Can we prevent disasters using socioeconomic and political policy tools?

by

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Abstract

Can a nation prevent a hazard-related disaster by investing in socioeconomic and political policy tools? Drawing on 8 global datasets (1960-2016) and using a fixed effects logit model, we examine the importance of socioeconomic and political factors in changing the likelihood of disasters in 224 countries. We find that socioeconomic factors are of more importance than political factors. Low-income countries are significantly more disaster prone than high-income countries; this effect is stronger and more robust for natural than technological disasters. Higher national population density increases the probability that a hazard turns into a disaster; this effect is much stronger and robust for technological than natural disasters. Educational endowment has a negative and statistically significant effect on the probability of all disasters, especially for natural-related disasters. In terms of political factors, there is no evidence that government composition and federalism influence a country's natural or technological disaster probability. Nevertheless, there is very weak evidence that quality of governance has a positive and statistically significant effect on the likelihood of disasters. Our findings point out that we can prevent natural and technological disasters by investing in economic development, investing in education, and managing disaster prone in high urban areas. These findings highlight the importance of focusing efforts on addressing larger scale macro-economic, social and cultural distortions that generate vulnerability, as well as the prioritizing investment in both the Sendai Priorities and the Sustainable Development Goals that previously have not been linked to disaster probability.

Keywords: disaster preparedness and prevention; natural disasters; technological disasters; socioeconomic environment; political environment

1. Introduction

Can we prevent hazard-related disasters? Decades of evidence shows that we cannot stop natural and technological hazards from occurring, but we can either prevent them to be turned into a disaster (i.e. we can reduce disaster probability) or make them less damaging (i.e. we can reduce disaster risk[1]) if we understand better why they happen, and where possible prevent or reduce the extent of the things exposed, and mitigate disaster probability or risk (World Bank and United Nations 2010; Ashdown 2011; Foresight 2012). Major work has gone into the mitigation of disaster risk over the last thirty years, by the United Nations International Strategy for Disaster Risk Reduction (UNISDR), documented in the 1995 Yokohama agreement, the 2005 Hyogo framework, and more recently the 2015 Sendai agreement. Despite this, the UNISDRs 2015 Global Assessment Report highlights the same three key messages that have been articulated by the UNISDR since the Yokohama agreement (UNISDR 2015). First, disaster losses in terms of lives lost, people affected and economic damages, remain substantial. Second, expected future losses threaten economic and social development in lower-income countries. Third, macro level drivers of risk are the most significant, e.g. income inequality and poverty. Ultimately, the biggest challenge to addressing disaster risk appears to come from the most intractable problem, i.e. reducing the underlying drivers of risk. At present, these drivers appear to be: poverty, high levels of inequality, growing urbanisation, and environmental degradation (World Economic Forum 2018; Tselios and Tompkins 2019). To address these gaps, there are calls for more evidence on the costs and risk reduction benefits of reducing poverty and inequality (i.e. economic and social vulnerability), and, on the impact of improvements in accountable decision making in hazard prone countries (World Economic Forum 2018; UNISDR 2015).

While a large body of research has been conducted on the impacts of disasters – socioeconomic and political (e.g. Strömberg 2007; Tselios and Tompkins 2017; Vaillancourt and Haavisto 2016; Yamamura 2012; Skidmore and Toya 2002; Escaleras and Register 2012; Skidmore and Toya 2013; Tselios and Tompkins 2019), only a few empirical studies have examined the determinants of a country's likelihood of happening a disaster (i.e. Ward and Shively 2017; Kahn 2005; Wheeler 2011; Cohen and Werker 2008; Davis and Seitz 1982). The results are mixed. To date, there has been a nearly 40 years old study (Davis and Seitz 1982) which draws on multiple, diverse, large data sets (up to 1973) to examine the role of economic, social and political factors. Davis and Seitz did not disaggregate natural and technological hazards, however, four social, economic and political factors emerged from their analysis, that appear important in driving disasters: government effectiveness, government instability, available resources and social context. A few years later, Kahn (2005) found that richer nations do not experience fewer natural-hazard driven consequence of disasters than poorer nations, but Wheeler (2011) and Ward and Shively (2017) find that low-income countries cannot prevent climate-related disasters and they are significantly more at risk of these disasters. Cohen and Werker (2008) investigated the feedback between policy interventions and the seriousness of disasters. Their findings pointed to the importance of investing in prevention, decentralising relief, encouraging

[1] Definitions of disaster and disaster risk are taken from EM-DAT [The Emergency Events Database – Université catholique de Louvain (UCL) – CRED, D. Guha-Sapir – www.emdat.be, Brussels, Belgium]. *Disaster* is a situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance. It is an unforeseen and often sudden event that causes great damage, destruction and human suffering. *Disaster risk* is the expected losses (of lives, persons injured, property damages and economic activity disrupted) due to a particular hazard for a given area (e.g. country) and reference period (e.g. year). Hence, *disaster risk* is related to *disaster outcomes*. Finally, according to EM-DAT, disaster risk is the product of hazard and vulnerability.

political openness and accountability, and rewarding states which managed to turn hazards into non-disasters.

The aim of this paper is to identify which socioeconomic and political factors affect a country's probability of happening a disaster as a result of exposure to a hazard, which is known as disaster propensity. We examine the following two research questions. A) Can a nation have high disaster propensity? We argue that some nations have higher disaster propensity than other nations, because they differ in socioeconomic and political environment. A socioeconomically and politically vulnerable society is significantly more likely to exposure to a disaster than a socioeconomically and politically secure society. For example, if a tropical cyclone event is heading for the Caribbean, most people would hypothesize that if hit, Haiti is more likely not to prevent a tropical-cyclone-associated disaster (and therefore it is more likely to experience more severe disaster outcomes) than neighboring countries. Reasons for this hypothesis might include: Haiti's higher social, economic and/or political frailty than neighboring countries. B) Can a nation reduce the likelihood of happening a disaster by investing in socioeconomic and political policy tools? Since the socioeconomic and political environment of a country plays a key role in the likelihood of the country to exposure to a disaster, we argue that a nation can reduce its disaster propensity by investing in socioeconomic and political policy tools. For example, if a decrease in income inequality in a nation reduces its disaster probability, this nation can apply policies for higher equity to reduce disaster propensity.

