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Evidence from Peru

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Abstract

This paper studies the allocation of total disaster risk reduction public spending among regions in Peru. The main objective of this work is to identify the main determinants of the distribution of these resources, and for this purpose an index of historical physical impacts of natural disasters, social vulnerability, and institutional capacity was created. It is found that historical impacts of climatological disasters are positively correlated with the per capita amount received by region in order to prevent future natural disasters. Impacts of geological disaster, on the other hand, affect the amount of executed and budgeted resources used to cope with the effects of past disasters. The prevention expenditure is mainly driven by climatological effects on the agriculture sector. Additionally, results confirm that higher social vulnerability is a main determinant of the distribution of prevention spending but conditioned on being affected by climatological disasters. Institutional capacity seems to define only the amount of recovery expenditure, positively for regions more seriously affected by geological disasters and negatively for regions devastated by climatological disasters.

JEL classification: Q54,Q56,H76,H84,R58

Keywords: Public expenditure, Natural disasters, Vulnerability

1 Introduction

Climate change has become a real concern for many regions around the world as they have begun to experience increasingly extreme and unpredictable weather conditions. According to the (IPCC (Intergovernmental Panel on Climate Change), 2013), the increase of greenhouse gas emissions resulting from human activities is a reason for this high frequency of extreme weather events. Such events imply huge changes in natural and social systems due to their effects on infrastructure, ecosystems, agriculture, and human morbidity and mortality, among other outcomes. Moreover, the inherent uncertainty surrounding the occurrence of extreme weather events underscores the importance of adaptation to climate change for developing and least-developed countries. Additionally, regions face other type of natural disasters such as geological or epidemiological disasters that highlight the importance of governments' interventions in order to adapt and give relief to regions affected by such devastating impacts. Resources to build resilience are therefore necessary, and they should be allocated according to clear standards that measure the country's or region's vulnerability.

The emphasis of this paper is to evaluate, through a case study in Peru, which determinants are driving the distribution among regions of public spending on prevention and recovery from natural disasters. Previous studies have used different frameworks by constructing indexes for vulnerability across countries for the purpose of using them as criteria for the distribution of international aid for adaptation. This analysis, however, will focus on the internal distribution of public expenditure dedicated to prevention of and recovery from natural disasters. Given the subnational focus of this work, the availability of regular and comparable information allows a more accurate picture of the actual vulnerability of regions within a country.

This work will be as well to determine whether the occurrence of previous natural disasters is an important condition for the distribution of public expenditure in both recovery and prevention categories. The concept of prevention will be used to define all public spending used to adapt to climate change, reduce vulnerabilities and risks of potential natural disasters, and to finance activities designed to provide protection against possible natural disasters. The magnitude of historical disasters can be a sign of the vulnerability of a region and the future incidence of natural disasters. Recovery, on the other side, is defined as all aid relief expenditure used to rehabilitate, rebuild, and support regions affected by natural disasters. Given the definition of recovery expenditures, historical natural disasters should determine the allocation of these resources.

In addition to historical natural disasters, a measure of vulnerability should be a significant factor affecting the allocation of prevention and recovery expenditures. However, there is presently no widely used measure or universally accepted definition of vulnerability. As a result, statements based on different definitions of vulnerability can have totally different implications (Eriksen and

Kelly, 2007). According to IPCC (Intergovernmental Panel on Climate Change) (2007), vulnerability to climate change is illustrated through three basic notions: exposure, sensitivity and adaptive capacity. Exposure refers to the degree to which a system is open to physical damage. Sensitivity, in contrast, is the extent to which a system is affected by exposure to stress. In other words, sensitivity denotes a system's responsiveness to climate hazards. Finally, adaptive capacity refers to a system's ability to cope and adjust to stress. In a more recent report, (IPCC (Intergovernmental Panel on Climate Change), 2012), vulnerability is defined as the propensity or predisposition to be adversely affected. This new definition highlights the importance of social factors in the constitution of risk and the social context—captured in the previous definition by sensitivity and adaptive capacity—is explicitly emphasized.

An appropriate distribution of resources for developing countries is essential in order to reduce vulnerability. Adaptation to natural hazards, i.e., the adjustments of a system in order to cope with external stresses (Brooks, 2003), could determine the final impact of an unpredictable natural disaster. Nonetheless, adaptation has only recently come to be seen as an area of public debate and action, as adaptation has previously been understood by many as a private action. When people experience changes such as impacts on agricultural conditions, water supply or the intensity of floods, they attempt to adapt on their own. This means that people find ways to improve their living standards by changing farming methods, improving the water supply, moving to a new home or any other available possible solution.

However, adaptation is primarily a concern for public policy. First, people lack the available information necessary to optimize adaptation; they do not necessarily know about the best farming techniques, ways to improve water supply or the best location to relocate. Second, adaptation implies provision of public goods such as flood barriers or public roads. Additionally, effectively adaptation requires collective action (Tompkins and Eakin, 2012). There are abundant examples of private actions providing adaptation public goods; for example, policies requiring households to dispose of standing can help to prevent the spread of mosquito-borne diseases. Finally, adaptation goes hand-in-hand with redistribution and poverty policies, as the level of poverty is one of the determinants of adaptation capacity. Poor communities face particularly difficult challenges in dealing with adverse climatic conditions; high agricultural dependence, lower education, lower nutrition, a higher age dependency ratio, fewer coping mechanisms (i.e., lower savings and access to financial instruments) and lower income make those communities especially susceptible to natural disasters.

Adaptation resources also enable communities to cope with increasingly challenging weather conditions. In developing countries public expenditure provides one of the main resources for adaptation and determines most distribution of external funds. These resources provide financial capacity for important investments in water management and coastal protection. Additionally, higher expenditure helps to ameliorate weaknesses in adjusting to climate change in areas such as improved risk management and knowledge enhancement.

Following Barr et al. (2010), this work will construct several indicators that measure the social vulnerability and implementation capacity of different regions in Peru and use those indicators to see if they are important in determining the allocation among regions of resources in to prevent natural disasters. Additionally, an index reflecting each region's previous history of natural disaster will be used. The paper then assesses how effectively and equitably adaptation expenditures are being focalized according to regions' respective degrees of vulnerability. As a second issue of interest, the paper examines expenditures made to cope with disasters.

2 Vulnerability Definition

Authors have identified several different dimensions of vulnerability to climate change, distinguishing primarily between the biophysical dimension and the socioeconomic dimension. Adaptive capacity, the main aspect of the socioeconomic dimension, is defined as a region's capacity to recover from extreme events and adapt to change over the long term (Moss et al., 2001). This capacity is mainly determined by socioeconomic factors such as education, health, income and institutional capacity. Adaptive capacity can thus be measured in terms of human, technological and financial capital as well as the quality of institutions and decision-making processes. In this way, adaptive capacity represents the assets available and the capacity to use them effectively in order to adapt to climate change and react to evolving hazards (Barr et al., 2010).

By contrast, exposure and sensitivity constitute the main determinants of structural or biophysical vulnerability. This concept designates the level of potential physical susceptibility to adverse impacts. Vulnerability, in this sense, defines the likelihood of occurrence and impact of climate-related events (Nicholls et al., 1999). Therefore, biophysical vulnerability should be used to capture the size of shocks, as it captures the effects of further droughts, floods, storms and sea level rise. An index of this dimension should reflect the likely size of recurrent external and natural shocks.

The classification and definition of vulnerability according to these two dimensions is not straightforward. First, the dimensions may overlap or be mutually dependent according to the precise definition used. Second, such a classification ignores another dimension of vulnerability: the external or internal sphere (Füssel, 2007). Internal sphere refers to the endogenous factors involved within the vulnerable system; on the other hand, an external sphere identifies external factors outside the vulnerable system. Sea level changes could be used as an example of an external biophysical factor affecting the vulnerability of the system. Topography, by contrast, is a biophysical internal condition within the system. Finally, a correct conceptualization of vulnerability must include the notions of starting-point or end-point vulnerability (Kelly and Adger, 2000). The former correspond to a framework emphasizing the reduction of internal socioeconomic vulnerability to any natural hazard; the latter is based on analysis of scenarios for future climate hazard conditioned on the size of shocks and on resilience.

In this work, the concept of starting-point vulnerability will be used. Such vulnerability will be understood as susceptibility to natural hazards determined by socioeconomic factors. This means that the concept will not be used to estimate future scenarios of climate hazards but rather vulnerability measured by the current effects of natural hazards. In other words, vulnerability implies a pre-existing state reinforced by political or economic marginalization, while adaptation represents the process whereby the adverse effects of climate change are moderated.

