domestic product per capita in 2012 (in current USD). See http://data.worldbank.org/country/vietnam (accessed 2/9/2013).

retail sales, using a firm-specific dataset for 64 provinces and cities in Vietnam for the period 2000-2008.[6] Reliable and detailed data on disaster impacts from a newly constructed and under-utilized dataset are provided by the *Desinventar* database for the years 2000-2011. Figure 1 shows the evolution of disaster measures during this time period for the four damage measures included in the *Desinventar* database. These include the numbers of people killed, the number of people injured, the numbers of houses destroyed, and numbers of houses damaged.

Table 3 reports the three largest disasters for each category of the disaster impact measures. Crucially for our estimation strategy, we observe that unlike in many other cases, Vietnam has not experienced unusually large catastrophic events. The absence of very large events allows us to treat these events as somewhat similar, and estimate their average impact (though we do control for the size of each event). A catastrophic event, one that leads to massive destruction of lives, infrastructure, and livelihoods, would have overwhelmed the more 'normal' disaster impacts, and would have necessitated a different research strategy.[7] In our empirical estimations, we examine the short-run aggregate effects of natural disasters on firms and compare these microeconomic costs of disasters across the different provinces and geographical region.

Using a combination of System-GMM and 3SLS estimations (details below), we find that the direction of the aggregate effects for different types of disaster damage measures is

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[6] 59 provinces and 5 cities: Hanoi and Hiphong in the North, Danang in Central Vietnam, and Ho Chi Minh and Cantho in the South.

[7] This issue is discussed in Noy (2013b). An alternative research strategy for catastrophic events is described and developed further in Cavallo et al. (2013) and implemented by, for example, duPont and Noy (2013).

similar—disasters decrease retail sales, and increase firm investment. However, the average adverse impacts results we identified, on closer inspection, reveal that disasters have a different impact on firms in different geographical regions and sub-regions (cities and provinces). Most noticeable is that the positive impacts of disasters on the levels of investment are unique for large cities and provinces with large urban population. Less urban sub-regions experience little or even negative impacts on investment.

Section two of this paper reviews the existing literature and places our contribution in context. Section three discusses the data and estimation methodology. Section four analyzes the results, while the last concludes with some caveats, open policy questions and suggestions for future research.

1. The Literature

2.1 The disaster impact literature

The economic literature on natural disasters distinguishes between the direct destructive effects of these events and their indirect impact.[8] Beyond their natural attributes—such as the strength of the tropical storm—disasters' direct and indirect impacts are a function of the social, economic, cultural and institutional structure of the communities they impact; and their choices regarding prevention, mitigation and preparedness. Thus, attempts to understand the determinants of these direct impacts are important for the social sciences and are ongoing. Here, we focus on natural disasters in a single country, so many of these literature's conclusions are less relevant given

[8] Cavallo and Noy (2011) and Kellenberg and Mobarak (2011) provide context and background to these distinctions while Lazzaroni and van Bergeijk (2013) provide a meta-analysis of this research.

the homogenous nature of many of these attributes across a country's regions. We focus on the indirect impacts at the regional/provincial level.

The secondary impact of natural disasters in the post-disaster period is potentially more severe than the direct ones.[9] These impacts may result from direct damage to the inputs used in production, to infrastructure, or from the fact that reconstruction and rehabilitation pull resources away from other sectors. In contrast to these adverse consequences, reconstruction spending, if funding for it is available, can provide a boost to the domestic economy. Both government funding and privately funded reconstruction from insurance payments, accumulated saving, or from other sources, is bound to provide some temporary stimulus to the local economy, but can also potentially lead to upgraded infrastructure and better long-term outcomes.

The earliest empirical/statistical literature on the short-run effects of natural disasters, in particular the seminal work of Albala-Bertrand (1993), generally identifies evidence for positive impact on GDP but adverse effects on both the government and the trade and current accounts. The basic mechanism that plausibly explains this observation is that the destruction reduces the stock of goods available, while it also leads to increased spending on reconstruction (a flow). These arguments fit well within the conventional wisdom that countries/regions recover rapidly from exogenous adverse shocks to the capital stock since the most important asset in most economies is not physical but human capital.[10]

[9] See, for example, Antilla-Hughes and Hsiang (2013) for evidence that the indirect impacts are more severe (in the case of the Philippines).

[10] Versions of this observation that economies recover quickly with a temporary boost to economic activity can already be found in Adam Smith (1776) who examines floods in Switzerland.

Research in the past decade, however, is less sanguine about the impact of these events, especially in the short-term. This recent research mostly focuses on developing countries, and especially small island states that appear to be especially vulnerable to disasters (e.g., Heger et al., 2008). Noy (2009) finds that the short-run adverse impact of disasters is significant in low- and middle-income economies; but that these countries with a higher literacy rate, better institutions, higher per capita income, higher degree of openness to trade, and higher levels of government spending are in a better position to deal with the initial negative shock and prevent further spillovers into the macro-economy. Given these findings, investigating Vietnam is potentially interesting, as although it is still a lower-middle income country, it has very high literacy rates, functioning institutions, and especially a central government that can mobilize significant amount of resources and re-distribute them regionally or temporally.

The literature on the regional impacts of natural disasters, even in developed economies, is less extensive, and in this case most papers identify some adverse local impact on income (GDP) which may potentially persist for a long time (e.g., Coffman and Noy, 2012; Fisker, 2012; Hornbeck, 2012; and Vigdor, 2008). Hornbeck (2012), for instance, examines US counties several decades after the Dust Bowl of the 1930s and finds that affected counties suffered long-term economic decline that was correlated closely with the extent of the damages to topsoil during the Dust Bowl years.

1.2 The impacts on households

All the papers mentioned above have examined aggregate macro-economic indicators. Here, we use microeconomic data on firms rather than macroeconomic equivalents; it is therefore useful to examine the papers that have previously used household surveys in 'disaster research.' As we already pointed out, we are not aware of research that specifically estimates the impact of disasters on firms.

Analyzing the impacts of natural disasters at the municipal level in Mexico, Rodriguez-Oreggia et al. (2013) argue that natural disasters reduce human development and increase measures of poverty. Baez and Santos (2008), on El Salvador, report that the combined effects of two earthquakes in 2001 led to reduction of household income by one-third from its pre-shocks average. In a companion paper, Baez and Santos (2007), investigate the impact hurricane Mitch in Nicaragua, and find a range of distinct adverse medium-term effects; in particular, increased probability of undernourishment and a significant increase in labor force participation among children.

The importance of credit in facilitating recovery is well documented. Credit constraints may also lead households to sub-optimally sell productive assets in order to smooth consumption after a major but temporary income shock (Mueller and Osgood, 2009). Anttila-Hughes and Hsiang (2012) also find similar dynamics for Philippine households. In their case, while both low- and high-income households experience similar level of damages in the initial impact following an exceptionally strong typhoon, it is only the lower-income households whose consumption does not recover in the years that follow. Chantarat et al. (2013) examine the catastrophic Greater Bangkok floods of 2011, and in contrast find most the adverse impact was borne by middle- and high-income households.

Impacts on local economies in the aftermath of a natural disaster can also occur through migration and/or remittances; though the direction of impact can be ambiguous (e.g., Halliday, 2012). Vietnam, with its Communist Party firmly in control, is probably less vulnerable to the kind of shifts in migration decisions that can manifest very quickly after a disaster event. Another worrying scenario is the possibility of creating poverty traps in post-disaster situations. Carter et al. (2007) examined two opposite results in the aftermath of two different case studies. In Honduras, in the medium-term, relatively wealthy households were able to partially rebuild their lost assets unlike the lowest wealth quintiles; whereas in Ethiopia, the poorest households (in wealth) try to hold on to their few assets despite consumption possibilities shrinking during drought periods of severe losses in agricultural production/income.[11]

1.3 Impacts in Vietnam

Even though Vietnam is very vulnerable to natural disasters, the literature on Vietnam's economic exposure to these events is fairly limited. Noy and Vu (2010) quantify the impact of natural disasters on provinces in Vietnam using macroeconomic data on gross provincial product and aggregate investment. They conclude that, in Vietnam, lethal disasters result in lower output growth but those disasters that destroy more property and capital actually appear to boost the economy in the short-run. They also identify different impact magnitudes on different geographical regions and speculate that these differences are related to transfers from the Vietnamese central government. Noy and Vu (2010) is closest to this work, but their use of macroeconomic data, rather than this paper's use of firm level data, coupled with our use here of a new (and plausibly more accurate) source for disaster data (from *Desinventar*),[12]

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[11] A more thorough survey of this literature, with a focus on the interactions between disasters and poverty, can be found in Karim and Noy (2013).

[12] For evidence that the *Desinventar* data obtained from government sources is a more comprehensive record of disaster losses than the more popular *EMDAT*, see UNISDR (2013).

and a different empirical methodology all differentiates this paper and enables us to provide new sights into Vietnam's post-disasters' recoveries.