The contribution of the present paper centers on the following aspects. First of all, to the best of our knowledge, this is the first empirical study which examines an array of socioeconomic and political factors and which of these factors effect disaster propensity. This study follows the focus of UNISDR Sendai Report (UNISDR 2015) and the Intergovernmental Panel on Climate Change (IPCC) Report on Global Warming of 1.5 ^{o}C (Roy et al. 2018) which stress the importance of the socioeconomic and political drivers of vulnerability. Since longer time-series datasets and more country datasets are becoming available, more opportunities are emerging to explore the complex relationships between disasters and economy, society (e.g. economic development, national productivity, urban population and income inequality, among others) and politics (e.g. quality of governing institutions and structures of government, among others). Yet, evidence of the relative impact of a range of policy factors (socioeconomic and political) in reducing a country's likelihood of happening disasters is limited (Pelling and Dill 2010). The analysis of this paper uses a unique global data set from 1960 to 2016, which contains data on disasters for 224 countries (from EM-DAT), data on economic and social characteristics of countries which represent the socioeconomic environment, and data on institutional, political and electoral results which represent the political environment. Moreover, this is the first empirical study which looks at both (hazard-related) natural and technological disasters[2] in order to explore possible differences between the drivers of these types of disasters. This study also looks at predictable disasters, because the predictability of disasters means that theoretically there is more time for countries to plan and prepare, and either prevent disasters or reduce disaster impacts (Vaillancourt and Haavisto 2016). From a methodological point of view, and in contrast with the methods applied in most of the literature so far, the analysis of this paper is based on a fixed effects

[2] Definitions of natural and technological disasters are taken from EM-DAT. The *natural disaster* category includes the following sub-categories: geophysical (earthquake, volcanic activity and mass movement), meteorological (storm, extreme temperature and fog), hydrological (flood, landslide and wave action), climatological (drought, glacial lake outburst and wildfire), biological (epidemic, insect infestation and animal accident), and extra-terrestrial (impact and space weather). The *technological disaster* category includes the following sub-categories: industrial accident (chemical spill, collapse, explosion, fire, gas leak, poisoning, radiation, oil spill and other), transport accident (air, road, rail and water), and miscellaneous accident (collapse, explosion, fire and other).

logit model, as it has the advantage of controlling for physical geography characteristics of nations. Moreover, it combines econometric analysis with mapping of the data, in order to explore, on a country-by-country basis, the associations between significant socioeconomic and political factors and disaster propensity. This is very important because a better understanding of the determinants of disaster propensity using econometric analysis, if combined with geo-physical characteristics, could enable greater targeting of pre-disaster (ex-ante) prevention funding and activity. From a policy point of view, exploring the determinants of disaster propensity is very important because planning and preparing for disasters is considered more cost-effective than post-disaster initiatives such as disaster relief and recovery (Vaillancourt and Haavisto 2016; Altay, Prasad, and Tata 2013; Christoplos, Mitchell, and Liljelund 2001; Skoufias 2003). While many recurrent natural disasters are predictable to some degree, e.g. hydro-meteorological events such as hurricanes, floods and droughts; some disasters are complex and unpredictable (e.g. the Fukushima Daiichi nuclear disaster, chemical spills, oil spills, explosions, fires, radiation, and road accidents). Unpredictability makes planning and preparation even more important (Beamon and Balick 2008). Therefore, this paper sheds light on disaster preparedness/ex-ante policies that could reduce the likelihood of happening disasters and on what governance arrangements are most appropriate for developing and delivering these policies.

This paper first reviews notions of hazards, disasters, and socioeconomic and political vulnerability. Section 3 presents the methodology and Section 4 the data and variables used. Section 5 is devoted to the presentation and theoretical justification of the results. The final section sums up the analysis, evaluates the findings, discusses some potential limitations and suggests areas for further research.

2. Disaster preparedness and prevention: vulnerable societies

Disasters occur when a hazard causes widespread destruction to society and the economy, and external aid for recovery is usually needed (Blaikie et al. 1994; Alexander 2004; Cardona et al. 2012). It is widely known that hazards happen often (Bull-Kamanga et al. 2003), but they do not always result in a disaster.

Disasters arise through the convergence of two distinct pressures: **natural or technological hazards** and **vulnerable societies** (Mirza 2003; Field et al. 2012). The larger the magnitude of a hazard that affects a society (e.g. the larger the magnitude of an earthquake or the larger the chemical spill), the higher the society's probability of experiencing a hazard-associated disaster. The magnitude of a disaster mainly depends on exogenous factors, such as geology, meteorology, and geophysical environment. For example, if the hypocenter of an earthquake is close to the Earth's surface, it will cause more damage than a deep earthquake. If an earthquake lasts only a few seconds, it is less likely to cause a disaster than a longer earthquake. Countries cannot control the exogenous factors that determine hazards, but can reduce hazard-associated disasters through planning and preparation of society (Peduzzi et al. 2009). Preparedness activities clearly vary with hazard type and geography, however, for most hazards there is reasonably well developed: i) literature on preparedness e.g. on early warning systems (Zschau and Küppers 2013), ii) practical guidance on mitigation e.g. on how to design buildings in earthquake zones (Anand S. Arya, Teddy Boen, and Yuji Ishiyama 2014), and iii) development of institutions to deliver preparedness for specific hazards, e.g. National Oceanic and Atmospheric Administration (NOAA) for Hurricane Centre in the USA (Rappaport et al. 2009), and the Famine Early Warning Systems Network (FEWS NET) in Africa (Verdin et al. 2005). Yet despite this documentation, in the latest IPCC 1.5 °C report, there is a clear articulation of the need to improve the enabling conditions, notably institutional capacity and governance, to support adaptation to current and future climate risks (de Coninck et al. 2018).

Socioeconomic vulnerability is shaped by economic structures and the characteristics of a society. The IPCC 2012 Special Report on Extreme Events recognizes that socioeconomic vulnerability is not well defined or explained in the literature, with definitions often overlapping with risk, resilience or exposure (Cardona et al. 2012). Social and economic vulnerability is shaped by macroeconomic conditions (e.g. economic development and growth, unemployment rate and tax revenues etc.) and thus by economic and social policy tools (e.g. development policies, employment policies, tax policies etc.). Hazards in countries with more stable and wealthier (secure) economies and societies face a lower probability of the hazards to be turned into a disaster than unstable and poor (insecure) ones. Rich societies, for example, can better afford to implement policies to prevent disasters, such as policies for the construction of strong and sustainable buildings, for building codes, for land zoning control, for irrigation to avoid droughts, and for warning systems for storms and hurricanes (Strömberg 2007; Escaleras and Register 2012). Unstable and poor macroeconomic environments lead to a reduction in public expenditures, which implies lower spending on education, health, infrastructure and sanitation, making societies more insecure and vulnerable (Botchwey et al. 1998). Moreover, countries with high levels of government spending are better able to withstand the shock of an extreme hazard (Noy 2009). High unemployment rates usually increase disaster probability and risk and death toll (Zhou et al. 2014) and, thus, social policies for lower unemployment reduce the probability a country will experience consequence of a disaster. Finally, an increase in income inequality is likely to increase the likelihood of happening a disaster, because inequality increases the share of the very poor as this group is particularly vulnerable (Chou et al. 2004).