Table 1 shows the series of variables used as proxies to construct an indicator of resilience for each region in Peru. The inverse of this indicator reflects the region's social vulnerability. Following previous works by Vincent (2004) and Moss et al. (2001), these variables measure economic well-being, infrastructure sensitivity, water resource access, demographic structure, food security, human health sensitivity, institutional structure, human and civic resources, natural resources dependence, and financial access. A higher level of resilience indicates less sensitivity to any natural hazard and better adaptive and coping capacity to face natural disasters. All these variables were obtained from household surveys from the National Institute of Statistics and Informatics (INEI).[1]

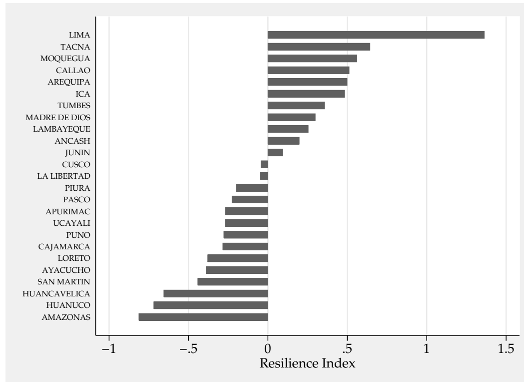
[1] For the summary statistics see Table A.2 in the Appendix

Table 1. Indicators of Resilience

Measure	Indicator
Economic Well-Being	Population above extreme poverty (%)
Infrastructure sensitivity	Inverse of qualitative housing deficit (% of population)
Water resource sensitivity	Population with access to clean water/sanitation (%)
Demographic structure	Households with low dependency (%)
Food security	Population with no caloric deficit (%)
Human Health Sensitivity	Population without health problems (%)
Institutional Structure	Households with beneficiaries from food programs (%)
Human and civic resources	Women's years of education
Natural Resource dependence	GDP not from agriculture (%)
Financial Access	Credits per capita

To construct an aggregate score of the indicator, the variables were normalized by converting to z-scores, and then taking the average. This provides a proxy measuring the internal sensitivity and coping adaptive capacity to climate disasters according to regions' respective socioeconomic factors. Figure 1 indicates the resilience of each region in Peru, showing that Lima and Tacna are the least vulnerable regions, while Amazonas and Huánuco present the highest levels of social vulnerability. This means that, in case of an external hazard in these regions, the incidence would be greater. Therefore, this indicator can explain why some regions can be more affected than others. The growing incidence and persistence of natural events is strongly associated with vulnerability of households and communities in developing countries. For instance, Rosemberg et al. (2010) using data from Peru demonstrate that having experienced a natural disaster increases the probability that a household will not be able to escape from poverty.

Figure 1. Resilience Indicator Average 1999-2011



Source: Authors' calculation based on INEI.

3 Impact Indicator of Natural Hazards in Peru

Regions are the first-level administrative subdivisions of Peru, which include 24 departments plus Callao Province.[2] A first notable feature of Peru is its huge geographical and climatological diversity among regions. The Pacific coastal region includes Lima and some of the other principal cities of Peru; consisting mainly of desert, this is one of the driest areas on Earth. Additionally, this region is prone to earthquakes and is affected by the Humboldt Current, the El Niñ o-Southern Oscillation and the Andes mountain range. The central coast of Peru, encompassing the regions of La Libertad, Ancash and Lima, has a subtropical desert climate with little annual rainfall. The southern coast, covering the regions of Ica, Arequipa, Moquegua and Tacna, has a warmer and drier climate, and Moquegua possesses the country's most active volcano. The northern coast, including the regions of Lambayeque, Piura and Tumbes, is characterized by a tropical dry climate and the presence of tropical dry and mangrove forests. Peru's largest and least populated region, covering almost 60% of the country's territory, is the Amazon Basin region in the northeast. This region consists largely of tropical rainforests. Finally, the regions situated on the Andean Mountain Ranges in the eastern part of the country have a large variety of climates depending on elevation and can experience heavy rainy seasons between October and April of each year. Table A.1 in the Appendix includes some descriptive variables for each region of Peru.

In recent decades Peru has suffered from the effects of climate change, manifested in a growing incidence and persistent of certain natural events. Increasing temperatures are causing glaciers to retreat, disturbing ocean currents and altering hydrological cycles. As a result, agricultural productivity and biodiversity are increasingly being affected by floods, diseases, epidemics and extreme weather events. Two main factors characterize the impacts of climate change in Peru:

[2] Lima Province, despite not being part of the Lima Region, will be included in this paper as part of the Lima Region

i) the retreat of glaciers and ii) the El Niño phenomenon. Retreat of glaciers—reduced by a total of 22% in the last 30 years—has affected water supply in coastal and highland regions by around 7 million cubic meters of water (Clements et al., 2010). Additionally, Peru is one of the main centers of the El Niño-Southern Oscillation, which magnifies the intensity of weather events.

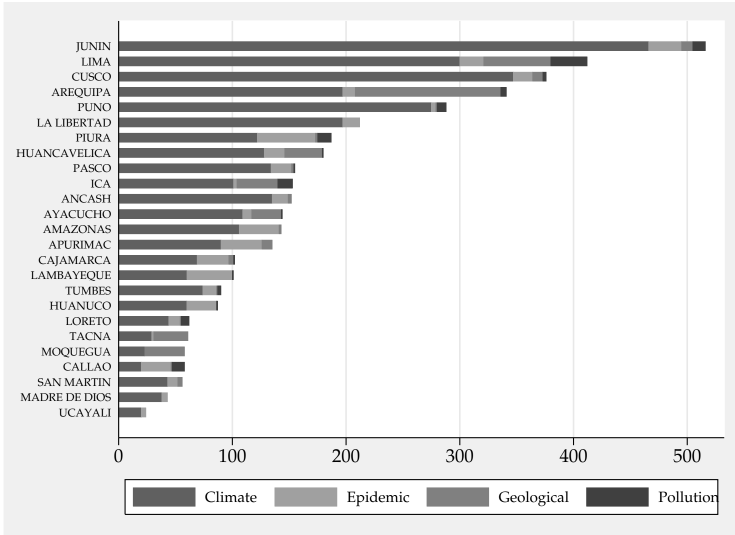
Natural hazards such as droughts, landslides, heavy rainfalls, frosts, hailstorms and floods, among others, constantly affect different regions in Peru, and some regions have also been affected by earthquakes and volcanic activity. Human activities are additionally responsible for worsening natural hazards through poor management of natural resources and large-scale pollution, particularly from mining activities in recent years. The total number of events is presented in Figure 2, which shows the total number of natural disasters between 1999 and 2011 independently of the population affected or any other impact measure. Disasters are classified by cause: climate, geological, epidemic-biological or pollution.

Data are taken from the Inventory System of the Effects of Disasters (DesInventar), which contains records of all major and medium disasters in Latin American countries. Based on these data, the Research Department (RES) of the Inter-American Development Bank constructed a dataset for Latin America containing data on 64 types of events including their causes: geological, human-related or meteorological. This dataset has the advantage of identifying the exact location of the event including cities and towns, and it provides the exact impact records of the events. An event is defined by DesInventar as a phenomenon that causes adverse effects on human lives and health, and economic or social infrastructure in a community. For the case of Peru, the sources used by DesInventar are information from the National Institute of Civil Defense (INDECI) and 11 national newspapers.

Analysis of physical impact based on DesInventar was undertaken using data from 1970 to the latest available data for Peru in 2009. Impacts indicators on humans, physical houses, roads, agriculture and forestry, livestock, and education and health centers were used to construct an index of physical impact. Variables on monetary losses and other dummy variables available in the Desinventar dataset were discarded. Additionally, all variables were reclassified in order to be comparable across regions in terms of percentages. Based on the Disaster Exposure Index (DEI) constructed by Garlati (2013), each of the variables was at first normalized, in this work by conversion to z-scores. In this way, the whole panel dataset of physical impact indicators has an average of zero and a standard deviation of one. After normalizing, the indicators were averaged to obtain an index at the region-year level.[3]

[3] This final index does not necessarily have an average of 0 and a standard deviation of 1.

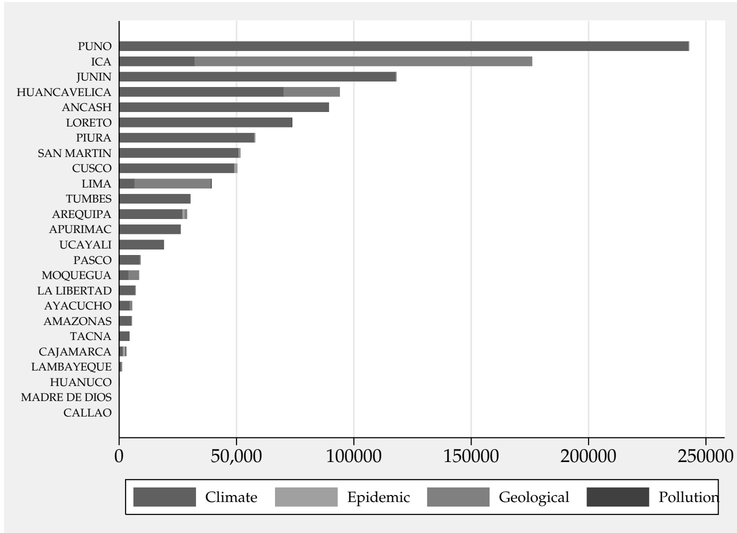
Figure 2. Number of Events between 1999 and 2011



Source: Authors' calculation based on DesInventar.