A limited number of other papers examined other data from Vietnam and its vulnerability to disasters. Bich et al. (2011) examine the impact of a devastating flood in Hanoi, in November 2008, and find significant morbidity impact from various diseases (notable are dengue fever and psychological problems). Navrud et al. (2012) use survey data in order to quantify the valuation people place on the morbidity, mortality and welfare losses they may experience from flood events. Using questions on their willingness to contribute labor for flood mitigation measures, they conclude that the direct economic damages usually cited significantly underestimate the total perceived costs of these flood events.

Thomas et al. (2010) use repeated cross-sections of a household living survey, coupling it with detailed data on natural hazards (rather than their initial direct impact), to examine the impact of disasters on household welfare. They find evidence that river-based floods and hurricanes caused very significant welfare losses, particularly in large urban areas. Like Noy and Vu (2010), Thomas et al, 2010) also find large disparities in the way different regions are impacted by these natural hazards. Their evidence suggests that areas that are further away from the two biggest cities, especially the central coast area, are especially vulnerable to these adverse indirect impacts of the natural hazards. We show more direct evidence that this disparity is associated with the differing abilities to invest in post-impact reconstruction.

3. Methodology and Data

3.1 Methodology

To account for the possible feedback effects among the variables, we write a system of equations to be estimated simultaneously:

$$INV_{i,t} = \alpha_1 DMS_{i,t} + \alpha_2 DMS_{i,t-1} + \beta X_{i,t} + t_i + u_t + \varphi_{i,t} \quad (1.1)$$

$$ENDO_{i,t} = \kappa DMS_{i,t} + \kappa_2 DMS + \phi Z_{i,t} + v_i + w_t + \omega_{i,t} \quad (1.2)$$

Where *DMS* are damages caused by disasters*, INV* is investment per worker from firms, *X* is a vector of the control variables, *ENDO* is a vector of endogenous variables that cause feedback effects or have measurement problems, and *Z* is a vector of variables that affect this endogenous variable. The last three terms are the regional specific disturbance, time specific disturbance, and the idiosyncratic disturbance (*i* and *t*). We include all explanatory variables provided by the General Statistics Office of Vietnam (GSOV) that might affect the dependent variables and employ the Variance Inflation Factor tests (VIF), as in Kennedy (2008), to investigate the possibility of multicolinearity. After removing highly correlated variables and performing Granger Causality tests, we have System (2), which comprises three equations:

$$INV_{i,t} = \theta_1 DMS_{i,t} + \theta_2 DMS_{i,t-1} + \lambda_1 SALE_{i,t} + \lambda_2 RINT_{i,t} + + \lambda_3 Y_{i,t} + t_i + u_t + \varphi_{i,t} \quad (2.1)$$

$$SALE_{i,t} = \kappa DMS_{i,t} + \kappa_2 DMS_{i,t-1} + \mu_2 INV_{i,t} + \mu_3 INFR_{i,t} + v_i + w_t + \omega_{i,t} \quad (2.2)$$

$$Y_{i,t} = \alpha_1 DMS_{i,t} + \alpha_2 DMS_{i,t-1} + \beta_1 CAP_{i,t} + \beta_2 INIT_{i,t} + \beta_3 INFR_{i,t} + q_i + s_t + \varepsilon_{i,t} \quad (2.3)$$

where *INV* is the flow of investment per person, *SALE* denotes value of retail sales per person, *RINT* real interest rate, *INFRA* infrastructure, *Y* firm income (value added) per worker, *CAP* is the stock of capital per worker, and *INIT* initial income per worker. Note that to compare investment per urban versus rural population later in this paper, we then use per capita investment measure instead of per worker investment.

From this system, one can see that investment per person does not Granger cause disaster damages (*DMS*). However, a modified Hausman test as discussed in Kennedy (2008) reveal that each of the aforementioned *DMS* still has an endogeneity problem, probably due to measurement errors, or because the extent of damage is not exogenous. So, instrument variables (IVs) for *DMS* are needed in addition to IVs for *Y*, *INV*, and *SALE.* Since there are feed-back effects in System (2), we estimate this system with three stages least squares (3SLS) procedures. In cross sectional estimations, finding an IV is very difficult. In the panel-data estimations, lagged variables excluded from each equation can be employed as IVs. A Hausman test for the model specification reveals that a fixed effect model is more appropriate than a random effect one, so System (2) is estimated using fixed effect 3SLS (FE3SLS) procedure. Based on these preliminary results, the reduced form for System (2) is written in System (3) as follows:

$$DMS_{i,t} = \pi_{11}DMS_{i,t-1} + \pi_{12}CAP_{i,t_{i,t}} + \pi_{13}INFR_{i,t} + \pi_{14}INIT_{i,t} + e_{i,t,1} \tag{3.1}$$

$$INV_{i,t} = \pi_{31}INV_{i,t-1} + \pi_{32}DMS_{i,t-1} + \pi_{33}INFR_{i,t} + e_{i,t,3} \tag{3.2}$$

$$SALE_{i,t} = \pi_{41}SALE_{i,t-1} + \pi_{42}DMS_{i,t-1} + \pi_{43}RINT_{i,t} + e_{i,t4} \tag{3.3}$$

$$Y_{i,t} = \pi_{21}Y_{i,t-1} + \pi_{22}DMS_{i,t-1} + \pi_{23}INFR_{i,t} + e_{i,t,2} \tag{3.4}$$

We estimate the reduced forms in System (3) using the Blundell-Bond System-GMM procedure as described in Bond (2002) and obtain the predicted values of *DMS, Y, INV* and *SALE* to use as IVs in the FE3SLS estimations for System (2).

3.2 Data

The data on natural disasters and their impacts for 64 provinces and cities (henceforth called sub-regions), in Vietnam are available from the Disaster Inventory System website (desinventar.net) provided by United Nations Office for Disaster Risk Reduction for the period 1992 to 2011. Data on disasters are also available from the Emergency Events Database website (EMDAT) provided by the Center for Research Epidemiology of Disasters (CRED) for the period from 1953 to 2012. However, the EMDAT data are collected for each incident and do not separate the impacts of a single disaster across sub-regions whereas data from *Desinventar* are collected separately for each of the 64 sub-regions. Hence, we use the *Desinventar* data for our estimations.[13]

We use four reported measures of the magnitude of the disaster to form the damage measures (*DMS*): (1) The number of people killed (*KIL*); (2) the number of people injured (*INJ*); (3) the number of houses destroyed (*HDE*); and (4) the number of houses damaged (*HDA*). The data for Vietnam also includes the number of people affected, but there are only a handful of data points and hence we eliminate this variable from our estimation. Data are divided by the provincial population, to obtain per capita measure for *KILP, INJP, HDEP* and *HDAP*.

Annual data on the flow of investment, firm income, number of worker, and stock of capital for all enterprises are from the General Statistics Office of Vietnam (GSOV) publication *Principle Indicators of Enterprises by Regions and Provinces*. It is available for the years 2000-2008, so this is our estimation period. They are in current values and are converted to real values using the producer price index. Data for other variables are from GSOV's *Statistical Yearbook*. The retail sale values are converted to the 1994 constant price using the consumer price index.

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[13] UNISDR (2013) also argues that the *Desinventar* data is more comprehensive.

Table 4 provides some information about the size distribution of firms across regions. It is apparent that many of the firms in the data are located in the two regions that include the biggest cities; 24% of firms are located in the Red River Delta (Hanoi and Haiphong) and 35% in the Southeast (Ho Chi Minh and Cantho). These regions, and the other regions of South Vietnam, also include a larger share of smaller firms; while the least developed regions of the North have the largest share of medium and large firms.[14] We also use initial income per worker based on the first observation in 2000 for each sub-region to account for output convergence.

Data for other variables are from *Vietnam's Statistical Yearbooks* provided by the GSOV. For school enrollments, we calculate the sum of primary, secondary, vocational, technical schools and college enrollments to obtain a proxy for education. Data on the number of medical staff are used as a proxy for available health care. Data on freight traffic are used as a proxy for infrastructure. Data on the real interest rate for Vietnam are from the International Monetary Fund's *International Financial Statistics*. We generate interaction terms of the interest rate with the sub-regional indicators to account for the regional differences in financial markets, and credit availability. There are a few missing observations; to obtain a balanced panel, we use binary dummies for these observations. Descriptive statistics for all the data, by region, are available in appendix table 1.

4. Estimation Results

[14] Regrettably, Vietnam does not publish the retail and investment data we use separately for firms of different sizes.

4.1 Benchmark Estimations

Table 5 shows regression results for the effects of disasters on Vietnamese firms. Since lagged values are involved, we calculate the sums of current and lagged values and perform tests on the significance of the sums. For example, summing up current and lagged values of "Killed" in Panel (5c) gives us – 0.3825. This implies that for one percent increase in the ratio of people killed to population, there is a decrease of income per worker by 38,250 VN Dong, and the p-value of 0.421 indicates that the estimated coefficient is not significantly different from zero. The same method of calculation applies for the other variables.