Political vulnerability refers to the impact of political ideologies and power structures on a society. It includes institutions for governance, e.g. nature of the institutions, scales of governance, conflicts between formal and informal governance and quality of measures adopted (Adger et al. 2005); quality of governance (Brooks, Adger, and Kelly 2005); power relations and risk perceptions that shape the political landscape (Cardona et al. 2012; Tierney 2012); different types of political ideologies and strategies, as the right-wing parties are based on economic freedom and the left-wing parties usually support egalitarianism (Tselios and Tompkins 2017); power structures that can marginalise some groups in society, reproducing inequalities (Pelling and Dill 2010); and different types of local representation (e.g. federalism and decentralisation). Since the government typically handles many of the macroeconomic mitigation measures, disasters may be prevented in countries with efficient and accountable governments (Strömberg 2007). Disaster management and response is enhanced where there is high quality governance and effective, collaborative and aligned disaster risk management institutions (Kapucu 2011; van Voorst 2016). Moreover, countries with better functioning institutions are better able to prevent a disaster (Noy 2009). As for decentralisation, on the one hand, it may improve the provision of local public goods and services and may better able to set the optimal mix of local policies prior to the disaster event than bureaucrats in distant central government (Skidmore and Toya 2013; Oates 1972; Tiebout 1956; Tselios et al. 2012; Lessmann 2009), and on the other hand, it may reduce the capacity of central government to transfer resources to the most affected areas from hazards and may not mean a better matching of the provision of local public goods and services in poor regions because these regions face capacity constraints (Prud'homme 1995; Rodríguez-Pose and Ezcurra 2011; Pelling 2011). Political vulnerability is perceived to be reduced where governments have a disaster response plan, trained personnel and the necessary physical resources (McEntire 1999; Oloruntoba 2005; Keefer, Neumayer, and Plumper 2011).

3. Methodology

We explore the socioeconomic and political drivers of disaster propensity using an econometric model with panel data analysis (i.e. the same variables measured at two or more points in time) in order to minimize potential problems of omitted variable bias, to increase degrees of freedom (i.e. to increase the number of observations that have the freedom to vary) and to improve the accuracy of the parameter estimates (i.e. to obtain narrow confidence intervals) (Baltagi 2005). The econometric model adopts the following form:

$$DisasterPr_{it} = \beta_0 + SocEconCh_{it}\beta_1 + PolitCh_{it}\beta_2 + u_{it}$$

where $DisasterPr_{it}$ is the disaster propensity of country *i* at time t. The disaster propensity is a dummy variable (i.e. a binary dependent variable) which equals 1 if country *i* at time *t* has experienced a disaster, and 0 otherwise. In other words, this variable shows whether a hazard turns into a disaster. Taking into account that hazards in a country happen often (Bull-Kamanga et al. 2003), we assume that the disaster propensity equals 0 if country *i* at time *t* may have experienced hazard(s) but it(they) did not cause any widespread destruction and loss of lives, and therefore it(they) did not cause disaster. For example, earthquakes occur very frequently in a country, but only a few of them cause great damage, destruction and human suffering, because most of them are of low magnitude, are not close to the Earth's surface, or last only a few seconds. $SocEconCh_{it}$ and $PolitCh_{it}$ represent a matrix of socioeconomic and political characteristics, respectively, for country *i* at time *t*, which may affect disaster propensity. β_0 is the constant, β_1 and β_2 are vectors of coefficients of the above matrices, and u_{it} is the composite error. The composite error (u_{it}) takes the form $u_{it} = c_i + \varphi_t + \varepsilon_{it}$, where c_i is an unobserved time invariant national effects (i.e. represents the fixed effects), φ_t is a vector of time-dummies (i.e. represents the time-period fixed effects), and ε_{it} is the disturbance term (idiosyncratic error) which is a zero-mean residual uncorrelated with all the terms on the right-hand side.

Taking into account that we have a binary dependent variable, we use a fixed effects logit model. We control for stable characteristics (i.e. national characteristics that do not change across time) whether they are measured or not. These include topography, latitude, location, elevation, incidence of natural resource endowment, soil, mountains, rivers, and climate, among others. These natural features are known as first-nature of geography factors (Krugman 1993; Rodríguez-Pose et al. 2013; Naudé 2009). The unobserved time-invariant national effects (c_i) also include the geophysical, meteorological, hydrological, climatological, and biological time-invariant characteristics which are key determinants of a country's natural disaster propensity. For example, some areas and countries are known for tremors and tectonic movement and therefore these areas are prone to seismic activity of some kind. The unobserved time-invariant national effects control for the seismic zone which is a time-invariant characteristic. Therefore, the fixed effect model can control for countries which are prone to natural disasters due to physical geography characteristics. However, the effects of physical geographic factors may vary depending on the particular disaster in question. The fixed effects methods also control for the size of countries (total land area) which is an important variable, because the larger the land area of a country the higher the probability that the country experiences consequences of a disaster. Generally, the fixed effect methods help to control for these omitted variables by having countries serve as their own controls, but the effects of these characteristics are not estimated. The fixed effects logit models explicitly include all time-varying socioeconomic and political variables. The socioeconomic and political variables must change across time for some substantial portion of the countries. Fixed effects estimates use only within-country differences, essentially discarding any information about between-country differences.

We also combine econometric analysis with mapping of the data in order to explore, on a country-by-country basis, the associations between significant socioeconomic and political factors and the disaster probability.

4. Data and variables

Data on **disasters** ($DisasterPr_{it}$) were obtained from EM-DAT[3]. For a disaster to be entered into the EM-DAT, which implies $DisasterPr_{it} = 1$, at least one of the following criteria must be fulfilled: ten (10) or more people reported killed, hundred (100) or more people reported affected, injured or homeless (i.e. people requiring immediate assistance during an emergency situation), declaration by the country of a state of emergency or call for international assistance.