Most of the disaster events are related to climatological causes, as presented in the previous figure. When considering the total of people affected by each of the events, it can be seen that events from climatological causes are also the most harmful events (see Figure 3). Therefore, climatological disasters are not only recurrent but also severe in their impacts. The only regions in which the most people were affected by an event other than climatological were Ica and Lima, for the abovementioned earthquake of 2007. Also, Moquegua has been seriously affected by volcanic activity.

Figure 3. Number of People Affected by Type of Event (1999-2011



Source: Authors' calculation based on DesInventar.

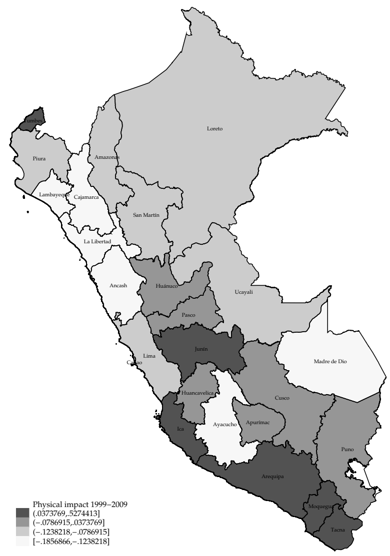
However, the number of people affected is not the only variable that reflects the total impact of an event. For instance, the total number of victims can be another important factor, or the total number of homes destroyed. Different variables measuring the effects of the disaster events can be used to construct an index for discrete recurrent hazards outcomes. In order to construct this indicator of physical impact we will use nine variables that reflect the effects of natural events. Table 2 shows the variables considered, which cover three areas of concern: human lives lost and affected, infrastructure, and agriculture and livestock. All variables are measured in percentages in order to be comparable across regions. The resulting index is a rough proxy for biophysical impacts. However, this indicator will only capture direct effects and not indirect effects such as changes in agricultural market prices.

Table 2. Indicators of Physical Impact

Indicator	Measure
Human Lives	Victims per each 100 inhabitants
Affected	Perc. population affected
Affected	Perc. of homes affected.
Infrastructure	Perc. homes destroyed
Infrastructure	Perc. health centers destroyed
Infrastructure	Perc. education centers destroyed
Infrastructure	Routes affected per each 1,000 km
Agriculture	Perc. crops destroyed
Agriculture	Perc. livestock affected

Figure 4 shows the average of the impact indicator index for the period between 1999 and 2011. According to the index, the most affected regions are Ica and Moquegua. They have been affected by particularly devastating geological disasters—an earthquake and volcanic activity, respectively—which implied a very high number of people affected and large amount of infrastructure destroyed. As discussed in the next subsection, Tumbes, the region that executed the greatest amount of dollars in prevention and recovery from disasters, is also one of the most affected regions in terms of physical impacts.

Figure 4. Impact Indicator Index (1999-2011



Source: Authors' calculation based on DesInventar.

3.1 Prevention and Recovery Expenditure in Peru

Due to the geographic, geodynamic, climatic and seismic conditions in Peru, the National System of Civil Defense, *Sistema Nacional de Defensa Civil*, (SINADECI) was created in 1972 to protect and assist populations affected by natural disasters and related events. This entity is in charge of prevention and risk management throughout the country, and Peruvian law additionally requires each body of the public sector to exercise civil defense functions. Moreover, a complex institutional network of public and private entities is coordinated by the National Institute of Civil Defense, *Instituto Nacional de Defensa Civil* (INADECI). However, each regional, provincial and local agency has relative autonomy in the planning and execution of projects (SINADECI (Sistema Nacional de Defensa Civil), 2004, 2007).

Since 2002, the Basic Law for Decentralization was introduced in order to foster norms in support of a decentralization process.[4] Nonetheless, decentralization has in fact been extremely limited, with only gradual advances over the years. Subnational governments still have limited fiscal autonomy, and they highly depend on transfers from the national central government (Castro, 2008). The same occurs with the public expenditure managed by the SINADECI, where most public resources still come directly from national transfers. However, different modifications to the law have allowed subnational governments to perform more autonomously in the use of resources

[4] Peru's administrative subdivision consists of regions, provinces and districts. The 2002 Organic Law of Regional Governments created the regions with the purpose of creating elected regional governments and starting a process of transferring functions from the central government to the regions.

for disaster prevention and recovery[5] under the parameters of the National Plan for Prevention and Recovery of Disasters (PNPAD).[6]

Some institutional arrangements have fostered the implementation of national-level policies with climate change awareness. In 2003, the guiding document for the National Strategy for Climate Change was formulated,[7] and three years later the special commission for Climate Change and Biodiversity was created. The Environmental Ministry was subsequently established in 2008, and several scientific entities[8] have been restructured in order to expand their research on natural disasters. Furthermore, noteworthy progress has been made in the participative budget process at the local level, and the Ministry of Economy and Finance has included risk managements formulations in all investment projects (GB and Ciudadana, 2009).[9] Despite these improvements serious regional inequalities still continue with regard to institutional capacity and availability of resources. For instance, some regions have made major advances in their regional strategies for climate change, while others have made almost no progress. This variation can affect the timing of climate change investments projects approved under the National System of Public Investments.

Public expenditure data from the Ministry of Economy and Finance (MEF) allow us to disaggregate expenditures in each region according to the exact activity or project; to disaggregate to the level of government (National, Regional or Local) in charge of executing the budget; and to distinguish to which function (health, defense, transport, etc.) the expenditure belongs. It is also possible to determine the share of expenditures related to investment in fixed assets. Thus, it is possible to identify all the items from the public budget related to prevention of natural disasters as well as expenditures made to deal with the occurrence of natural disasters.

Figure 5 shows the total level of executed[10] expenditure for disaster prevention and recovery by national, regional and local levels of government. As the figure shows, prevention expenditures have been gradually increasing since 1999 with a peak in 2002, in part because of a series of investments executed in order to avoid a recurrence of disasters related to the El Niño phenomenon

[5] Regional, Provincial and Local INDECI Directorates operate jointly with INADECI in planning, programming and execution.

[6] This national long-term plan was introduced after 2004 in order to coordinate disaster prevention and risk reduction, and was the first time in which prevention, vulnerability and mitigation were considered by SINADECI to be key factors in resource planning.

[7] In practice, however, few sectors within the central government, as well in the regional governments, have included in their policies, projections and plans based on the National Strategy for Climate Change

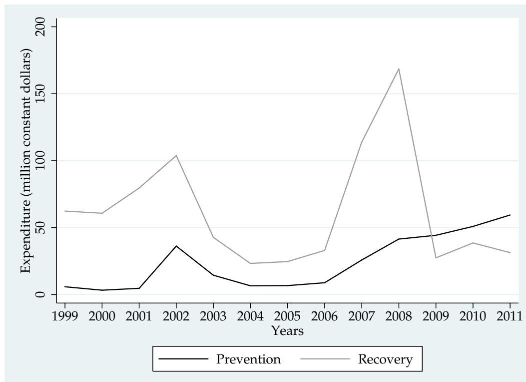
[8] Including the Geophysical Institute, Meteorological and Hydrological National Service, Mining Geological and Metallurgical Institute, National Geographic Institute, Seismic Research Center and Disaster Mitigation. The Scientific Research Agency for Climate Change was created in 2009.

[9] Since 2009 the concept of eco-efficiency have also been taken into account in the budget process. In 2011 a new law for the National System for Disaster Risk Management (*Sistema Nacional de Gestión de Riesgo de Desastres*) was approved with the goal of identifying and reducing risk, minimizing effects and dealing with hazard situations with specific management guidelines.

[10] For our purposes executed represents committed expenditure at the time when the competent authority sets its budget for the fiscal year.

of that year. Executed expenditure to address disasters peaks in 2002 and in 2007-2008. The major disasters during those two periods were the 2002 El Niño mentioned above and the earthquake that affected the central coast's Lima and Ica regions in 2007.

Figure 5. Prevention and Recovery Expenditure 1999-2011



Source: Authors' calculation based on Ministry of Economy and Finance.