Panel (5a) shows the effects of disaster damages on firm investment: they are positive and significant except for the number of people injured measure, where the coefficient is negative. The sums for each damage measure bears the same sign with the current effect and are also statistically significant. For example, summing up current and lagged values of "Killed" implies that for a one percent increase in the ratio of people killed to population, there is an increase of per capita investment by 2.653 million VN Dong, and the p-value of 0.035 indicates that it is statistically significant at 5% level. Similar interpretation is applied for the other variables.

Panel (5b) reveals that the effects of all four damages measures on retail sales of the businesses are negative and significant, confirming the results from the existing literature on the macroeconomic impact of disasters on trade in general. For example, a one percent increase in the ratio of people killed to population, there is a decrease of retail sale values per person by 2.854 million VN Dong, and the p-value of 0.038 indicates that it is statistically significant at 3.8% level. From panel (5c), one can see that all four disaster damages do not affect firms' income per-worker and the sum of their individual values is also always statistically (and economically) insignificant.

As discussed in Greene (2003) and Wooldridge (2003), an adjusted R^2 in IV estimation does not have a meaningful interpretation; instead we report the root mean square error (RMSE) in each of our regressions. A small RMSE implies a good fit in addition to a p-value smaller than 0.05 for the model. Estimations using the original dataset with only even-number years or the alternative EMDAT dataset for disaster damages yield similar results—available upon request—and provide further evidence on the robustness of the estimated model.

4.2 Regional and Sub-Regional Impacts

The main focus of our investigation is the regional differences in post-disaster impacts; there are several reasons to believe, based on the theoretical and empirical findings discussed in section 2, that the impact of disasters may be different across Vietnam's sub-regions. We want to specifically examine disasters' effects on different regions and sub-regions in Vietnam on firms and households.

We use the Red River Delta region, which has the lowest frequency of disasters, as the reference group and generate seven slope dummies for the other regions. Regarding sub-regions, we use Bac Ninh Province, which also has the lowest frequency of disasters, as the base dummy and generate 63 slope dummies for the other sub-regions. Table 6 and 7 report the effects of the four damage measures on investment in the eight regions and 64 sub-regions.

From these tables, one can see that most of the regions and sub-regions with higher frequencies of disasters do not enjoy higher investment than the base region. These results support the macroeconomics findings in Noy and Vu (2010) concerning output and output growths in Vietnam, as accumulated investment is a crucial factor in recovery. Only the Southeast, which ranks fifth in disaster frequency and which has a higher level of development, has a coefficient that is significantly greater than that of the base region. This finding also supports the observation that only regions with high levels of development can enjoy capital upgrading after the occurrence of natural disasters (Cuaresma at al., 2008).

One interesting observation is that the positive effects of KILP on investment are concentrated in large cities and provinces, leaving these effects on other sub-regions either negative or insignificant. For example, the positive effects in the Red River Delta are distributed to its three large cities: Hanoi, Haiphong, and Namdinh. In the Southeast region, these positive effects are on Baria-Vungtau Province and Ho Chi Minh City. Additionally, the effect is negative for the whole Northwest region and for each of its provinces. While the effects of INJP are negative for most regions, they are positive for the Red River Delta and the Southeast regions with the positive effects again go to the large cities and provinces, and in the case of the Red River Delta to Hanoi alone.

Table 8 reports the effects of the damage measures on retail sales in the eight regions. They reveal the same negative signs across the board but with huge disparity in the magnitudes among the eight regions. South Vietnam suffers much less severe effects of disasters on retail sales than North Vietnam. This seems to confirm the observation that the market economy in South Vietnam from 1955 to 1975, during which North Vietnam had a command economy, provided the South with commercial and management skills that allow its firms to more nimbly react and recover from external shocks. Even the least developed regions in the South such as Central Highlands and Mekong River Delta appear to experience much less severe consequences to their retail sales than the Northern regions. The South Central Coast region suffers the smallest effect on retail sales although it has a high frequency of disasters.

We find no coherent pattern that can easily be explained with the data we have access to when we examine the sub-regional impacts (table 9). The differences across provinces for this measure appear to be smaller, and the patterns of differences that that we do observe, do not seem to have an intuitive explanation, and are probably related to the sectoral composition of the retail sector in each sub-region.[15]

4.3 Investment and Urbanization

We have found that the positive impacts of disasters on investment appear to be mostly relevant in large cities and provinces with large urban populations; here we examine this observation in more detail. Since measures for urban versus rural disaster and investment are not available, but data for urban and rural population by sub-region are available, we examine the robustness of the large-city phenomenon by writing the coefficient of each disaster measure as a function of urban and rural population:

$$q_1 = h_1 + h_2 URB_{i,t} + h_3 RUR_{i,t} + f_{i,t} \quad (4)$$

where $URB_{i,t}$ are $RUR_{i,t}$ are values for urban and rural population, respectively, and $f_{i,t}$ is the error term. Substitute Equation (4) into Equation (2.2),

[15] For retail sales in sub-regions, the damage effects are spread more evenly across cities and provinces except for the following cases: (1) the negative effects of *KILP* are unique to Binhduong province alone in the Southeast region and to only two provinces in the Mekong River Delta region, Angiang and Haugiang; (2) the negative effects of *INJP* are concentrated in only two provinces in the Northeast region, Thainguyen and Tuyenquang, and to only Hatinh province in the North Central Coast region; (3) the negative effects of HDEP are focused on Ninhthuan province in the South Central Coast region and two provinces in Mekong River Delta region, Angiang and Haugiang.

$$
\begin{aligned}
INV_{i,t} &= (\eta_1 + \eta_2 URB_{,it} + \eta_3 RUR_{,it} + f_{it}) DMS_{i,t} + ... + t_i + u_t + \varphi_{i,t} \\
&= \eta_1 DMS_{i,t} + \eta_2 URB_{i,t} * DMS_{i,t} + \eta_3 RUR_{i,t} * DMS_{i,t} + ... + f_{it} DMS_{i,t} + t_i + u_t + \varphi_{i,t} \quad (5) \\
&= \eta_1 DMS_{i,t} + \eta_2 URB_{,it} * DMS_{i,t} + \eta_3 RUR_{i,t} * DMS_{i,t} + ... + g_{i,t},
\end{aligned}
$$

where $g_{i,t}$ is the composite disturbance with a built-in heteroskedasticity that can be corrected using a fixed effect feasible generalized least squares procedure (FEFGLS) before performing the System-GMM and 3SLS procedures (an appendix discusses the FEFGLS procedure in details). We can then obtain an interpretation of each coefficient from $INV_{i,t} = \eta_2 URB_{i,t} * DMS_{i,t}$. The coefficient h_2 measures the change in investment per urban population due to one percent change in the ratio of each disaster measure such as KILP, INJP, etc.

Table 10 reports the different effects of each measure of disaster damage on urban and rural investment and retail sales. The interpretation for the urban area, which is the reference group, remains the same as in Table 5. For example, the entry "Urban$_t$" reports the effect of people killed on investment in urban area in period t, which is 3.125, and the entry "Urban$_{t-1}$" reports this effect in period (t-1), which is 0.643, so the overall effect is 3.768 (= 3.125 +0 .643). This implies that for one percent increase in the ratio of people killed to population, there is an increase of investment per urban population by 3.768 million VN Dong, and a p-value of 0.003 indicates that this estimate is statistically significant at 0.3% level.

In order to understand the impact of disasters on investment in rural areas, we need to account for the fact that the default in these specifications is the urban impact. The entry "Rural Comparative$_t$" reports the difference between rural and urban investment in period t, which is – 4.344, implying being in the rural area decreases per capita investment by 4.344 million VN Dong relative to an urban area. The entry "Rural Comaprative$_{t-1}$" reports this difference in period (t-1), in this case equals – 0.213. The "Overall Effect on Rural" reports the magnitude of the investment per capita in rural area, which is – 1.211 (= 3.768 – 4.344 – 0.213). This implies that for a one percent increase in the ratio of people killed to population, there is a decrease of investment for a rural area by 1.211 million VN Dong, and a p-value of 0.034 indicates that it is statistically significant at 3.4% level. Similar interpretations are applied for the other damage measures. In short, we confirm that, post-disasters, large cities and more urban provinces in Vietnam do experience higher firm investment than more rural sub-regions.

4.4. Magnitudes of impacts

Finally, we quantify the aggregate and regional effects of disasters by converting the impact into US dollars and share in per capita income so that the implications of the results are explained clearly in comparative terms. Table 11-12 report the aggregate effects of an increase of 1 percentage point in one of the disaster variables on the two largest cities (Ho Chi Minh and Hanoi) and two largest rural provinces (Thanh Hoa and Nghe An). More broadly, based on the USD-VND average exchange rate for the estimation period, we calculate that for a one percentage point increase in the ratio of people killed to population, aggregate per capita investment in Vietnam increases by $US 126.54 or 28.51% of firm income per worker.