Figure 1 displays the global distribution of annual probability of natural or technological disasters.[4] We observe that some countries have a higher probability of disaster than other countries. The countries with the highest natural disaster probability are: USA, Mexico, Peru, Columbia, Brazil, India, Bangladesh, Indonesia, the Philippines, and Japan. While those with the lowest probability are Mayotte, Qatar, Malta, the United Arab Emirates, Brunei Darussalam, Saint Helena Ascension and Tristan da Cunha, Bahrain and Equatorial Guinea. As for technological disasters, the countries with the highest probability of disaster (based on past trends) are: USA, Brazil, Spain, the Philippines, India, and Indonesia. There are many countries with zero probability of technological disasters (i.e. these countries have not experienced a technological disaster). Generally, the larger the physical land area of the country (e.g. USA), the higher its disaster probability, as it is likely to experience more hazards per annum. Nevertheless, there are some exceptions (e.g. Russia). For example, earthquakes in Russia have occasionally been damaging and deadly, because the tectonic plates of Russia are inactive. This stresses the importance of geographical factors that this study controls through the unobserved time invariant national effects (c_i). We also observe that the neighboring countries do not have the same disaster probability. If a hazard event (e.g. tropical cyclone event) is heading for a Region (e.g. the Caribbean), some countries (e.g. Haiti) are more likely to experience consequences of a disaster as a result of the hazard than the neighboring countries. Neighboring countries do not have the same disaster propensity, because they differ in socioeconomically and politically.

Insert Figure 1 around here

Data on the **socioeconomic determinants** ($SocEconCh_{it}$) of a country's disaster propensity were obtained from three (3) international databases: the World Bank (WB) database which is a global development database compiled from officially-recognised international sources, the Penn World Table version 9.0 (PWT) database which is a macroeconomic database covering 182 countries between 1950 and 2014 (Feenstra, Inklaar, and Timmer 2015), and the Standardized World Income Inequality Database (SWIID) which provides estimates of the Gini index of income inequality for 174 countries for as many years as possible from 1960 to 2016 (Solt 2016). We use variables or proxy variables for

[3] The EM-DAT contains essential data on the occurrence and effects of over 22,000 mass disasters in the world from 1900 to the present day. Two main groups of disasters are distinguished in the EM-DAT: natural disasters and technological disasters.

[4] For example, let us take into account the period 1991-2000 (i.e. 10 years). If a hazard in a country in 1991, 1993, 1994, 1995, 1996, 1998, 1999, 2000 has been turned into a disaster (i.e. disaster propensity is 1) while in 1992 and 1997 has not been turned into a disaster (i.e. disaster propensity is 0), the annual probability of this country to experience a disaster is 8/10=0.8.

economic development and economic growth[5], agglomeration economies[6], urbanisation economies[7], sectoral composition, unemployment, public sector, investment, technological change and innovation, educational endowment and income inequality (see Table 1). These socioeconomic variables were chosen after considering the literature and the existing empirical studies on disasters, as well as the number of observations.

Insert Table 1 around here

Economic development is measured by the Gross Domestic Product (GDP) per capita (in *ln*) and economic growth by the annual percentage growth rate of GDP per capita. Population density (in *ln*) represents the market thickness of a country and can be considered as a proxy for agglomeration economies, while the urban population as a percentage of total population can be considered as a proxy for urbanisation economies. The sectoral composition of a country is the proportionate contribution of the agricultural, industrial and service sector in GDP. The unemployment rate is the share of the labour force that is without work but available for and seeking employment. We use two proxies for public sector: the tax revenue transferred to the central government for public purposes as a percentage of GDP and the expense of the government as a percentage of GDP. The capital stock (in *ln*) is a proxy for the cumulated investment flows. Total factor productivity is a proxy for technological change and innovation, and educational endowment is proxied by a human capital index which is based on years of schooling and returns to education. Finally, we measure income inequality as the Gini index of net- and market-income inequality.

Data on the **political determinants** ($PolitCh_{it}$) of a country's disaster propensity were obtained from four (4) political databases: the Database of Political Institutions 2015 (DPI2015) which presents institutional and electoral results data for about 180 countries from 1975 to 2015 (Cruz, Keefer, and Scartascini 2016); the Worldwide Governance Indicators (WGI) which report on six broad dimensions of governance for over 200 countries over the period 1996-2016 (Kaufmann, Kraay, and Mastruzzi 2010); the Regional Authority Indexes (RAI) by Hooghe et al. (2016) which provide the authority of regional governments for 81 countries from 1950 to 2010; and the Comparative Political Data Set (CPDS) which is a collection of political and institutional data for 36 democratic OECD and/or EU-member countries for the period of 1960 to 2015 (Armingeon, Wenger, Wiedemeier, Isler, Knöpfel, and Weisstanner 2017; Armingeon, Wenger, Wiedemeier, Isler, Knöpfel, Weisstanner, et al. 2017). These databases provide data for government composition, quality of governance and federalism (see Table 2). Once more, these political variables were chosen after considering not only the literature and the empirical studies on disasters, but also the number of observations.

Insert Table 2 around here

Government composition is measured by four (4) different proxy variables: a) by the party orientation with respect to economic policy (i.e. right, center and left), b) by the Cabinet posts of right-wing parties, center parties and left-wing parties, c) by the relative power position of right-wing parties, center parties and left-wing parties, and d) by the Parliamentary seat share of right-wing parties, center parties and left-wing parties. The quality of governance[8] is measured by the views and

[5] Economic development focusses on the wellbeing of the people of a nation, whereas economic growth reflects market productivity.

[6] An agglomeration economy is one which has concentrated output and housing in particular areas in order to generate economies of scale.

[7] Urbanisation economies arise when growth in the size of a city leads to an increase in productivity.

[8] According to the WGI, "'*Governance' consists of the traditions and institutions by which authority in a country is exercised. This includes the process by which governments are selected, monitored and replaced; the capacity*

experiences of citizens, entrepreneurs and experts in the public, private and NGO sectors from around the world on a) voice and accountability, b) political stability and absence of violence, c) government effectiveness, d) regulatory quality, e) rule of law, and f) control of corruption. These measures of governance are in units of a standard normal distribution, with mean zero, standard deviation of one, and running from approximately -2.5 to 2.5, with higher values corresponding to better governance. Finally, federalism is measured by the following eight (8) different proxy variables which denote: a) whether there are autonomous regions, b) the electoral level of the municipal governments, c) the electoral level of the state/provincial governments, d) whether the state/provinces have authority over taxing, spending, or legislating, e) whether the constituencies of the senators are the states/provinces, f) the authority a regional government exerts within its territory (in ln), known as self-rule, g) the authority a regional government or its representatives exerts in the country as a whole (in ln), known as shared-rule, and h) the sum of the self- and shared-rule (in ln), known as RAI total.

After merging the eight (8) global databases, we end up with 12,789 observations for 224 countries from 1960 to 2016. The descriptive statistics of the final dataset (see Appendix 1) show that it is an unbalanced dataset (Rodríguez-Pose and Tselios 2009), because the number of observations is different for each variable, which is amenable to estimation methods that manage heterogeneity bias. Data on the socioeconomic and political factors are missing for certain countries and years. Provided the reason we have missing data for some countries (‘*attrition*’) is not correlated with the idiosyncratic errors (ε_{it}), the dataset (sample) is random, and the unbalanced panel causes no problems. Since we probably have a nonrandom dataset, the missing data for some countries are correlated with the idiosyncratic error, and then it can cause biased estimators. Nevertheless, a useful feature of a fixed effects analysis is that it does allow attrition to be correlated with the unobserved effect (c_i) (Wooldridge 2003).