Each project activity from annual expenditures was carefully checked in order to classify it as a prevention or recovery expenditure. Recovery includes all expenditures related to emergency, reconstruction and rehabilitation works and social support to provide emergency assistance.[11] Prevention expenditures are classified as those activities associated with public information campaigns, strengthening of capacities against natural disasters, construction of defenses along riverbanks and retaining walls, channeling of rivers, irrigation infrastructure, soil conservation, reforestation, diking and other expenditures related to prevention against floods and landslides.[12] The classification does not include expenditures related to research on climate change or disaster prevention, as most of these expenditures were executed in Lima and beneficiary regions cannot be readily identified. Table 3 shows the list of activities within each function[13] associated with prevention or recovery prevention expenditure.

[11] Other activities explicitly indicate by name that they are intended to address emergencies.

[12] In 2009 the Risk and Emergency Management program was created to classify expenditures; the program contains all project expenditures related to disaster prevention or recovery.

[13] In Peru, every expenditure project is classified in ascending order into components, activities, sub-program, program and function. In 2012 this classification was changed.

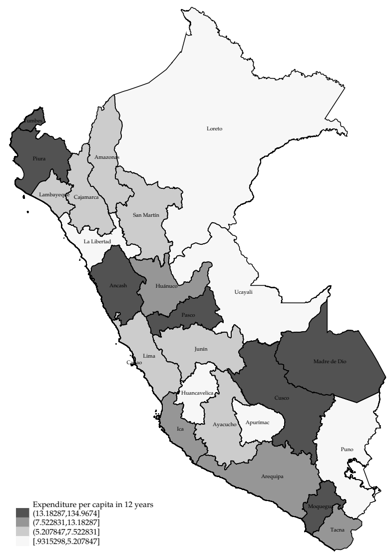
Table 3. Expenditure Activities Classification

Function	Prevention of disasters	Recovery of disasters
Social Protection and Prevention	Various related to defenses along riverbanks and retaining walls; Various related to defenses against floods; Channelling of rivers; Prevention of Natural Disasters; Strengthening Capacities against Natural and Anthropogenic Disaster; Actions to Prevent Disasters;	Community support in case of emergency; Social Support and Emergency works; Emergency works; Recovery from Disasters and Rehabilitation and Reconstruction Supports; Seismic Rehabilitation and Reconstruction; Coordination of National System of Civil Defense
Administration and Planning	Rehabilitation of Tropical Ecosystems	Recovery from Disasters and Reconstruction and Rehabilitation Support
Agriculture	Various related to defenses along riverbanks, fluvial protection, retaining walls, and canals; Various related to irrigation activities; Various related to soil conservation; Various related to defenses against floods; Rehabilitation of Tropical Ecosystems	Mitigation to heavy rainfalls impacts
Defense and National Security	Prevention and Mitigation of disasters; Various related to strengthening prevention capacities; Various related to defenses against floods	Community support in case of emergency; Social Support and Emergency works; Emergency works; Recovery from Disasters and Rehabilitation and Reconstruction Supports; Coordination of National System of Civil Defense
Education		Recovery from Disasters and Rehabilitation and Reconstruction Supports; Rehabilitation of zones affected by disasters; Various related to rehabilitation works; Mitigation to heavy rainfalls impacts
Fishing		Mitigation to heavy rainfalls impacts
Health and Sanitation	Various related to defenses against floods; Various related to defenses against erosion; Various related to Environmental Health	Community support in case of emergency; Support to Emergencies; Recovery from Disasters and Rehabilitation and Reconstruction Supports; Mitigation to heavy rainfalls impacts
Transport	Various related to improvements of roads and routes	Mitigation to heavy rainfalls impacts; Recovery from Disasters and Rehabilitation and Reconstruction Supports
Housing and Urban Development	Various related to protection to houses	Recovery from Disasters and Rehabilitation and Reconstruction Supports; Mitigation to heavy rainfalls impacts; Support to Emergencies

Note: Since 2009 the Function of Public Order and Security was created alongside the Risk and Emergencies Management program. Many activities were reclassified into this new function.

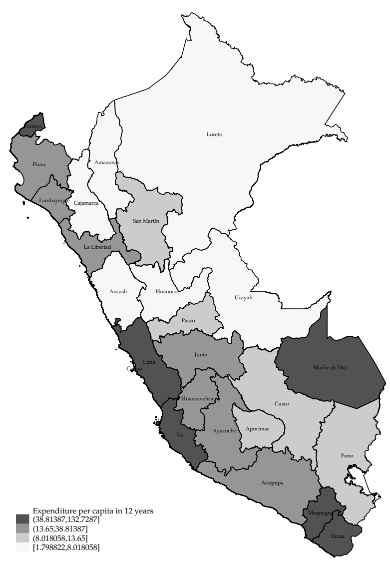
Total prevention and recovery expenditures per capita for 12 years are shown in Figures 6 and 7, respectively. The great disparity in the distribution of these resources among regions is reflected in both figures. Tumbes, for example, executed almost 134 dollars for prevention expenditure per capita while Apurímac perceived less than a dollar per capita. Tumbes is also the region that executed the greatest amount of recovery expenditures, with a total of 132 dollars per capita in the 12 years considered. Ica displays the second-largest amount of recovery expenditures, primarily because of the earthquake impacts of 2007. As shown in the previous subsection, the total impacts of natural disasters occurring in these regions have had a greater incidence.

Figure 6. Prevention Expenditures per Capita by Region (1999-2010)



Source: Authors' calculation based on Ministry of Economy and Finance.

Figure 7. Recovery Expenditures per Capita by Region (1999-2010)



Source: Authors' calculation based on Ministry of Economy and Finance.

3.2 *Institutional Capacity*

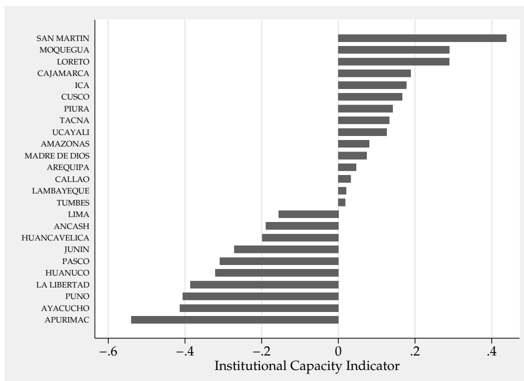
The capacity of sub-national governments to effectively use resources and budget in order to prevent and address disasters is determined in part by their institutional capacity. In order to measure this variable, an indicator of institutional capacity will be created based on variables measuring corruption, institutional stability, local technical capacity, citizen participation, environmental management capacity, and institutional capacity to respond to disasters. A region with a high level of corruption, for example, is almost certain to face serious problems in the management of public resources. Variables on corruption at the regional level were obtained from data on perceptions of corruption in *Proetica*. These variables can affect the proper administration and availability of resources and, by consequence, impede equitable access and distribution of entitlements. Institutional instability is also an important indicator of the level of institutional strength, and the variable used here shows the percentage of local elected offices without vacancies. Vacancies occur when any elected public official is removed from his office by recall election, in the case of mayors (from a municipality or province) and regional governors, or removed by other legal authority.

Table 4. Indicator of Institutional Capacity

Indicator	Measure
Corruption	Perc. low corruption (self-perception)
Corruption	100-index of corruption
Institutional stability	Perc. of local elected authorities without vacancies
Institutional response to disasters	Perc. of municipalities with appropriate Civil Defense
Technical Capacity	Perc. Municipalities with Civil Defense technical capabilities
Environmental Management	Perc. municipalities with environmental management plan
Citizen Participation	Perc. municipalities participatory budgeting

Access to information and communication infrastructure can play a key role in dealing with natural disasters. Likewise, institutions able to ensure appropriate pre-disaster planning, hazard monitoring, information dissemination and preparation for emergencies can help to reduce the potential impact of a natural hazard. Thus, the construction of the indicator included variables on institutional response capacity, technical capacity and level of environmental management.[14] Finally, citizen participation in public budgeting can facilitate the spread of information, identify points of potential vulnerability and promote appropriate administration of public resources. Figure 8 shows the average of the institutional capacity indicator for the period 2002 to 2011. San Martín, Moquegua and Loreto are the regions with the strongest institutional capacity, and the weakest institutional capacity is displayed by the regions of Apurimac, Ayacucho, Puno and La Libertad.

Figure 8. Institutional Capacity Indicator (2002-2011



Source: Authors' calculation based on INEI and Proetica.