In table 11, we observe that while both large cities are estimated to see an increase in investment post-disaster, the increase of firm investment in Hanoi (the Vietnamese national capital) is twice as large as the one we estimate for Ho Chi Minh. This observation further suggests that the crucial issue is the links between the firms and the Central Government (and the Communist Party). For the rural provinces we highlight here, there is no increase in investment and by some measures there is a statistically observable decrease.

For retail sales (table 12), the patterns we observe earlier are again highlighted. Ho Chi Minh suffers only a very mild decline in retail sales (and not always statistically distinguishable from no impact), while Hanoi experiences a much larger and statistically significant decline. For the two largest rural provinces we focus on in this table, the impact is negative and statistically significant, but the variation in its magnitude is quite large.

5 Conclusions

Understanding the impact of disaster shocks on firms is a necessary piece of the puzzle if we are to more fully understand the general impact of disasters on economic activity. Vietnam is highly exposed to predictable natural hazards, and as such provides us with an interesting and informative case to focus on in this quest to understand and estimate the future impact of natural hazards on economic activity in developing countries. We use sub-national data (for 64 provinces and urban centers) on disasters and on firms' retail sales and investments to find, using a system of estimated equations, the impacts of natural hazards and differences across provinces. We find that the direction of the aggregate effects for different types of disaster damage measures is similar—disasters decrease retail sales, and increase firm investment. The average adverse impacts results we identified, on closer inspection, reveal that disasters have a different impact on firms in different geographical regions. The positive impacts of disasters on the levels of investment are unique for large cities and provinces with large urban population. Less urban sub-regions experience little or even negative impacts on investment.

For large urban locations, the increase in investment appears to be financed from external sources (most likely from government assistance) so that we do not observe a long-term adverse affect from this short-term boost to spending on investment for reconstruction. Neither do we observe any adverse impact beyond the short-term on retail sales in any of the specifications we estimate. The crucial role of (government-financed) investment in the reconstruction period appears to provide the safety net so that household income is not also adversely affected.

Our investigation does not yet provide a full picture of what happens to firms in a disaster's aftermath. With more and better time-series data on firms balance sheets, we would have been able to observe more directly the way the boost to investment is financed, the impact of the increased spending and decreased revenue on debt levels and possible other consequences like changing access to financial markets. In addition, we would have also liked to be able to quantify the impact of this investment surge on future productivity and profitability in the regions in which it occurred. This data is not available for Vietnam, but potentially similar data from other countries may shed more light on these questions in future research.

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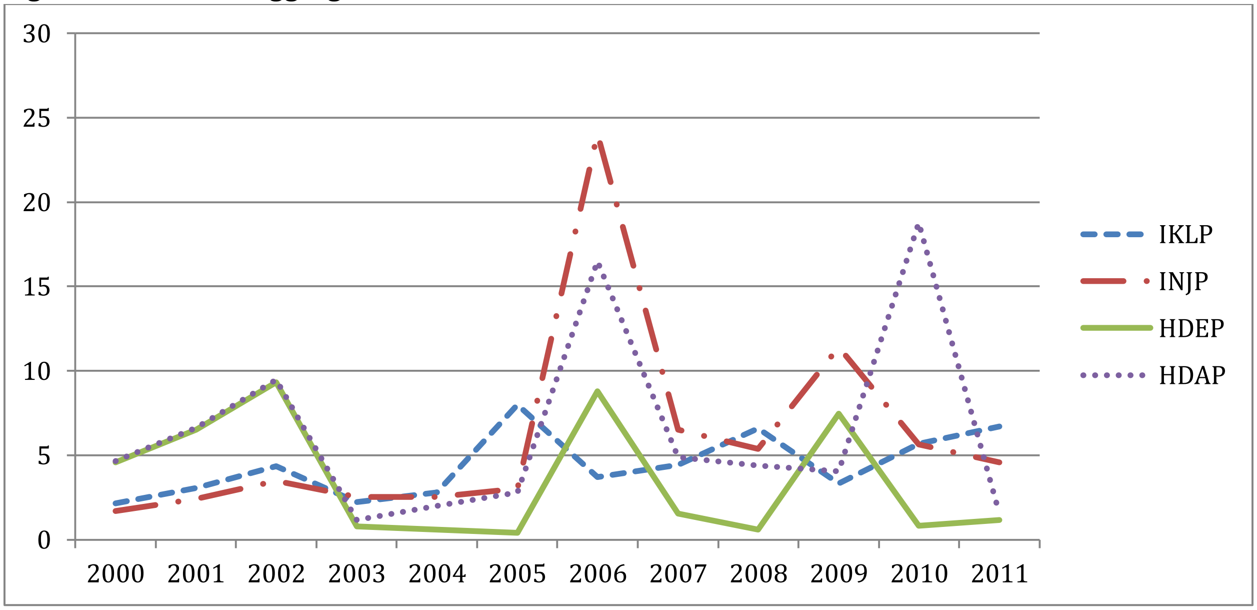
Figure 1. The Four Aggregate Disaster Measures for 2000-2011



Note: KILP = the number of people killed per capita
INJP = the number of people injured per capita
HDEP = the number of house destoyed per capita
HDEP = the number of house damaged per capita

Source: desinventar.net

Table 1. Frequency of Disasters in Vietnam's Eight Regions for 2000-2011

Region	Number	Mean	Standard Deviation
Red River Delta	24	2.0	2.23
Northeast	71	5.92	6.51
Northwest	32	2.67	2.64
North Central Coast	109	9.08	7.75
South Central Coast	86	7.17	5.96
Central Highlands	29	2.42	1.97
Southeast	39	3.25	2.34
Mekong River Delta	62	5.62	6.16
Total	452	37.67	30.07

Source: desinventar.net

Table 2. Types of Disasters in Vietnam's Eight Regions for 2000-2011

Region	Storm	Flood	Epidemic	Drought	Land Slide	Other	Total
Red River Delta	6	7	5	1	2	2	27
Northeast	31	23	6	2	2	3	67
Northwest	12	10	2	1	3	5	33
North Central Coast	44	42	5	6	5	4	106
South Central Coast	32	29	4	5	6	5	81
Central Highlands	8	9	3	2	3	2	27
Southeast	9	11	10	1	4	6	41
Mekong River Delta	10	24	9	5	7	5	63
Total	152	158	48	23	32	32	445

Note: other consists of hailstones, extreme weathers, and miscellaneous events.

Source: emdat.be

Table 3. Three Largest Natural Disasters in Each Category: 2000-2011

Region	Year	KIL (#)	INJ (#)	HDES (#)	HDAM (#)
By population killed					
Quang Ngai	2008	325	301	24,143	45,248
Dong Thap	2006	150	316	21,324	35,454
Yen Bai	2009	145	235	19,243	51,233
By population injured					
Baria-Vung Tau	2006	132	763	25,165	48,537
Ben Tre	2006	118	492	29,048	92,600
Quang Ngai	2009	127	348	23,187	49,275
By the number of houses destroyed					
Can Tho	2002	143	275	66,000	52,011
Quang Tri	2009	96	165	41,800	42,058
Ben Tre	2006	118	492	29,048	92,600
By the number of houses damaged					
Quang Binh	2010	124	276	27,956	162,002
Ben Tre	2006	118	492	29,048	92,600
Ha Tinh	2002	85	324	24,374	53,210

Source: desinventar.net

Table 4. Firm Distribution in Vietnam (by size): 2000-2008

		Percent of firms in region that are:			
Region:	% of total firms	Very small (1-9 worker)	Small (10-99)	Medium (100-199)	Large (>200)
Red River Delta	24	55	38	3	4
Northeast	4	37	50	6	7
Northwest	2	30	59	4	7
North-Cent. Coast	7	50	40	4	6
South Cent. Coast	11	49	42	4	5
Central Highlands	3	62	31	3	4
Southeast	35	64	30	3	4
Mekong Delta	14	67	29	1	2