5. Empirical results

5.1 Socioeconomic drivers

Table 3 presents the regression results of the impact of socioeconomic factors on the probability that a country experiences either a natural or a technological disaster after controlling for time-invariant factors (e.g. physical geography environment factors) of the country. We start the analysis with a fixed effects logit model where economic development, economic growth and agglomeration economies are the explanatory factors. This model is our benchmark model as it explains a significant variation in the probability of a country to experience a disaster. We then add a series of other socioeconomic factors taking into account multicollinearity problems; e.g. due to the high correlation between GDP per capita (in *ln*) and human capital index, we have dropped the effect of GDP per capita in Regression 9.

Insert Table 3 around here

We observe that low-income countries (i.e. countries with low **economic development**) have significantly higher probability for hazard-related disasters than high-income countries, as the

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of the government to effectively formulate and implement sound policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them” (http://info.worldbank.org/governance/wgi/#home).

coefficient[9] on income per capita is negative and statistically significant for almost all regressions (Table 3a), but this effect is stronger and more robust for natural disasters (Table 3b) than for technological disasters (Table 3c), as the coefficient for natural disaster is higher than those for technological one. This could be evidence that high-income societies can better afford measures to prevent natural disasters. The results also suggest that higher **population density**, which is a proxy for agglomeration economies, increases the disaster probability (Table 3a). This effect is much stronger and robust for technological (Table 3c) than natural (Table 3b) disasters. Agglomeration economies may positively affect the disaster possibility because the concentration of economic agents in particular areas increases the probability of human and economic damages. **Educational endowment** has a negative and statistically significant effect on the probability of all disasters (Table 3a), and especially for natural-related disasters, the lower the years of schooling, the higher the likelihood of disaster (Table 3b). The coefficient on educational endowment has the same sign as the coefficient on economic development, possibly due to the high correlation between GDP per capita and human capital index. Hence, both high-income societies and higher-education societies can better afford measures to prevent natural disasters. Overall, our findings provide evidence that economic development, population density and educational attainment are drivers for disaster prevention.[10]

Surprisingly, the other socioeconomic factors (i.e. economic growth, urbanisation economies, sectoral composition, unemployment, public sector, investment, technological change and income inequality) are not statistically significant for both natural and technological disasters (Table 3a). The results show that urbanisation economies matter for natural disasters, and public sector, investment and technological change matter for technological disasters. More specifically, we find: a) while higher economic development seems to reduce the probability for a disaster, there is no evidence that rapid **economic growth** may come at the expense of weak or ignored building codes, poor land zoning controls and the like (Escaleras and Register 2012); b) there is evidence that countries which are full of **urbanisation economies** (for example Singapore and Bermuda) have lower probability of turning a natural hazard into a disaster than countries with low urbanisation economies (for example Burundi and Trinidad and Tobago (Table 3b); c) as for **sectoral composition**, the results do not indicate that natural disasters have serious welfare consequences for workers employed in the agricultural sector (Kirchberger 2017); d) there is no proof that countries with high **unemployment** rates are more likely to experience natural or technological disasters; e) there is evidence that the size of the **public sector**, proxied by either tax revenue or expense, has a positive and statistically significant effect on the probability of technological disasters (i.e. in the preparedness and prevention of technological disasters) which suggests that large-country governments have higher possibility of technological disasters (Table 3c), but this finding is in contrast with that of Noy (2009) who shows that countries

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[9] This coefficient is a statistical measure of the average relationship between economic development and disaster propensity. Since we use unweighted regressions, each country contributes equally to this average relationship.

[10] Appendix 2 displays the distribution of economic development, population density and disaster probability. Here, we do not display the distribution of educational endowment in order to avoid the complexity of the mapping in the interpretation of the results. However, human capital index is highly correlated with GDP per capita. This map shows the associations between economic development and disaster probability as well as population density and disaster probability. Qatar, the United Arab Emirates, Luxembourg, Bermuda, Kuwait and Brunei Darussalam are rich countries with low disaster probability, but Ethiopia, Mozambique, Myanmar, Nepal, and Bangladesh are poor countries with high disaster probability (negative association between economic development and disaster probability). Hong Kong, Bangladesh, the Republic of Korea, and Belgium have high population density and high disaster probability, but Mongolia, Namibia, Libya, Botswana, Iceland and Suriname have low population density and low disaster probability (negative association between population density and disaster probability).

with high levels of government spending are better able to withstand the shock of an extreme hazard; f) **investment**, proxied by capital stock, and **technological change,** proxied by total factor productivity, have a negative and statistically significant effect on the probability of technological disasters, possibly because high-tech goes hand-in-hand with higher technological security and disaster prevention (Table 3c); and g) there is no evidence that an increase in **income inequality** increases the probability of a natural or technological disaster, due to the fact that inequality increases the share of the very poor and this group is particularly vulnerable (Chou et al. 2004), because the coefficients on income inequality are statistically insignificant in all regressions.

We also examine whether the socioeconomic structures and characteristics of a society can be powerful forces influencing pre-hazard preparedness in order to prevent **predictable disasters** (recurrent events i.e. flood and storms). The results show some differences between the socioeconomic causes of disasters arising from all natural hazards (Table 3b) and of those arising from flood and storms (Appendix 3). The most significant differences are the following: a) while low-income, low-urbanised or low-education countries have significantly higher probability of climate disasters (Table 3b), there is no evidence that this is the case for flood and storms (Appendix 3); and b) while unemployment, investment and technological change do not seem to matter for all climate disasters (Table 3b), there is evidence that countries with high unemployment rates, poor investments or low technological progress are more likely to happen disasters associated with flood and storms (Appendix 3).

5.2 Political drivers

Table 4 presents the regression results of the impact of political factors on the probability that a country is exposure to natural or technological disaster after controlling for time-invariant factors of the country. It should be noted here that many observations have been dropped because of all positive or all negative outcomes (i.e. the time-series variation is zero).

Insert Table 4 around here

We find that there is no evidence that **government composition** (political party orientation) influences a country's natural or technological disaster probability, because all coefficients on proxies for government composition (i.e. party orientation, cabinet posts, relative power position and parliamentary seat share) are not statistically significant. Despite the differences in political strategies between the right-wing, the center and the left-wing parties, the probability a country is prone to a disaster does not differ by whether the country is governed by a right, center or left party.