4 Hypothesis

The first hypothesis on the allocation of prevention resources is that regions with higher historical impacts of natural disasters receive a greater amount of resources. First, regions historically more affected by natural disasters may be more prone to suffer again from a natural disaster due to physical vulnerabilities based on topographical, climatological or geological conditions. Therefore, it is expected that regions learn from history by investing in assets that enable them to cope with potential effects of future natural disasters. For example, regions in flood-prone regions may invest in flood barriers, and seismically active regions may invest in earthquake-resistant construction. In addition to physical conditions, however, pre-disaster socio-economic conditions represent another source of potential vulnerability. For this reason, regions with higher social vulnerability would be expected to receive more resources, as their socio-economic conditions may magnify the impact of a natural disaster. Regions with higher levels of poverty or higher infrastructure sensitivity may be more easily affected, *ceteris paribus*, by a natural disaster.

[14] Data from INEI

The definition of recovery expenditures used here implies that these resources should be allocated according to the impact of a given natural disaster. However, it is necessary to test whether such public spending is in fact being allocated according to the historical physical impact in each region. One strand of the relevant literature has analyzed relief aid allocation at the household level. For instance, Lazo and Santos (2004) analyzed aid received by households in Nicaragua after Hurricane Mitch, finding that the amount received was unrelated to either the degree of losses suffered or households' income levels. Kurosaki and Khan (2011) find that distribution of aid to cope with damage caused by floods in Pakistan in 2010 was distributed to households that had suffered greater damage to their houses but not to households with greater damage to land, crops, or other assets. For this reason it would be necessary to distinguish by the type of impact (impacts on population, agriculture or other infrastructure) to determine if this type of public spending is affected only by certain types of impacts. Higher social vulnerability can be another important determinant of aid relief allocation, as regions with higher social vulnerability would require more resources in order to cope with the disaster. Difference in wealth, for example, should be a critical factor in the distribution of aid in order to target first poor communities with little else to fall back on. However, the nature of some emergencies makes such targeting difficult or impossible to achieve. In fact, Morris and Wodon (2003) find that the probability of receiving relief after Hurricane Mitch in Honduras was negatively correlated with wealth. Nonetheless, social vulnerability should matter only conditional on a natural disaster's occurrence. For that reason, it is important to include interacted terms of the physical impact of natural disasters with the resilience indicator.

Another strand of the literature has examined the effect of politics on environmental policy. This literature suggests that the targeting of relief is not always effective, particularly because of political considerations and local institutional capacity. The variable of institutional capacity may therefore be related with the allocation of expenditures for both disaster prevention and disaster relief. Higher institutional capacity means lower corruption and higher technical and management capacities to use resources. To efficiently distribute resources, central government should allocate them to regions with higher institutional capacity. However, it would not be strange to see a negative correlation between expenditures and resource allocation, as some prevention expenditure may be related to enhancing capacities to deal with future natural disasters. Moreover, higher corruption could lead to higher investment in certain projects that facilitate the capture of rents.

Part of the literature has examined the political economy behind public goods distribution. For instance, Takasaki (2011) show that allocation of natural disaster reconstruction funds in Fiji is affected by local elite capture, but only during early periods when the supply of funds is limited. Francken et al. (2012) studied the case of cyclone Gafilo, which struck Madagascar in 2004, and concluded not only that aid was allocated to areas with higher need for relief but also to areas with stronger support for the government. Bastos and Miller (2013) analyzed drought declarations in Brazil and found that partisan considerations play a role in driving emergency declarations associated with drought. Drought declarations were systematically higher in municipalities where the incumbent mayor was affiliated with the President's party and prior to local elections. In the following estimation, a variable indicating support for the president will be included as well.

5 Results

The following model will be estimated in order to examine the correlation between prevention and recovery expenditure and the indicators of historical physical impact, social resilience and institutional capacity:

$$Exp^m_{rt} = \alpha + \theta^m P.I._{\cdot rt-1} + \beta^m_1 S.R._{\cdot rt} + \beta^m_2 I.C._{\cdot rt} + \gamma' X_{rt} + \nu_r + \lambda_t + \varepsilon_{rt} \quad (1)$$

where Exp_{gsct} is expenditure per capita in region r and year t, m indicates recovery or prevention expenditures, $P.I._{\cdot rt}$ is a vector for the different indicators of physical impact (geological, climatological, epidemic and pollution) for region r in year $t-1$ (or cumulative impact in previous last five or 30 years). $S.R$ is the social resilience indicator, $I.C$ the institutional capacity indicator, ν_r denotes region fixed effects, λ_t captures year fixed effect, and X_{rt} denotes region controls including population density, total expenditure per capita, and percentage of votes for the president in the previous election.[15] Finally, ε_{gst} is the error term capturing all other observed and unobserved determinants. Fixed effects will help to control for unobservable time-constant factors, and the time fixed effect will help capture sample-wide effects for each year. Time-constant factors capture variables such as geographical, topographical, and other end-point vulnerability variables such as estimated number of people affected by future sea-level rise.

The results from the fixed effects estimation are shown in Table 5. In this table, prevention and recovery expenditure are used as dependent variables. Both executed expenditure and the initial budget for the fiscal year are included. In Columns 1 to 4 in panel A, it is found that none of the natural disasters that occurred in the previous year seems to be affecting the level of prevention expenditure in each region. When including the institutional capacity index, the results remain unchanged.[16] Additionally, column 2 suggests some negative correlation of the executed prevention expenditure and the resilience index; the results, however, are not robust. Apparently, regions with less electoral support for the president execute less prevention expenditure; however, this is not the same for the budgeted expenditure for natural disasters prevention.

As would be expected, columns 5 to 8 show that regions more affected by geological natural events during the previous year have higher executed and budgeted expenditure to deal with

[15] Using data from second-round presidential elections.

[16] Number of observations are reduce in these estimations because of missing information data of the institutional capacity index for years before 2002.

the physical impacts of disasters. In previous sections, it was shown how regions affected more by earthquakes or volcanic activities were more seriously affected in terms of number of victims and infrastructure destroyed. These regressions thus show that most of the recovery expenditure is used to deal with the effects of this type of disasters. An increase of 1.26 standards deviations in the geological impact variable is associated with an increase of between 3.6 and 4.0 dollars per capita in executed recovery expenditure (67% and 75% of a standard deviation). This represents a huge increase, around 1% of total average expenditure per capita. Additionally, the results suggest a positive association with climatological physical impacts, but none of the coefficients are significant. Again, with these expenditures there seems to be no association between the resilience index and the institutional capacity index.

As shown in panel B, executed prevention expenditures seem to be influenced by the physical impacts of climatological natural disasters. An increase of almost 2 standard deviations in the climatological impact variable would increase executed prevention expenditure per capita by 0.7 to 1.7 dollars. This represents an increase of between 18.4 and 44.7% of a standard deviation in executed expenditure. Columns 3 and 4 show that none of the coefficients of the climatological physical impact are statistically significant, suggesting that only the final executed expenditure, and not the initial budget, is positively associated with impacts from climatological natural disasters. The coefficients from the variables of geological, epidemic or pollution physical impacts are not statistically different from zero. Results from columns 5 to 8 continue showing a positive association of recovery expenditure with physical impacts from geological natural disasters. Each increment of 1.53 standard deviations in the geological impact variable is associated with 5.7 dollars per capita more in recovery expenditure (1.4 standard deviations) and 7.4 dollars in the initial budget (2.4 standard deviations). Again, the magnitudes of the coefficients are much higher for budgeted expenditure than for executed expenditure. This appears to indicate low efficiency in the execution of these expenditures with respect to the initial budget. Coefficients for the resilience and institutional index are not significant for any of the regressions in panel B.

Finally, panel C includes the cumulative impacts of the last 30 years for each type of natural disaster. Some of the results suggest that prevention expenditure, both executed and the initial budget, are affected by the total level of physical impacts from climatological natural events. These results are repeated in the regressions using recovery expenditure as dependent variable: these expenditures are conditioned by the physical impacts of geological disasters. As in previous results, neither the institutional capacity index nor the resilience index appears to influence expenditures.

In summary, the distribution of recovery and prevention resources seems to be influenced by neither the vulnerability nor the institutional capacity of a region. Long-term impacts from climatological disasters, however, seem to affect the distribution of prevention expenditure, while both short-term and long-term impacts of geological disasters strongly affect the distribution of recovery expenditures. In order to control for a possible autocorrelation of spending on disaster risk reduction, Table A.3 in the Appendix includes the first lag of this variable as a control. It is estimated using fixed effects and an Arellano-Bond Dynamic Panel GMM, the latter to avoid inconsistencies in the estimations when including the lagged dependent variable. Results in these estimations are almost unchanged with respect to our previous estimations.