Source: GSOV's *Principle Indicators of Enterprises by Regions and Provinces*

Table 5. Aggregate Effects of Disasters on Firms and Businesses in Vietnam

Variable	Killed	Injured	Houses Destroyed	Houses Damaged
Panel (5a) Dependent Variable: Per Capita Investment from Firms				
$Damage_t$	3.786***	-1.723**	.3901***	.7312**
	(.001)	(.028)	(.007)	(.017)
$Damage_{t-1}$	-1.133	-.582	.0332	.0231
	(.239)	(.174)	(.231)	(.532)
SUM of Damages	2.653**	-2.305**	.4232**	.7844**
	(.035)	(.026)	(.045)	(.032)
SALE	.6331**	.3227**	.5002**	.7412***
	(.046)	(.024)	(.032)	(.008)
RINT	-.4021***	-.4121**	-.4375**	-.3832***
	(.004)	(.027)	(.043)	(.009)
Y	.0331**	.0293*	.0343*	.0292*
	(.042)	(.069)	(.077)	(.089)
Panel (5b) Dependent Variable: Per Capita Retail Sale Values from Businesses				
$Damage_t$	-2.855**	-2.075**	-.4056***	-.3515***
	(.043)	(.041)	(.006)	(.002)
$Damage_{t-1}$	.001	-.7471**	.2451**	-.0102
	(.651)	(.015)	(.023)	(.525)
SUM of Damages	-2.854**	-2.734**	-.1605**	-.3617**
	(.038)	(.045)	(.028)	(.036)
INFR	1.061**	.9298***	.6681***	.7154***
	(.029)	(.003)	(.008)	(.005)
INV	.1323***	.0587**	.1167**	.2243***
	(.002)	(.032)	(.029)	(.009)
Panel (5c) Dependent Variable: Per Worker Income from Firms				
$Damage_t$	.0023	-.0003	.0004	.0002
	(.159)	(.692)	(.991)	(.315)
$Damage_{t-1}$	-.3848	.0416	.0123	-.0253
	(.424)	(.339)	(.465)	(.603)
SUM of Damages	-.3825	.0413	.0127	-.0251
	(.421)	(.651)	(.508)	(.729)
CAP	.3398***	.3431***	.3519***	.3395***
	(.007)	(.006)	(.002)	(.004)
INFR	.0007*	.0008*	.0006*	.0009*
	(.079)	(.085)	(.064)	(.092)
INIT	-.0005**	-.0006**	-.0008**	-.0007**
	(.043)	(.031)	(.048)	(.038)
Observations: 488; average RMSE for the system: .6376; average p-value for the model: .000				

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively, with p-values in parentheses.

Table 6. Effects of Disasters on Firm Investment in Northern Regions and Sub-Regions

Dependent Variable: Per Capita Investment from Firms				
Region	Killed	Injured	Houses Destroyed	Houses Damaged
Read Riv. Delta	3.255*** (.008)	3.86** (.028)	.324** (.035)	.574** (.039)
Bac Ninh	4.423** (.039)	-.434 (.749)	.162* (.096)	.512** (.027)
Ha Nam	.668 (.534)	-.192 (.576)	.202 (.743)	.641** (.042)
Ha Noi	5.687*** (.004)	2.524** (.042)	.841** (.035)	.635** (.036)
Ha Tay	.265 (.329)	-.662* (.087)	.079 (.461)	.294** (.047)
Hai Duong	.203 (.181)	-.732** (.021)	.062 (.357)	.327** (.039)
Hai Phong	2.425* (.076)	-.203 (.485)	.028 (.626)	.091 (.176)
Hung Yen	.437 (.328)	-.324 (.469)	.024 (.312)	.448** (.026)
Nam Dinh	3.36** (.047)	-.948** (.031)	.069 (.296)	.138* (.067)
Ninh Binh	.314 (.682)	-.232 (.349)	.038 (.354)	.414** (.042)
Thai Binh	.197 (.571)	-.873** (.048)	.059 (.415)	.302** (.043)
Vinh Phuc	.231 (.382)	-3.26** (.015)	.045 (.436)	.251** (.032)
Northeast	3.038** (.032)	-1.723** (.041)	.442*** (.006)	.596*** (.008)
Bac Can	-.152 (.371)	.502 (.437)	.067 (.431)	.037 (.149)
Bac Giang	4.18** (.034)	.437 (.416)	.581*** (005)	.655** (.005)
Cao Bang	.506 (.323)	-1.752** (.041)	.083 (.182)	.645** (.024)
Ha Giang	.206 (.513)	-.684* (.086)	.048 (.562)	.569** (.037)
Lang Son	.185 (.458)	.412 (.332)	.033 (.721)	.602** (.041)
Lao Cai	.257 (.542)	.253 (.635)	.082 (.155)	.524*** (.008)
Phu Tho	2.42** (.029)	-.591 (.175)	.039 (.564)	.343** (.035)
Quang Ninh	.084 (.548)	-.713 (.549)	.024 (.533)	.291** (.049)
Thai Nguyen	.0746 (.329)	-.195 (.231)	.018 (.639)	.734*** (.034)
Tuyen Quang	.238 (.422)	.424 (.228)	.061 (.192)	.675** (.027)
Yen Bai	.264 (.345)	-.275 (.542)	.009 (.187)	.592** (.028)
Northwest	-1.525** (.042)	-1.428** (.044)	.289** (041)	.643** (.025)
Dien Bien	-1.538** (.033)	-1.273** (.031)	.394** (.032)	.523** (.014)
Hoa Binh	-.401* (.074)	-.512* (.092)	.138 (.843)	.621** (.034)
Lai Chau	-.527* (.059)	-.452* (.064)	.037 (.701)	.554** (.041)
Son La	-.531* (.072)	-.632* (.091)	.053 (.561)	.643** (.027)
N. Central Coast	.842** (.028)	-4.523** (.048)	-.184** (.022)	-.314** (.037)
Ha Tinh	.614* (.076)	-4.535* (.069)	-.123 (.435)	.325** (.026)
Nghe An	-.676 (.433)	-5.893** (.042)	-.238** (.043)	-.573** (.035)
Quang Binh	.332 (.741)	.462 (.533)	.056 (.563)	-.351** (.024)
Quang Tri	.734** (.024)	.274 (.472)	-.039 (.458)	.367** (.036)
Thanh Hoa	.468 (.503)	-6.183** (.046)	-.236 ** (.043)	-.574** (.019)
T.Thien-Hue	-.324 (.372)	-4.632* (.087)	-.045 (.642)	.365** (.032)
Observations: 488; average RMSE: .4734; average p-value for the model: .001				

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively with p-values are in parentheses.

Table 7. Effects of Disasters on Firm Investment in Southern Regions and Sub-Regions

Dependent Variable: Per Capita Investment from Firms

Region	Killed	Injured	Houses Destroyed	Houses Damaged
S. Central Coast	2.254** (.021)	-3.91** (.042)	-.249** (.042)	.634** (.031)
Binh Dinh	3.674* (.086)	-4.35** (.035)	-.238** (.023)	.856** (.027)
Binh Thuan	.463 (.414)	.712 (.564)	-.005 (.768)	.396** (.029)
Da Nang	4.574** (.032)	-.634 (.162)	-.048 (.423)	.657** (.043)
Khanh Hoa	-2.193* (.057)	-4.436* (.065)	-.039 (.675)	.625** (.042)
Ninh Thuan	.708 (.412)	-.735 (.328)	.302** (.031)	.753** (.038)
Phu Yen	.431 (.465)	-.549 (.421)	-.003 (.684)	.527** (.026)
Quang Nam	-.213 (.224)	-.321 (.387)	-.041 (.275)	.454** (.031)
Quang Ngai	-.535 (.337)	-.438 (.516)	-.142* (.078)	.286** (.019)
Central Highland	2.304** (.034)	-3.141** (.042)	.312** (.038)	.519** (.034)
Dac Lac	-.413 (.320)	-3.524* (.098)	.071 (.442)	.321** (.026)
Dac Nong	-.647 (.465)	-3.406* (.067)	.063 (.355)	.234** (.035)
Gia Lai	.534 (.351)	-.875 (.482)	.007 (.804)	.392** (.038)
Kon Tum	3.741** (.038)	-4.251** (.032)	.338*** (.007)	.724** (.013)
Lam Dong	2.093** (.016)	-.658 (.361)	.275* (.065)	.607** (.039)
Southeast	3.431** (.026)	3.527** (.033)	.479** (.022)	.856*** (.004)
Ba Ria-V. Tau	5.232*** (.008)	3.696* (.069)	.805*** (.004)	1.02*** (.008)
Binh Duong	3.423** (.037)	-.469 (.284)	.093** (.032)	.296* (.067)
Binh Phuoc	.624 (.528)	-.553 (.665)	.089* (.075)	.972** (.035)
Dong Nai	-2.018* (.068)	.354 (.432)	.052 (.571)	1.04** (.038)
Ho Chi Minh	5.244** (.034)	4.481** (024)	.003 (.312)	1.02** (.029)
Tay Ninh	.352 (.605)	-.946 (.138)	.029 (.369)	.871** (.016)
Mekong Riv. Del.	3.057** (.029)	-4.447** (.024)	.322** (.031)	.668** (.032)
An Giang	4.96** (045)	-4.623** (.033)	.352** (.045)	.815*** (.003)
Bac Lieu	.364 (.412)	.745 (.629)	.082 (.602)	.354** (.028)
Ben Tre	.748 (.283)	.156 (.569)	.037 (.549)	.442** (.047)
Ca Mau	-.826* (.078)	.938 (.159)	.047 (.621)	.602** (.035)
Can Tho	1.426* (.087)	-.341 (.248)	.033 (.719)	.312** (.034)
Dong Thap	-1.431* (.069)	-3.289** (.027)	.019 (.256)	.082* (.082)
Hau Giang	.476 (.502)	-.186 (.655)	.005 (.746)	.582** (.045)
Kien Giang	3.929** (.046)	-4.213* (.086)	.084 (.462)	.741** (.032)
Long An	.729 (.361)	-3.582* (.069)	.068 (.348)	.092* (.085)
Soc Trang	.554 (.419)	-.854 (.626)	.045 (.603)	.411** (.025)
Tien GIang	.452 (.324)	-4.637* (.065)	.037 (.532)	.656** (.029)
Tra Vinh	.634 (.501)	-.713 (.425)	.019 (.432)	.587** (.034)
Vinh long	.838 (.435)	-.903 (.543)	.039 (.636)	.645** (.036)

Observations: 488; average RMSE: .5476; average p-value for the model: .002

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively, with p-values in parentheses.