There is a very weak evidence that **quality of governance** (i.e. 'voice and accountability' and 'control of corruption') has a positive and statistically significant effect on the probability of natural or technological disasters.[11] This is somewhat surprising because most studies in the field find that countries with better institutions are better able to withstand the initial disaster shock (e.g. Noy 2009), and therefore we expected that the higher the quality of governance, the higher the prevention of disaster. Our results show that a country's citizens who are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media (which is a

[11] Appendix 4 displays the distribution of voice and accountability, control of corruption and disaster risk. New Zealand, the Netherlands, Switzerland, Canada and Australia have high disaster risk and high voice and accountability, while Turkmenistan, Eritrea, Uzbekistan, Equatorial Guinea and Syrian Arab Republic have low disaster risk and low voice and accountability (positive association between voice and accountability and disaster risk). New Zealand, Switzerland, Canada, Australia, United Kingdom and Hong Kong have high disaster risk and high control of corruption, but Equatorial Guinea, South Sudan and Turkmenistan have low disaster risk and low control of corruption (positive association between control of corruption and disaster risk).

proxy for a country's high 'voice and accountability') are more prone to natural-related disasters (Table 4b). This might be an issue with data quality in relation to governance, and we acknowledge that 'voice and accountability' is one out of six pillars of quality of governance. Moreover, the six composite WGI measures '*are often too blunt a tool to be useful in formulating specific governance reforms in particular country contexts. Such reforms, and evaluation of their progress, need to be informed by much more detailed and country-specific diagnostic data that can identify the relevant constraints on governance in particular country circumstances*.' (WGI[12]).

We then explore whether differences in a country's disaster propensity are associated with **federalism**. As has been mentioned, we cannot predict the sign of this association because of the dual potential effects of federalism. Our results show evidence that federalism matters only for technological disasters (Table 4c). In countries where there are autonomous regions or the state/provinces have authority over taxing, spending or legislating have significantly lower probability of technological disasters. However, an increase in self-rule and rai-total (i.e. an increase in regional authority) increases the probability of technological disasters. Hence, there is no clear evidence that regional governments have a comparative advantage over national governments in the management of land use, economic development, safety and other regional-based policies.

We finally move on to the **predictable disasters** (Appendix 5). All proxies for government composition and federalism do not seem to affect the probability of flood and storms. However, there is evidence that countries with high voice and accountability are significantly more at risk of predictable disasters.

5.3 Robustness

We explore the robustness of our results using random effects estimator, as it allows for both inter-country (across-country) and intra-country (within-country) variation from the data (Tselios and Tompkins 2019). It could be mentioned here that if we take into account that the random effects coefficients reflect long-run effects (because they allow for both inter- and intra-country variation from the data), while the fixed effects coefficients reflect short/medium effects or time-series effects (because they soak up all cross-national differences and what is left over is within-country variation) (Tselios and Tompkins 2019; Durlauf and Quah 1999), the examination of both fixed and random effects on disaster propensity is important, as a nation may not be able to prevent a disaster in the short/medium run, but it may be able in the long run.

The fixed effects regression results of Table 3 have provided evidence that economic development, population density and educational attainment are drivers for disaster prevention. Moreover, urbanisation economies are drivers for natural disaster prevention, while sectoral composition, public sector (both tax revenue and expense), investment (capital stock) and technological change (tfp) are drivers for technological disaster prevention. Table 5 presents the random effects results only for the statistically significant results of Table 3. We observe that the findings of Table 3 are robust to the estimator, apart from the public sector proxies for the technological disasters.

Insert Table 5 around here

The fixed effects regression results of Table 4 have provided evidence that quality of governance, proxied by voice and accountability and control of corruption, affects disaster propensity. Furthermore, voice and accountability is a political factor for the prevention of natural disasters, and federalism, proxied by a dummy for autonomous regions, a dummy for local authority, self-rule and rai-total, is a political factor for the prevention of technological disasters. The random effects

[12] http://info.worldbank.org/governance/wgi/#doc

regression results of Table 6 show that voice and accountability matters for natural disasters, and federalism proxies (apart from the dummy for local authority) matter for technological disasters.

Insert Table 6 around here

6. Discussion and conclusions

For the first time, we have drawn on 56 years of data to consider the trends and relationships that are emerging in socioeconomic and political vulnerability, and disaster probability in 224 countries. Our objective was to explore the relationships between socioeconomic and political factors and disaster propensity, to answer two questions: why are some countries more disaster prone; and, can socioeconomic and political policy tools change a country's disaster propensity?

Our focus on socioeconomic and political factors is driven by the narratives in the IPCC 1.5 ^{o}C report, the Sendai Agreement and the Sustainable Development Goals (SDGs) reports, all of which articulate the need to improve the social, economic and political enabling conditions for disaster prevention and disaster risk reduction, climate change adaptation and sustainable development. For example, SDGs #9 (Industry, Innovation and Infrastructure) promotes sustainable infrastructure and industrialization, noting the need for efficiencies in the development of new industries and information and communication technologies – which agglomeration economies are designed to address. The IPCC 1.5 ^{o}C report promotes enhanced multi-level governance, and institutional capacity building to improve governance of disaster risk (de Coninck et al. 2018) – this is mirrored in our 'political' determinants of disasters. The Sendai Framework Priorities 2 (strengthen disaster risk governance) and 3 (enhance social and economic wellbeing of communities) are about improving economic and social opportunities – which we consider in our analysis. Our research looks at the empirical evidence of the effectiveness of these high level policy objectives. Consequently, our findings have implications for future IPCC, UNISDR and UN reporting and progress on sustainable development, climate change adaptation and disaster prevention. Our findings offer new insights into how disaster can be prevented. By comparing both natural and technological hazards, and comparing across 224 countries, we are able to identify trends that have previously been masked by: national level analyses, focus on only one type of hazard, and/or analysis by year.

From our analysis, our key findings are: a) low-income countries are significantly more hazard-related disaster prone than high-income countries, more so for natural disasters than for technological disasters; b) higher population density increases the probability that a country experiences a disaster, especially for technological disasters; c) higher levels of educational attainment reduce the probability of hazard-related disasters, especially for natural hazards; d) countries which are full of urbanisation economies have a lower probability of natural disaster than countries with low levels of urbanisation economies; e) an increase in the size of the public sector increases the probability of technological disasters, but an increase in investment and technological change (tfp), reduces the probability of technological disasters; and f) there is very weak evidence that quality of governance has a positive and statistically significant effect on the likelihood of disasters.