Table 5. Fixed Effects Estimation for Prevention and Recovery Expenditure per Capita

VARIABLES	(1) Prev. Execut. p.c.	(2) Prev. Execut. p.c	(3) Prev. Budget p.c	(4) Prev. Budget p.c	(5) Rec. Execut. p.c	(6) Rec. Execut. p.c	(7) Rec. Budget p.c	(8) Rec. Budget p.c
Panel A: Cumulative 1 year								
Climate Physical impact	0.539	0.211	0.277	0.142	1.147	1.423	4.361	3.759
	(0.386)	(0.211)	(0.200)	(0.221)	(1.090)	(1.457)	(3.106)	(3.485)
Geological Physical impact	0.0449	0.0298	-0.0420	-0.00495	3.683***	4.066***	3.533**	5.023***
	(0.0701)	(0.0539)	(0.0436)	(0.0380)	(0.372)	(0.124)	(1.310)	(0.182)
Epidemic Physical impact	-0.524	-0.788**	-0.0932	0.0104	0.0145	-1.186*	0.580	-0.00564
	(0.404)	(0.377)	(0.0906)	(0.199)	(0.485)	(0.615)	(0.481)	(0.331)
Pollution Physical impact	-0.378**	-0.307	0.0980	0.230***	0.990	-0.349	1.033	0.368
	(0.139)	(0.313)	(0.140)	(0.0766)	(0.816)	(0.642)	(0.732)	(0.637)
Resilience Indicator	-1.022	-1.506*	0.633	0.701	-0.227	0.132	0.0479	2.632
	(0.701)	(0.844)	(1.150)	(1.400)	(2.094)	(2.621)	(3.143)	(3.476)
Institutional Capacity		-0.382		-0.248		-0.711		0.211
		(0.376)		(0.253)		(0.662)		(0.634)
Government's electoral support	-0.0154**	-0.0224**	0.0106	0.0110	0.0423	0.0520	0.0706	0.0732
	(0.00661)	(0.00910)	(0.0178)	(0.0184)	(0.0306)	(0.0334)	(0.0501)	(0.0500)
Panel B: Cumulative 5 year								
Climate Physical impact 5y	0.762*	1.752*	0.346	0.492	2.105	2.357	3.089	2.933
	(0.429)	(1.008)	(0.209)	(0.322)	(1.825)	(1.850)	(2.094)	(2.843)
Geological Physical impact	-0.0873	-0.0130	-0.288	-0.259	5.792***	5.479***	7.360***	7.441***
	(0.0648)	(0.142)	(0.182)	(0.159)	(1.343)	(1.499)	(2.261)	(2.225)
Epidemic Physical impact	0.0289	0.646	-0.991	-1.009	1.946**	1.281	0.0608	0.339
	(0.333)	(0.905)	(0.778)	(0.790)	(0.848)	(0.792)	(1.453)	(1.402)
Pollution Physical impact	0.247	0.312	0.363	0.362	-0.325	-1.116	1.075	0.952
	(0.237)	(0.331)	(0.486)	(0.553)	(1.049)	(1.211)	(1.140)	(1.040)
Resilience Indicator	-0.645	-0.552	0.111	0.100	1.442	-0.0487	-0.241	1.056
	(0.643)	(0.897)	(0.712)	(0.857)	(1.808)	(2.128)	(1.886)	(2.214)
Institutional Capacity		-7.21e-05		-0.322		-0.568		0.0486
		(0.246)		(0.286)		(0.659)		(0.605)
Government's electoral support	-0.0100	-0.0192	0.0188	0.0198	0.00774	0.0135	0.0391	0.0357
	(0.00596)	(0.0118)	(0.0207)	(0.0222)	(0.0207)	(0.0232)	(0.0439)	(0.0441)
Panel C: Cumulative 30 year								
Climate Physical impact	7.140	7.726*	11.79	16.06*	-3.161	-2.098	8.026	6.751
	(5.350)	(4.080)	(8.319)	(8.695)	(3.835)	(2.469)	(5.025)	(6.271)
Geological Physical impact	0.0182	-0.00370	0.0950	0.0694	7.588***	7.829***	10.48***	10.57***
	(0.289)	(0.291)	(0.216)	(0.227)	(1.295)	(1.183)	(1.616)	(1.717)
Epidemic Physical impact	-0.783	-2.846	-0.931	-11.83	1.578	-1.706	-0.0708	-2.620
	(1.450)	(11.26)	(1.294)	(18.39)	(1.838)	(8.712)	(0.654)	(11.15)
Pollution Physical impact	0.136	-0.227	0.998	0.911	1.731	-1.896	3.260	0.859
	(0.449)	(1.521)	(0.711)	(1.184)	(2.021)	(1.598)	(3.305)	(2.160)
Resilience Indicator	-0.337	-0.576	0.119	-0.0992	2.257	1.376	2.015	2.517
	(0.529)	(0.642)	(0.587)	(0.532)	(1.405)	(1.330)	(1.686)	(1.944)
Institutional Capacity		-0.528		-0.819		-0.0739		0.735
		(0.623)		(0.680)		(0.647)		(0.769)
Government's electoral support	-0.00966	-0.0144	0.00125	0.000324	0.0253	0.0329	0.0359	0.0358
	(0.00790)	(0.0109)	(0.00608)	(0.00681)	(0.0182)	(0.0196)	(0.0312)	(0.0331)
Observations	225	199	225	199	225	199	225	199
Number of codigo_depto	25	25	25	25	25	25	25	25
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Executed expenditure (Exec) represents committed expenditure. Budget denotes the initial budget expenditure for the fiscal year. Both are measured in constant 2005 US dollars. Control variables include: population density, total expenditure per capita, and percentage of votes for the president in the previous election. Including time and region fixed effects. Robust standard errors in parenthesis. * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Source: Authors' calculations based on data from Ministry of Economy and Finance (MEF), DesInventar, National Institute of Statistics and Informatics (INEI) and Proetica.

Table 6 displays the same estimations but including some interactions of the resilience and institutional capacity indicators with the physical impacts of geological and climatological disasters. The purpose of doing this is to identify whether vulnerability and institutional capacity may matter in regions more affected by natural disasters. In fact, the results show that the effects of the institutional capacity and resilience indexes are conditional on the impacts of natural disasters. For the case of executed prevention expenditure, regions with lower resilience capacity receive more dollars per capita if the region was more seriously affected by climatological disasters. Note that the same results are found for the executed recovery expenditure in column 5. Higher vulnerability means that the region may suffer more from disasters in the short and long run, and consequently more resources in order to attend or prevent disasters are necessary. This is exactly what these results may be showing.

Additionally, column 5 shows that regions with higher institutional capacity receive less recovery expenditure conditioned on the impacts of climatological disasters. The coefficient from this interacted term may indicate that regions with greater institutional capacity are likely to have greater facilities to cope with disasters and therefore less need for additional resources. However, this would also imply some inefficiency in the distribution of resources. Nonetheless, the opposite results are found for the case of geological disasters in columns 7 and 8; regions with higher institutional capacity receive more resources to deal with disasters conditional on having greater impacts. Likewise, results differ for regions more affected by geological disasters. The interacted resilience index coefficient is positive in columns 7 and 8. This suggests that regions more seriously affected by geological disasters and with higher social vulnerability are associated with receiving a smaller amount of recovery expenditure. However, these coefficients are not significant.

Table 6. Fixed Effects Estimation for Prevention and Recovery Expenditure per Capita

VARIABLES	(1) Prev. Exec.	(2) Prev. Budget.	(3) Prev. Exec.	(4) Prev. Budget.	(5) Rec. Exec.	(6) Rec. Budget.	(7) Rec. Exec.	(8) Rec. Budget.
Climate impact x Inst. Capacity	-1.777	0.775*			-2.804***	0.257		
	(1.589)	(0.445)			(0.667)	(2.964)		
Climate impact x Resilience ind.	-3.161*	1.875			-5.267**	-2.227		
	(1.715)	(1.588)			(2.547)	(4.190)		
Geolog. impact x Inst. Capacity			-0.130	0.209			5.452*	8.842**
			(0.261)	(0.240)			(2.674)	(3.774)
Geolog. impact x Resilience ind.			-0.523	-1.885*			4.253	1.640
			(0.684)	(1.021)			(3.603)	(6.131)
Climate Physical impact	1.393	0.541			0.0666	0.952		
	(0.905)	(0.379)			(1.858)	(3.563)		
Institutional Capacity	0.0580	0.0842	-0.122	0.0901	-0.330	0.394	-0.677	0.121
	(0.334)	(0.130)	(0.286)	(0.0970)	(0.506)	(0.679)	(0.665)	(0.727)
Resilience Indicator	-1.639	1.789*	-1.815	1.637	0.744	3.061	-0.857	0.136
	(1.253)	(0.977)	(1.677)	(1.134)	(1.823)	(3.316)	(1.507)	(2.380)
Observations	199	199	199	199	199	199	199	199
Number of codigo_depto	25	25	25	25	25	25	25	25
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: All physical impact variables indicate cumulative effects in last five years. Executed expenditure (Exec) represents committed expenditure. Budget denotes the initial budget expenditure for the fiscal year. Both are measured in constant 2005 US dollars. Control variables include: population density, total expenditure per capita, and percentage of votes for the president in the previous election. Including time and region fixed effects. Robust standard errors in parenthesis. * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Source: Authors' calculations based on data from Ministry of Economy and Finance (MEF), DesInventar, National Institute of Statistics and Informatics (INEI) and Proetica.