Table 8. Effects of Disasters on Retail Sales in Northern Regions and Sub-Regions

Dependent Variable: Per Capita Retail Sale Values from Businesses				
Region	Killed	Injured	Houses Destroyed	Houses Damaged
Read Riv. Delta	-4.815*** (.003)	-4.232*** (.006)	-.873*** (.003)	-.512** (.032)
Bac Ninh	-1.513** (.036)	-1.132** (.032)	-.238** (.021)	-.276* (.097)
Ha Nam	-.935 (.404)	-.194 (.785)	-.008 (.791)	-.293** (.031)
Ha Noi	-5.596*** (.001)	-6.035*** (.002)	-.876*** (.004)	-.518** (.033)
Ha Tay	-3.709* (.078)	-3.042* (.083)	.006 (.652)	-.411** (.034)
Hai Duong	-3.423* (.087)	-3.283* (.068)	-.029 (.562)	-.352** (.027)
Hai Phong	-3.274** (.032)	-3.447** (.34)	-.046 (.512)	-.304** (.045)
Hung Yen	-4.172** (.042)	-2.564* (.069)	-.027 (.471)	-.494** (.029)
Nam Dinh	-4.073** (.048)	-3.348** (.041)	-.043 (.567)	-.433** (.036)
Ninh Binh	-5.463** (.033)	-4.165** (.026)	-.029 (.382)	-.375** (.037)
Thai BInh	-5.672** (.018)	-4.093** (.031)	-.328* (.085)	-.458** (.049)
Vinh Phuc	-.873 (.531)	-.354 (.852)	.008 (.659)	-.282** (.036)
Northeast	-4.568** (.032)	-1.757** (.017)	-.892** (.024)	-.397** (.025)
Bac Can	-4.386** (.029)	.325 (.451)	.029 (.462)	-.383** (.029)
Bac Giang	-5.27*** (.009)	.218 (.342)	-.397* (.089)	-.289** (.023)
Cao Bang	-4.685** (.045)	.657 (.409)	-.486* (.098)	-.471** (.032)
Ha Giang	-5.145*** (.001)	.534 (.472)	-.843** (.034)	-.432** (.047)
Lang Son	-.879 (.532)	.485 (.389)	.007 (.685)	-.302* (.081)
Lao Cai	-5.021** (.041)	.216 (.545)	.099 (.358)	-.463** (.032)
Phu Tho	-4.631* (.065)	-.458 (.352)	-.007 (.786)	-.449** (.041)
Quang Ninh	-.993** (.037)	-.759 (.249)	.068 (.252)	-.347** (.024)
Thai Nguyen	-2.243** (0.044)	-.523 (.368)	-.009 (.768)	-.363** (.022)
Tuyen Quang	-5.856** (.019)	-1.364** (.026)	-.871** (.038)	-.458** (.028)
Yen Bai	-6.545** (.018)	-1.831** (.037)	-.079 (.525)	-.461** (.015)
Northwest	-4.065*** (.006)	-2.056** (.033)	-.767** (.026)	-.534** (.042)
Dien Bien	-.846** (.024)	-1.968** (.022)	-.684** (.035)	-.523** (.039)
Hoa Binh	-5.765*** (.004)	-2.147** (.034)	-.839** (.021)	-.498** (.020)
Lai Chau	-.158 (.267)	-.328 (.742)	-.126 (.521)	-.578** (.045)
Son La	-5.537*(.089)	-1.478* (.086)	-.069 (.496)	-.532** (.027)
N. Central Coast	-5.132** (.043)	-3.983** (.021)	-.845** (.036)	-.395** (.034)
Ha Tinh	-4.645** (.042)	-4.015** (.038)	-.781** (.023)	-.377** (.035)
Nghe An	-.978* (.089)	-.814** (.035)	-.512* (.075)	-.411** (.049)
Quang Binh	-5.143** (.034)	.945 (.249)	.044 (.549)	-.302* (.075)
Quang Tri	-.469 (.570)	-.242 (.451)	-.618* (.063)	-.311** (.042)
Thanh Hoa	-4.856** (.034)	-.951* (.068)	- .829** (.012)	-.427** (.030)
T.Thien-Hue	-4.452* (.083)	-.375 (.429)	.009 (.684)	-.398** (.039)
Observations: 488; average RMSE: .5476; average p-value for the model: .000				

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively, with p-values in parentheses.

Table 9. Effects of Disasters on Retail Sales in Southern Regions and Sub-Regions

Dependent Variable: Per Capita Retail Sale Values from Businesses				
Region	Killed	Injured	Houses Destroyed	Houses Damaged
S. Central Coast	-2.014** (.024)	-.753*** (.004)	-.081** (.033)	-.287** (.033)
Binh Dinh	-1.532* (.075)	.435 (.256)	.008 (.651)	-.399** (.027)
Binh Thuan	-1.638* (.085)	-1.045** (.029)	-.005 (.789)	-.079* (.068)
Da Nang	-1.153** (.027)	-.137 (.452)	.063* (.078)	-.304** (.022)
Khanh Hoa	-1.861* (.077)	-1.021** (.033)	.007 (.639)	-.258** (.033)
Ninh Thuan	-3.657* (.085)	.634 (.473)	-.082** (.031)	-.396** (.032)
Phu Yen	-2.366* (.068)	-.887** *(.002)	-.007 (.625)	-.371** (.027)
Quang Nam	-2.646** (.035)	.352 (.439)	-.051* (.074)	-.399** (.038)
Quang Ngai	-2.352* (.073)	.253 (.689)	.004 (.756)	-.308** (.034)
Central Highland	-2.143** (.042)	-1.121** (.048)	-.617** (.034)	-.342** (.031)
Dac Lac	-1.867* (.086)	-.365 (.642)	.038 (.546)	-.353** (.024)
Dac Nong	-.672 (.544)	-.213 (.768)	.056 (.583)	-.347** (.028)
Gia Lai	-2.546** (.022)	-1.215** (.031)	-.062 (.576)	-.395** (.019)
Kon Tum	-2.657** (.042)	-.382** (.038)	-.617** (.033)	-.401** (.042)
Lam Dong	-.562 (.538)	-.435* (.086)	-.003 (.685)	-.322** (.024)
Southeast	-1.349*** (.002)	-.864*** (.006)	-.319*** (.001)	-.348** (.033)
Ba Ria-V. Tau	-.576 (.249)	.436 (.357)	-.312** (.025)	-.387** (.026)
Binh Duong	-2.167** *(.003)	-.534* (.068)	-.026 (.342)	-.381** (.035)
Binh Phuoc	-.674 (.471)	.145 (.452)	.004 (.761)	-.398** (.023)
Dong Nai	.463 (.762)	-.645* (.067)	-.306** (.028)	-.422** (.034)
Ho Chi Minh	-.382 (.149)	-.673*** (.003)	.006 (.739)	-.093* (.081)
Tay Ninh	.248 (.537)	.324 (.473)	.008 (.547)	-.234** (.027)
Mekong Riv. Del.	-1.542** (.043)	-.847** (.026)	-.229*** (.006)	-.248** (.042)
An Giang	-2.312** (.045)	.715 (.169)	-.421*** (.008)	-.423** (.044)
Bac Lieu	.437 (.219)	-1.102** (.046)	-.002 (.918)	-.088* (.072)
Ben tre	-.525 (.421)	.313 (.387)	.028 (.196)	-.305** (.036)
Ca Mau	.292 (.271)	-1.497** *(.006)	-.025 (.148)	-.332** (.045)
Can Tho	.427 (.323)	-.216 (.286)	.084 (.118)	-.293** (.042)
Dong Thap	-.187 (.516)	.428 (.188)	.005 (.644)	-.086* (.079)
Hau Giang	-2.857** (.032)	-.582* (.085)	-.181** (.035)	-.483** (.026)
Kien Giang	-.731 (.172)	-.635* (.069)	.019 (.251)	-.495** (.037)
Long An	.514 (.277)	-.528 (.212)	.017 (.212)	-.362** (.029)
Soc Trang	-.691 (.168)	-.475 (.147)	.004 (.652)	-.395** (.027)
Tien GIang	.327 (.354)	-.576* (.075)	.007 (.544)	-.307** (.026)
Tra Vinh	-.732 (.421)	-.159 (.704)	.008 (516)	-.293** (.022)
Vinh long	-.892 (.516)	.256 (.293)	.017 (.466)	-.282** (.024)
Observations: 5488; average RMSE for the system: .5487; average p-value for the model: .000				

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively, with p-values in parentheses.