This paper can provide useful insights for policy. A key policy question is: what do the findings of this research mean for disaster prevention policy? In other words, which policies should be pursued to prevent disasters? First, there is clear evidence that low-income countries are significantly more hazard-related disaster prone than high-income countries. Our research hints that in richer societies, buildings may be constructed of stronger and durable materials; houses can have raised platforms to better withstand floods; agricultural areas can be irrigated to avoid droughts; and warning systems can be resourced for certain natural disasters, such as hurricanes (Strömberg 2007). This reinforces the need to invest, not just in poverty reduction measures, but in active economic growth, as a key step in disaster prevention. This could mean that prioritizing SDG#8 (Decent Work and Economic Growth), alongside SDG#1 (No Poverty), could produce sizeable co-benefits in terms of disaster risk prevention or reduction.

Second, we found that higher population density increases the probability that a hazard turns into a disaster in a country. We found this effect to be much stronger and robust for technological than natural disasters. We assume that this is due to the increase in the amount of people, livelihoods and assets that are affected in any hazard. This reconfirms analysis by Pielke et al. (2003), who showed that high population density areas are more vulnerable to storms in Latin America and the Caribbean. Improving local resilience to disasters in highly populated areas, is critical to delivering Sendai Priority 2 (Strengthening Governance). Disaster risk management in such areas is challenging, and more focus is needed on this, both in disaster prevention and risk reduction policy, and risk research. Questions remain about: how can highly concentrated populations be best prepared for major disasters? What policy lessons can be learnt from 'brightspots', i.e. comparable places with high population density and high exposure to hazards?

Third, we find that educational endowment has a negative and statistically significant effect on the probability of all disasters, but especially for natural-related disasters. Our findings indicate that educational endowment may be correlated with economic development. Not only can high-income societies better afford measures to prevent natural disasters, but also higher-education societies can. However, we do not know: what types of education make a difference? What levels of education (early years, primary, secondary) are most important in preventing disaster? Does it matter who is educated within a society to make a difference to disaster prevention?

Fourth, countries which are full of urbanisation economies have a lower probability of a natural disaster than countries with low levels of urbanisation economies. We hypothesise that this could be due, in part, to the effective situating of agglomeration economies (i.e. concentrated areas of business investment in infrastructure, communication and technology) away from major hazard zones. Our findings inform SDG#11 (Sustainable Cities and Communities), and Sendai Priority 1 (Understand risk). Specifically, to increase the sustainability of cities in hazard prone locations, evaluation and mapping of all hazard risks has to be central to land use planning. This leads us to ask: how can urban planning and management practices be modified to create jobs and prosperity in a way that does not increase vulnerability to hazards?

Fifth, the size of the public sector, investment and technological change matter for the probability of technological disasters. Large-country governments have higher possibility of technological disasters, and higher investment and technology can prevent technological disasters, because high-tech goes hand-in-hand with higher technological security and disaster prevention. Hence, policies for smaller public sector and policies for higher investment and technology can prevent technological disasters. But, how countries with low levels of government spending, as a result of small public sector, are able to withstand the shock of an extreme technological hazard? Is new technology associated with higher technological security? How can technology help poor countries?

Finally, there is very weak and surprising evidence that quality of governance has a positive and statistically significant effect on the likelihood of disasters. Thus, an increase in the quality of governance can increase the probability for natural or technological disasters. This unexpected finding might be an issue with data quality in relation to governance. This highlights for us, the importance of more data collection in this area, and to enable a reassessment of the quality of governance in the future. But a key question remains. How governance quality affects hazard-associated disasters?

Some caveats regarding the six key findings and the relevant policy outcomes are in order, and these could be examined in future work. First of all, it would be useful a regionally disaggregated analysis, because natural and technological hazards usually strike a local part of a country and they are rarely national. Moreover, this analysis of this paper has some limitations which result from the quality of the data available, such as the quality of governance data. Finally, it would be useful to examine the interaction effects between the socioeconomic and political characteristics. This will allow us to examine whether either the socioeconomic effects are moderated by the political factors or the political effects are moderated by the socioeconomic factors.

Overall, this paper has shed light on disaster preparedness/ex-ante policies that could reduce the risks of disasters and on what governance arrangements are most appropriate for developing and delivering these policies. We asked, can we prevent disasters? Our findings suggest that yes we can, but to do this there needs to be committed to increasing investment to delivering both the SDGs and the Sendai priorities, notably in economic growth (infrastructure, communication and technology) and education, as well as requiring all disaster possibility and risk to be considered in spatial planning, and improved resilience building in urban areas.