5.1 Results by Type

Table 7 proceeds by estimating the same regressions but disaggregating by type of impact: on population, agriculture or infrastructure. All the regressions in this table include cumulative physical impact during the five previous years. Notice that impacts of natural disaster on population determine only prevention expenditure but not recovery expenditure. This suggests that expenditure to prevent future disasters is not conditioned by historical impacts on population. However, recovery expenditure does correlate with this impact, as would be expected. Greater impacts in terms of population killed and affected necessarily require greater resources in order to provide relief to affected regions. But results from columns 1 to 4 suggest that this is not the same for prevention expenditure; the historical impacts on population do not drive the distribution of these resources.

Another interesting result from this table is that impacts of natural disaster on agriculture affect prevention expenditures. Therefore, historical impacts on agriculture seem to be another important factor in deciding where to execute expenditure related to preventing future disasters. Many of the prevention expenditure activities, as mentioned above, consist of irrigation and soil conservation projects which benefit the agricultural sector. This would suggest that these projects are directed toward regions whose agriculture is more seriously affected by natural disasters. However, this allocation could also reflect pressure from special interest groups in this sector, as most prevention expenditure is being driven by impacts on agriculture and not on population or infrastructure.

Finally, effects on infrastructure do not seem to be correlated with either prevention or recovery expenditures. Even column 2 suggests that effects on infrastructure may be negatively correlated with prevention expenditure. The resilience indicator again shows a negative coefficient in columns 1 and 2, suggesting that a negative association of regions' resilience capacity with the amount of resources to prevent natural disasters. In the same way, the institutional capacity index is significant only in column 6 which reflects that regions with higher institutional capacity receive higher resources to deal with the effects of natural disasters.

Table 7. Fixed Effects Estimation for Prevention and Recovery Expenditure per Capita by Type of Impact

VARIABLES	(1) Prev. Exec.	(2) Prev. Exec.	(3) Prev. Budget	(4) Prev. Budget	(5) Rec. Exec.	(6) Rec. Exec.	(7) Rec. Budget	(8) Rec. Budget
Population impact	0.229	0.721	-0.164	-0.0592	6.513***	6.350***	6.697***	7.787***
	(0.197)	(0.551)	(0.146)	(0.198)	(0.937)	(1.043)	(1.803)	(1.679)
Agriculture impact	0.199	1.151***	0.599***	1.120**	0.406	0.178	-0.162	0.0104
	(0.329)	(0.398)	(0.211)	(0.490)	(1.054)	(1.029)	(0.714)	(1.364)
Infrastructure impact	-0.168	-0.949**	-0.193	-0.450	-0.453	-0.840	0.478	-0.603
	(0.225)	(0.341)	(0.263)	(0.499)	(0.660)	(0.757)	(1.130)	(0.837)
Resilience Indicator	-1.292**	-2.207*	0.650	1.125	0.0799	-0.280	0.999	2.529**
	(0.574)	(1.247)	(1.087)	(1.199)	(0.942)	(1.170)	(1.421)	(1.218)
Institutional Capacity		-0.385		-0.324		-1.070*		-0.189
		(0.235)		(0.202)		(0.621)		(0.712)
Observations	225	199	225	199	225	199	225	199
Number of codigo_depto	25	25	25	25	25	25	25	25
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: All physical impact variables indicate cumulative effects in last 5 year. Executed expenditure (Exec) represents committed expenditure. Budget denotes the initial budget expenditure for the fiscal year. Both are measured in constant 2005 US dollars. Control variables include: population density, total expenditure per capita, and percentage of votes for the president in the previous election. Including time and region fixed effects. Robust standard errors in parenthesis. * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Source: Authors' calculations based on data from Ministry of Economy and Finance (MEF), DesInventar, National Institute of Statistics and Informatics (INEI) and Proetica.

5.2 Cumulative Expenditure

If we use three-year cumulative expenditure instead of year-by-year expenditure the results are somewhat different, as reflected in Table 8. The table shows that climatological physical impacts influence recovery expenditure, which was not found in previous results. Many of the recovery expenditures include rehabilitation and rebuilding that involve long-term rather than one-year projects. In particular, reconstruction of flood barriers and retaining walls involves multi-year work and expenditure, and it thus reasonable to see cumulative recovery expenditure as dependent on previous history of climatological disasters. Another difference with the results above is that none of the physical impacts of any of the natural disasters seem to affect prevention expenditure. Instead, the resilience indicator has a significant positive coefficient. This suggests that regions with higher resilience capacity are receiving higher expenditure to prevent natural disasters.

Table 8. Fixed Effects Estimation for Recovery Expenditure per Capita in Three-Year Cumulative Periods

VARIABLES	(1) Prev. Exec.	(2) Prev. Budget	(3) Rec. Exec.	(4) Rec. Budget
Climate Physical impact	-5.990	-1.857	12.48***	12.84***
	(5.227)	(4.269)	(3.838)	(3.975)
Geological Physical impact	-2.353	-1.900	22.14***	27.07***
	(2.321)	(1.635)	(1.698)	(5.818)
Epidemic Physical impact	0.816	-4.210	4.361	-4.656*
	(2.662)	(4.078)	(4.449)	(2.314)
Pollution Physical impact	5.458	-0.261	-0.408	-2.446
	(4.327)	(1.325)	(2.627)	(3.250)
Resilience Indicator	10.23**	8.190***	-2.904	-5.076
	(4.487)	(2.610)	(2.396)	(3.322)
Institutional Capacity	-4.036	-2.335	-0.0580	-3.082
	(3.639)	(2.542)	(1.711)	(2.784)
Observations	100	100	100	100
Number of codigo_depto	25	25	25	25
Controls	Yes	Yes	Yes	Yes

Note: Executed expenditure (Exec) represents committed expenditure. Budget denotes the initial budget expenditure for the fiscal year. Both are measured in constant 2005 US dollars. Control variables include: population density, total expenditure per capita, and percentage of votes for the president in the previous election. Including time and region fixed effects. Robust standard errors in parenthesis. * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Source: Authors' calculations based on data from Ministry of Economy and Finance (MEF), DesInventar, National Institute of Statistics and Informatics (INEI) and Proetica.

6 Final Remarks

Public resources play a crucial role in adaptation and, given that those resources are limited, it is crucial to distribute them appropriately. Their deployment can be a matter of life and death when providing relief to populations affected by a natural disaster. However, a disaster's impact can be minimized if public resources are able to enhance the capacity to react to shocks. In this work an index of resilience based on a definition of social vulnerability was constructed to measure the adaptive and coping capacity of each region according to some socio-economical variables. However, when analyzing the relation of the index with the total expenditure used to prevent natural disasters, the results suggest that social vulnerability is not a robust factor of influence on where to spend those resources. In fact, three-year cumulative spending is negatively correlated with a region's vulnerability. Similarly, an index of institutional capacity was used to measure a region's ability to use resources effectively, and this index also seems not to be determinant in the distribution of prevention or recovery expenditures.

However, by looking at the interacted terms, the results show that the resilience indicator is significant in affecting prevention and recovery expenditure. This suggests that, conditioned on greater impacts of climatological disasters, prevention and recovery expenditure are executed mainly in more vulnerable regions. However, the opposite is found for geological impacts; recovery expenditure occurs largely in regions with lower social vulnerability. The nature of geological events must be borne in mind, though, as they are few in number but with huge effects on population and infrastructure that require massive transfers of resources. Similarly, the coefficients for institutional capacity variable show contradictory results depending on the natural disaster. Conditioned on high impacts of climatological disasters, institutional capacity seems to have a negative effect on executed recovery expenditure. Conditioned on greater geological impacts, however, this variable is positively correlated with the dollars per capita used to deal with natural disasters.

The results for the physical impacts index suggest that prevention expenditure is mainly conditioned by historical climatological disaster events. This only suggests that expenditure is used largely to cope with potential natural disaster, but it is not possible to analyze whether expenditure has been used for long-term adaptation. The regions most affected by climatological disasters in the last five to 30 years are receiving greater amount of dollars per capita for disaster prevention expenditures. Recovery expenditures, in contrast, are driven by biophysical impacts, mainly for geological disasters.