Table 10. Different Effects of Disasters on Urban versus Rural Investment and Retail Sales

Panel (10a) Dependent Variable: Per Capita Investment from Firms

Variable	Killed	Injured	Houses Destroyed	Houses Damaged
$Urban_t$	3.125***	2.387***	.6651**	.7354**
	(.001)	(.004)	(.041)	(.043)
$Urban_{t-1}$	.643**	-.542***	.0164	-.0003
	(.019)	(.002)	(.144)	(.422)
Overall Effect on Urban	3.768***	1.845**	.6815**	.7348**
	(.003)	(.017)	(.046)	(.036)
Rural $Comparative_t$	-4.344***	-4.576***	-.4541**	-.8534***
	(.005)	(.008)	(.029)	(.004)
Rural $Comparative_{t-1}$	- .213**	.623	.003	.0013**
	(.042)	(.359)	(.171)	(.018)
Overall Effect on Rural	-1.211**	-2.108**	.2304*	.1173**
	(.029)	(.032)	(.068)	(.027)
SALE	.8957***	.9072**	.816***	.8898***
	(.004)	(.026)	(.001)	(.007)
RINT	-.7856**	-.6348***	-.3712*	-.3569**
	(.019)	(.003)	(.059)	(.019)
Y	.0093**	.0058**	.0032*	.0067**
	(.037)	(.044)	(.064)	(.021)
Panel (10b) Dependent Variable: Per Capita Retail Sale Values from Businesses				
$Urban_t$	-1.458***	-1.579**	-.4668***	-.3979**
	(.001)	(.042)	(.008)	(.017)
$Urban_{t-1}$	.112**	.124**	.0004	.0132
	(.028)	(.048)	(.145)	(.281)
Overall Effect on Urban	-1.346***	-1.468**	-.4664**	-.3847**
	(.007)	(.045)	(.027)	(.029)
Rural $Comparative_t$	-.042	-.005	-.0012	-.0002
	(.659)	(.164)	(.179)	(.312)
Rural $Comparative_{t-1}$	.021	.002	.0001	.0003
	(.336)	(.193)	(.274)	(.458)
Overall Effect on Rural	-1.367**	-1.471**	-.4675**	-.3848**
	(.037)	(.035)	(.043)	(.036)
INFR	1.54***	1.51***	1.41***	1.43***
	(.005)	(.001)	(.005)	(.003)
INV	.086***	.069**	.0753***	.1135***
	(.006)	(.024)	(.001)	(.009)
Observations: 487; average RMSE for the system: .5476; average p-value for the model: .000				

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively, with p-values in parentheses.

Table 11. Effects of Disasters on Representative Sub-regions: Comparative Quantification

Dependent Variable: Per Capita Investment from Firms

Variable	VN Dong	$US	Per Worker Income Share
Largest City: Ho Chi Minh City			
SUM of Killed	5,244,000** (.034)	349.13	66.68%
SUM of Injured	4,481,000** (.024)	298.34	48.04%
SUM of Houses Destroyed	3,000 (.312)	.199	.004%
SUM of Houses Damaged	1,020,000** (.029)	67.91	12.91%%
Second Largest City: Hanoi			
SUM of Killed	5,687,000*** (.004)	379.01	83.65%
SUM of Injured	2,368,000** (.042)	157.66	34.80%
SUM of Houses Destroyed	851,000** (.039)	56.57	12.51%
SUM of Houses Damaged	634,000** (.034)	42.21	9.32%
Largest Rural Province: Thanh Hoa			
SUM of Killed	468,000 (.503)	33.02	7.81%
SUM of Injured	-5,036,000** (.046)	-344.43	81.72%
SUM of Houses Destroyed	-236,000** (.044)	-15.71	3.73%
SUM of Houses Damaged	-544,000** (.023)	- 36.22	8.60%
Second Largest Rural Province: Nghe An			
SUM of Killed	-676,000 (.433)	-48.12	12.02%
SUM of Injured	-5,124,000** (.042)	- 352.34	95.59%
SUM of Houses Destroyed	-238,000** (.049)	-15.85	3.94%
SUM of Houses Damaged	-513,000** (.017)	-34.15	84.96%

Observations: 487; average RMSE for the system: .5476; average p-value for the model: .000

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively, with p-values in parentheses

Table 12. Effects of Disasters on Representative Sub-regions: Comparative Quantification

Dependent Variable: Per Capita Retail Sales from Businesses

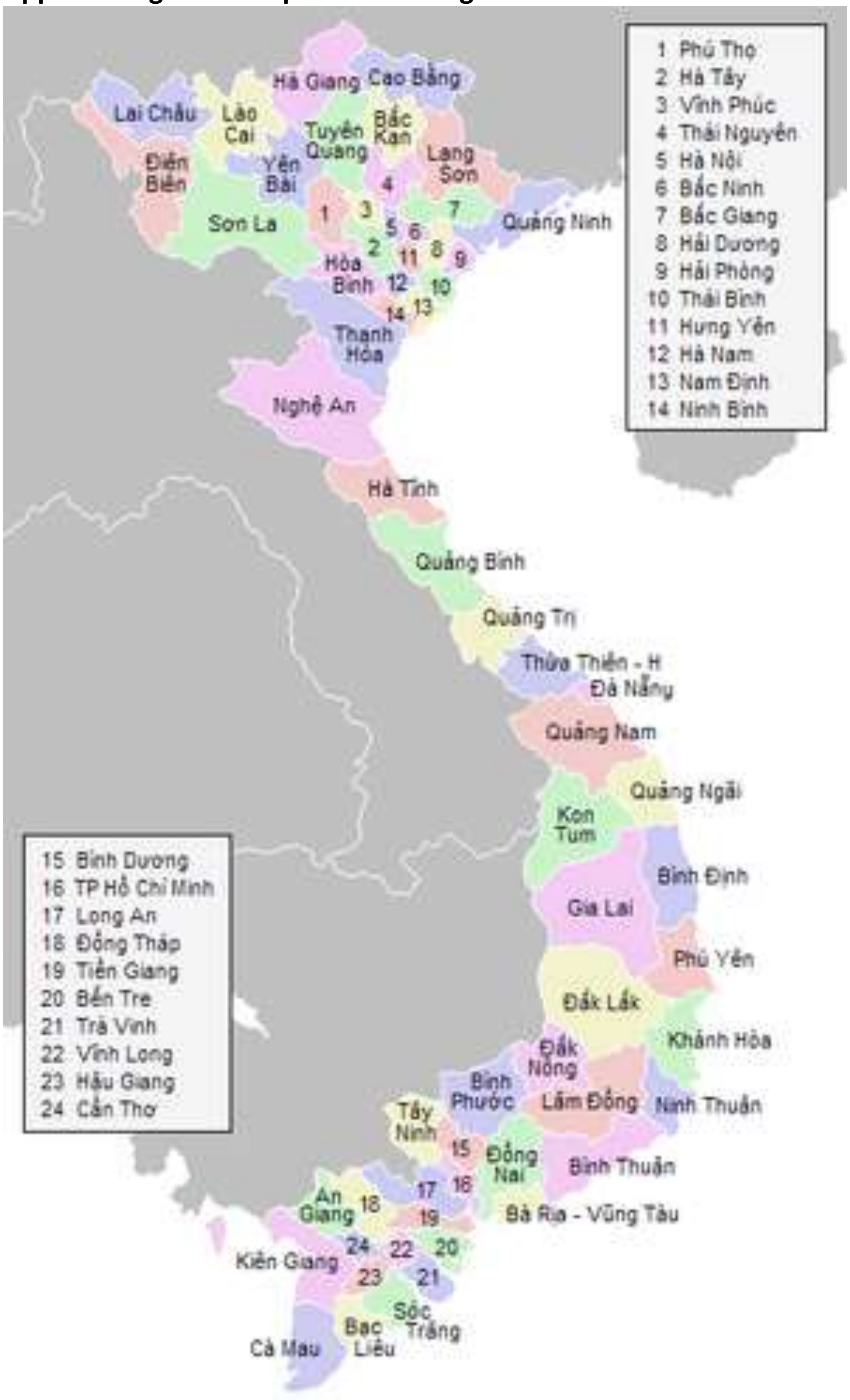
Variable	VN Dong	$US	Per Worker Income Share
Largest City: Ho Chi Minh City			
SUM of Killed	- 382,000 (.149)	- 25.43	3.86%
SUM of Injured	- 673,000*** (.003)	- 44.80	7.13%
SUM of Houses Destroyed	- 6,000 (.734)	- .399	.006%
SUM of Houses Damaged	- 93,000* (.081)	- 6.19	.9%
Second Largest City: Hanoi			
Ha Noi -.521** (.038)			
SUM of Killed	-5,596,000*** (.001)	- 372.57	82.24%
SUM of Injured	- 6,035,000*** (.002)	- 401.79	88.69%
SUM of Houses Destroyed	- 876,000*** (.004)	- 58.32	12.87%
SUM of Houses Damaged	- 518,000** (.035)	- 34.49	7.61%
Largest Rural Province: Thanh Hoa			
SUM of Killed	- 4,816,000** (.034)	- 320.64	76.16%
SUM of Injured	- 951,000* (.068)	- 63.31	15.04%
SUM of Houses Destroyed	- 829,000** (.012)	55.19	13.11%
SUM of Houses Damaged	-424,000** (.030)	-26.63	8.61%
Second Largest Rural Province: Nghe An			
SUM of Killed	-978,000* (.089)	-65.11	16.19%
SUM of Injured	-814,000** (.035)	-54.19	13.48%
SUM of Houses Destroyed	-432,000* (.075)	-28.76	7.15%
SUM of Houses Damaged	-411,000** (.049)	-27.36	6.81%
Observations: 487; average RMSE for the system: .5476; average p-value for the model: .000			