The evidence presented in this paper indicates that an important fraction of prevention and recovery expenditure is guided by hazard risk, measured by long-term previous exposure. The economic significance of these results is remarkable, showing that an increase of 2.12 standard deviations in the climatological physical impact variable for 30 years is positively associated with an increase of between 2.0 and 4.2 standard deviations of prevention spending per capita. In the same way, an increase of 1.6 standard deviations of the geological physical impact variable for 30 years would imply an increase of between 1.4 and 2.0 standard deviations in recovery spending per capita. While an increase of this magnitude would entail an increase in average spending per capita for all regions, exposure to previous disasters accounts for only 15% to 25% of total expenditure variability.

In regard to the attributes of concern, i.e., impacts on population, agriculture or infrastructure, the estimations suggest that recovery expenditures are being driven by the effects on population of past natural disasters. In contrast, prevention spending is being distributed according to the natural disaster effects on agriculture. In fact, a great part of this expenditure goes to projects related to irrigation and conservation of land.

According to the results, spending is being used as a response to historical natural disasters. Further work is needed to determine if these expenditures are also being used in anticipation of future vulnerability. It is additionally important to study the dynamic nature of vulnerability, especially in relation to potential effects of climate change.

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A Appendix Tables

Appendix Table A.1. Descriptive Table (Averages 1999-2011)

Region	Mean			
	Population	Area (km2)	GDP per cap (thousands)	Perc Poverty
AMAZONAS	399,911	39,249	US$0.77	64.47%
ANCASH	1,083,345	35,914	US$1.66	45.79%
APURIMAC	433,238	20,896	US$0.51	70.77%
AREQUIPA	1,153,093	63,345	US$2.30	28.95%
AYACUCHO	611,276	43,815	US$0.75	68.86%
CAJAMARCA	1,455,211	33,318	US$0.96	64.93%
CALLAO	865,937	147	US$2.87	
CUSCO	1,225,922	71,986	US$1.01	56.57%
HUANCAVELICA	455,578	22,131	US$0.92	83.51%
HUANUCO	787,727	36,849	US$0.62	72.18%
ICA	703,375	21,328	US$1.91	24.95%
JUNIN	1,251,744	37,667	US$1.24	48.17%
LA LIBERTAD	1,635,511	25,500	US$1.35	43.71%
LAMBAYEQUE	1,148,178	14,231	US$1.12	43.76%
LIMA	8,454,560	34,802	US$2.87	26.12%
LORETO	916,391	368,852	US$1.03	62.06%
MADRE DE DIOS	105,136	85,301	US$1.69	25.38%
MOQUEGUA	161,902	15,734	US$4.22	28.67%
PASCO	280,103	25,320	US$1.90	62.68%
PIURA	1,691,732	35,892	US$1.13	53.17%
PUNO	1,290,555	66,997	US$0.81	71.20%
SAN MARTIN	722,617	51,253	US$0.82	49.49%
TACNA	295,484	16,076	US$2.22	23.76%
TUMBES	203,307	4,046	US$1.07	24.64%
UCAYALI	428,484	101,831	US$1.17	49.46%

Source: INEI

Appendix Table A.2. Summary Statistics

Variable	Mean	(Std. Dev.)
Prevention expenditure per capita (US 2005 constant prices)	1.377	(3.894)
Recovery expenditure per capita (US 2005 constant prices)	2.21	(5.329)
Climate Physical impact 1y	-0.048	(0.348)
Geological Physical impact 1y	0.014	(0.793)
Epidemic Physical impact 1y	0.012	(0.565)
Pollution Physical impact 1y	-0.036	(0.265)
Climate Physical impact 5y	-0.022	(0.458)
Geological Physical impact 5y	0.015	(0.659)
Epidemic Physical impact 5y	0.023	(0.548)
Pollution Physical impact 5y	-0.04	(0.362)
Climate Physical impact 30y	0.016	(0.47)
Geological Physical impact 30y	0.021	(0.680)
Epidemic Physical impact 30y	0.039	(0.527)
Pollution Physical impact 30y	-0.004	(0.441)
Perc. health centers destroyed 30y	0.262	(1.936)
Perc. education centers destroyed	0.353	(2.158)
Perc. victims per each 100 inhabitants	0.6	(4.085)
Perc. population affected	0.531	(1.898)
Perc. of homes affected.	0.262	(1.446)
Perc. homes destroyed	0.27	(2.567)
Routes affected per each 1,000 km	0.846	(4.425)
Perc. crops destroyed	0.934	(5.299)
Perc. livestock affected	0.019	(0.128)
Population above extreme poverty (%)	77.165	(17.542)
Inverse of qualitative housing deficit (%)	86.675	(12.337)
Households with low dependency (%)	98.167	(1.11)
Population with hygienic services (%)	73.608	(15.913)
Population with no caloric deficit (%.)	66.893	(11.779)
Households with beneficiaries from alimentary programs (%)	39.074	(12.616)
Women's years of education	8.821	(1.005)
Perc. GDP not from agriculture	83.745	(8.814)
Population without health problems (%)	28.102	(11.1)
Credits per capita	1.176	(1.753)
Perc. low corruption (self-perception)	30.173	(8.826)
Perc. of local authorities without vacancies	96.544	(1.723)
100-index of corruption	95.39	(2.314)
Perc. of municipalities with appropriate Civil Defense	52.823	(13.267)
Municipalities with Civil Defense technical capabilities	54.891	(12.07)
Perc. municipalities with environmental management plan	8.774	(8.67)
Perc. municipalities participatory budgeting	89.878	(8.677)

Source: Ministry of Economy and Finance (MEF), DesInventar, National Institute of Statistics and Informatics (INEI) and Proetica.

Appendix Table A.3. Estimation for Prevention and Recovery Expenditure per Capita including lagged dependent variable

VARIABLES	(1) Exec Prev. FE	(2) Exec Prev. GMM	(3) Budget Prev. FE	(4) Exec Prev. GMM	(5) Exec Rec. FE	(6) Exec Rec. GMM	(7) Budget Rec. FE	(8) Exec Rec. GMM
Climate Physical impact	1.883	3.005**	0.478	1.190**	2.463	2.294*	2.928	4.233***
	(1.183)	(1.218)	(0.325)	(0.489)	(1.826)	(1.251)	(2.752)	(1.340)
Geological Physical impact	0.00658	-0.196	-0.211	-0.108	5.801**	4.354***	7.420**	5.569***
	(0.157)	(0.164)	(0.152)	(0.129)	(2.139)	(0.699)	(3.068)	(0.790)
Epidemic Physical impact	0.661	1.116*	-0.931	-0.171	1.385	1.460	0.340	0.918
	(0.895)	(0.580)	(0.677)	(0.206)	(0.891)	(0.915)	(1.378)	(0.957)
Pollution Physical impact	0.265	-0.417	0.261	-0.824*	-1.157	0.790	0.946	0.656
	(0.353)	(0.409)	(0.449)	(0.447)	(1.307)	(1.558)	(1.116)	(1.675)
Expenditure per cap (lag 1)	0.0757	0.657***	0.178	0.247	-0.0700	0.203*	0.00344	0.286***
	(0.0478)	(0.102)	(0.268)	(0.176)	(0.143)	(0.107)	(0.153)	(0.0834)
Resilience Indicator	-0.408	1.109	-0.00510	0.0729	0.108	0.384	1.065	0.207
	(0.984)	(0.721)	(0.699)	(0.403)	(2.122)	(1.100)	(2.326)	(1.126)
Institutional Capacity	0.0120	-0.0565	-0.325	-0.254	-0.548	-0.706	0.0530	0.252
	(0.244)	(0.326)	(0.267)	(0.215)	(0.681)	(0.733)	(0.629)	(0.782)
Observations	199	199	199	199	199	199	199	199
Number of codigo_depto	25	25	25	25	25	25	25	25
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR(2)		0.560		0.167		0.945		0.00762
Hansen Test		0.539		0.830		0.796		0.517

Note: All physical impact variables indicate cumulative effects in the last five years. Executed expenditure (Exec) represents committed expenditure. Budget denotes the initial budget expenditure for the fiscal year. Both are measured in constant 2005 US dollars. Control variables include: population density, total expenditure per capita, and percentage of votes for the president in the previous election. Including time and region fixed effects. For the Arellano-Bond Dynamic Panel GMM, a two-step estimator is applied using the level equation and the first difference regression equation, where the first order difference variables and the lagged variables are employed as instrument variables for the level and first difference equation, respectively. Robust standard errors in parenthesis. * significant at 10% level, ** significant at 5% level, *** significant at 1% level. Source: Authors' calculations based on data from Ministry of Economy and Finance (MEF), DesInventar, National Institute of Statistics and Informatics (INEI) and Proetica.