Notes: ***, **, * indicate 1, 5, and 10% significant, respectively, with p-values in parentheses

Appendix Figure 1. Map of Eight Administrative Regions in Vietnam

Source: http://en.wikipedia.org/wiki/Geography_of_Vietnam

Appendix Figure 2. Map of 64 sub-Regions in Vietnam



Source: http://upload.wikimedia.org/wikipedia/commons/thumb/9/96/VietnameseProvincesMapTiengViet.png/300px-VietnameseProvincesMapTiengViet.png

Appendix Table 1

Table 5. Descriptive Statistics for Other Data: 2000-2008

Region/Variable Country & Northern)	Mean (Per Year)	Stand. Dev.	Region/ Variable (Southern)	Mean (Per Year)	Stand. Dev.
Firm Income					
Country (Billion VND)	391,297	6203.34			
Red River Delta	89,381	231.58	South Central Coast	17,952	152.39
Hanoi	30,870	113.53	Central Highlands	2,542	61.35
Northeast	4,998	82.58	Southeast	97,208	316.57
Northwest	2,678	60.24	Ho Chi Minh City	112,456	153.45
North Central Coast	12,385	141.26	Mekong River Delta	20,827	143.74
Stock of Capital					
Country (Billion VND)	311,545	6,032.43			
Red River Delta	79,826	834.15	South Central Coast	15,259	287.48
Hanoi	32,984	915.87	Central Highlands	4,440	102.32
Northeast	6,989	675.43	Southeast	93,589	675.09
Northwest	3,797	143.86	Ho Chi Minh City	41,533	67.34
North Central Coast	8,373	328.65	Mekong River Delta	14,755	564.22
Freight Traffic					
Country (Ton*km)	19,427,21	658.48			
Red River Delta	4,240.65	253.98	South Central Coast	2,687.04	243.78
Hanoi	398.69	19.52	Central Highlands	956.34	121.54
Northeast	1,056.92	327.33	Southeast	3,204.57	354.89
Northwest	416.32	78.05	Ho Chi Minh City	2,132.78	267.43
North Central Coast	1,320.47	315.42	Mekong River Delta	3,013.43	342.86
School Enrollment					
Country (‘000 students)	133,051.7	2,523.42			
Red River Delta	21,987.3	2,071.19	South Central Coast	14,565.18	1,866.33
Hanoi	3,278.91	142.88	Central Highlands	8,043.43	1,196.62
Northeast	25,075.4	2,246.3	Southeast	18,181.06	1,859.75
Northwest	4,309.69	2,080.4	Ho Chi Minh City	4,489.09	186.49
North Central Coast	8,393.04	1,029.45	Mekong River Delta	24,728.57	1,918.11
Firm Investment					
Country (Billion VND)	105,740.9	1,203.54			
Red River Delta	14,566.49	623.44	South Central Coast	11,012.31	598.43
Hanoi	6,128.37	42.43	Central Highlands	7,767.98	435.87
Northeast	11,146.18	587.57	Southeast	19,107.69	903.46
Northwest	6,483.09	487.94	Ho Chi Minh City	7,544.83	74.56
North Central Coast	8,888.29	523.66	Mekong River Delta	13,145.69	834.62
Retail Sales					
Country (Billion VND)	256,573.7	7,834,12			
Red River Delta	49,362.56	5,646.19	South Central Coast	16,578.86	4,323.76
Hanoi	21,159.39	1,111.48	Central Highlands	5,549.93	2,314.56
Northeast	9,323.43	4,186.94	Southeast	67,694.1	5,784.76
Northwest	5,953.72	3,877.26	Ho Chi Minh City	40,142.71	2,588.12

North Central Coast	10,146.86	3,660.46	Mekong River Delta	30,662.16	314.44
Medical Staff					
Country (persons)	5,304	114.33			
Red River Delta	740	70.05	South Central Coast	380	47.45
Hanoi	362	13.78	Central Highlands	164	34.25
Northeast	223	50.23	Southeast	1,341	68.47
Northwest	96	42.78	Ho Chi Minh City	996	43.52
North Central Coast	249	49.05	Mekong River Delta	754	36.98
Population					
Country (‘000 persons)	74,273.39	1,217.34			
Red River Delta	15,071.97	2,867.53	South Central Coast	6,593.01	1,325.89
Hanoi	3,060.52	32.98	Central Highlands	4,659.69	1,143.65
Northeast	7,534.85	1,143.98	Southeast	11,461.72	1,312.78
Northwest	3,055.26	1,012.54	Ho Chi Minh City	5,813.17	57.48
North Central Coast	5,071.62	1,458.42	Mekong River Delta	12,050.49	1,108.34
Real Interest rate					
Country (percentage)	3.76	1.85			
Urban Population					
Country “000 persons)	21.574.8	1,856.34			
Red River Delta	3,212,2	536.47	South Central Coast	1,566.7	214.65
Hanoi	2,071.9	353.98	Central Highlands	857.9	121.34
Northeast	1,073.7	142.56	Southeast	5,714.8	645.86
Northwest	577.6	54.87	Ho Chi Minh City	4,052.5	57.43
North Central Coast	831.7	103.58	Mekong River Delta	1,915.8	252.58
Rural Population					
Country (‘000 persons)	52,698.59	365.92			
Red River Delta	11,859.77	335.78	South Central Coast	5,026.31	68.43
Hanoi	988.62	124.61	Central Highlands	3,801.79	135.76
Northeast	6,461.15	46.68	Southeast	5,746.92	324.54
Northwest	2,477.66	36.87	Ho Chi Minh City	1,762.67	82.06
North Central Coast	4,239.92	102.46	Mekong River Delta	9,734.69	1,341.53
Firm Employees					
Country (persons)	5,270,671	9,368.49			
Red River Delta	1,608,812	4,562.65	South Central Coast	524,673	3,143.68
Hanoi	812,324	2,435.27	Central Highlands	176,354	978.45
Northeast	215,398	1,321.56	Southeast	2,16,935	5,649.52
Northwest	121,203	1,023.54	Ho Chi Minh City	1,204,127	2,046.81
North Central Coast	315,967	2,549.83	Mekong River Delta	420,836	2,452.73

Note: Mean is the average value per year

Appendix: The FEFGLS Procedure

Since the heteroskedasticity is specific to the model, a special generalized least squares method (GLS) will be needed. Theoretically, after the fixed-effect estimation of Equation (5), the sectoral disturbance, v_i, is eliminated, and this equation can be written as: $y = X\beta + w$, where X is of dimension (T x K), $E[w]=0, \quad \text{cov}[w]=E[ww']=W, \quad W \neq \sigma^2 I_T,$ where W is the covariance matrix. Since the composite disturbance includes $DMS_{i,t}$, which varies across sectors, another fixed effect estimation is needed. After the sectoral effects are eliminated once more, we can factor a constant out of the matrix W and write it in the alternative form $W = \sigma^2 Q,$ where the diagonal elements of Q are $q_t = \{q_1, q_2, \ldots, q_T\}$. The transformed error term is: $w^* = [(w_1 / q_1^{1/2}), (w_2 / q_2^{1/2}), \ldots, (w / q_t^{1/2})]$.
The heteroskedasticity is then corrected by transforming the original model to: $y^* = Py = X^*\beta + w^* = PX\beta + Pw, \quad P'P = Q^{-1}$. The general least square estimator is the minimum variance linear unbiased estimator under any general error covariance specification that could reflect heteroskedasticity or autocorrelation or both: $\hat{\beta} = (X'W^{-1}X)^{-1}X'W^{-1}y$. In reality, since W is unknown, the feasible general least square estimator (FGLS) is: $\tilde{\beta} = (X'\hat{W}^{-1}X)^{-1}X'\hat{W}^{-1}y$, which is not best linear unbiased but consistent. Its approximate large sample properties are the same as those of the GLS estimator.