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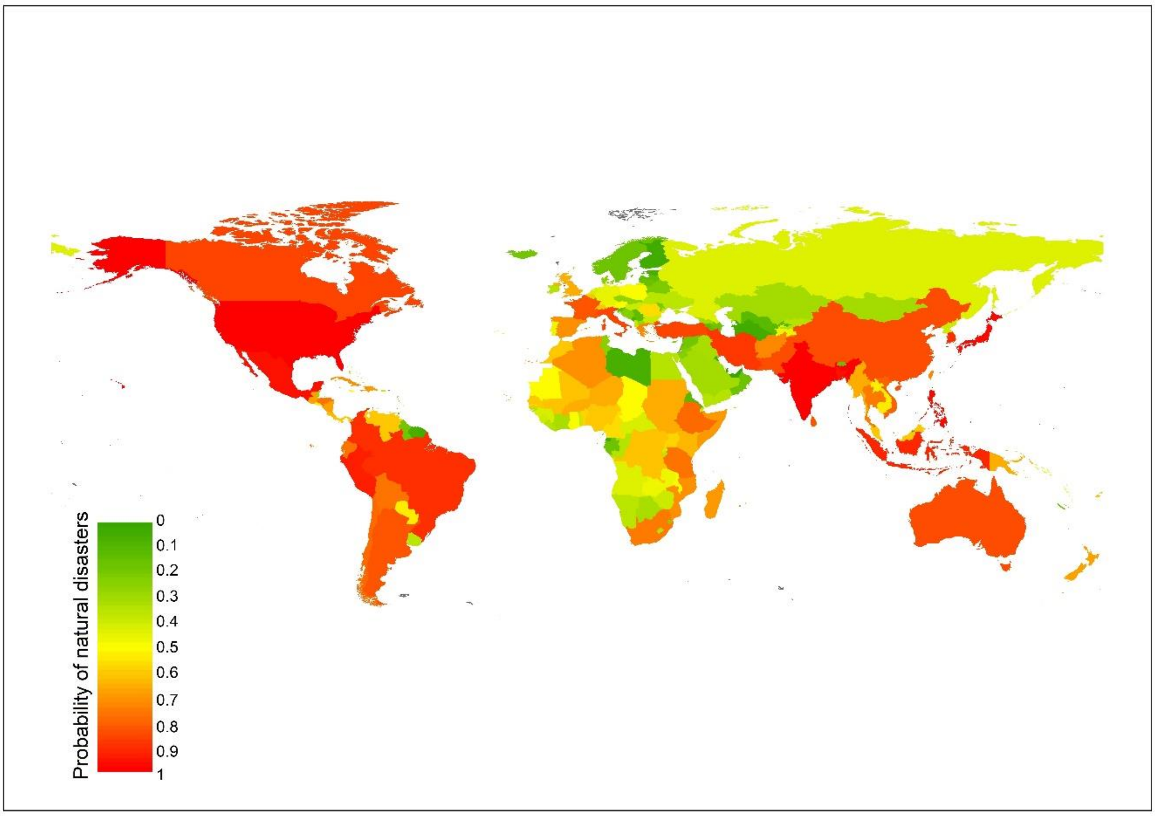
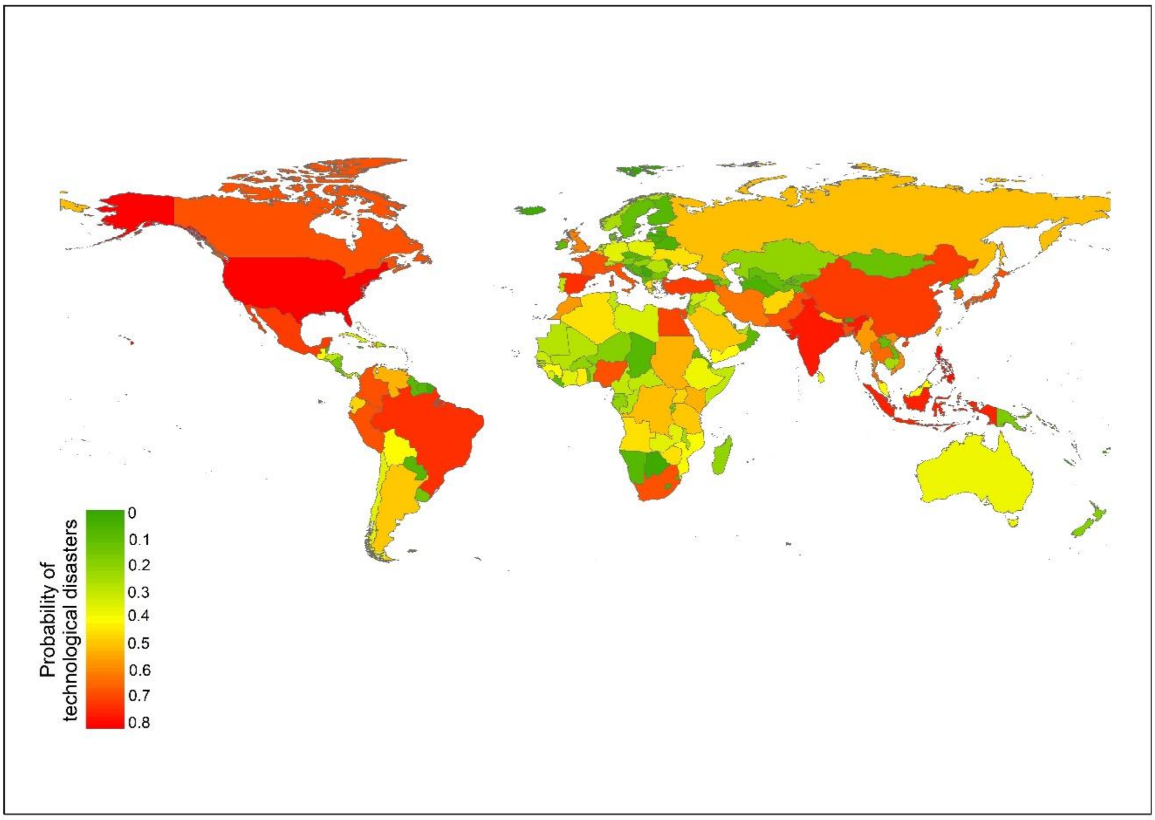
Figure 1: Global probability of a disaster*

a) Annual probability of a natural hazard in country to be turned into a disaster



b) Annual probability of a technological hazard in a country to be turned into a disaster



Notes: For Figures a) and b) a disaster is identified when at least one of the following criteria is fulfilled: ten (10) or more people reported killed, hundred (100) or more people reported affected, injured or homeless (i.e. people requiring immediate assistance during an emergency situation), declaration by the country of a state of emergency or call for international assistance. High annual probability is depicted as red (maximum=1), and low annual probability as green (minimum=0). * 'Probability of a disaster' is based frequency of past disasters from data 1960-2016.

Table 1: Socioeconomic determinants of disasters

Variable	Measurement	Description	Year	Source and key references
Economic development	GDP per capita	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2010 U.S. dollars.	1960-2016	WB; Tselios and Tompkins 2017, 2019
Economic growth	GDP per capita growth (annual %)	Annual percentage growth rate of GDP per capita based on constant local currency. Aggregates are based on constant 2010 U.S. dollars.	1961-2016	WB; Tselios and Tompkins 2017, 2019
Agglomeration economies	Population density (people per sq. km of land area)	Population density is midyear population divided by land area in square kilometers. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship--except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.	1961-2016	WB; Tselios and Tompkins, 2019
Urbanisation economies	Urban population (% of total)	Urban population refers to people living in urban areas as defined by national statistical offices. The data are collected and smoothed by United Nations Population Division.	1960-2016	WB; Tselios and Tompkins, 2019
Sectoral composition	Agriculture, value added (% of GDP) Industry, value added (% of GDP) Services, etc., value added (% of GDP)	Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Industry corresponds to ISIC divisions 10-45 and includes manufacturing (ISIC divisions 15-37). It comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas. Services correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services. Also included are imputed bank service charges, import duties, and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and	1960-2016	WB

		degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Note: For VAB countries, gross value added at factor cost is used as the denominator.		
Unemployment	Unemployment, total (% of total labour force)	Unemployment refers to the share of the labour force that is without work but available for and seeking employment.	1991-2016	WB; Tselios and Tompkins, 2019
Public sector	Tax revenue (% of GDP)	Tax revenue refers to compulsory transfers to the central government for public purposes. Certain compulsory transfers such as fines, penalties, and most social security contributions are excluded. Refunds and corrections of erroneously collected tax revenue are treated as negative revenue.	1972-2016	WB
Public sector	Expense (% of GDP)	Expense is cash payments for operating activities of the government in providing goods and services. It includes compensation of employees (such as wages and salaries), interest and subsidies, grants, social benefits, and other expenses such as rent and dividends.	1972-2016	WB
Investment	Capital stock	Capital stock at constant 2011 national prices (in mil. 2011US$).	1950-2014	PWT
Technological change and innovation	Total factor productivity	Total factor productivity at constant national prices (2011=1).	1950-2014	PWT; Tselios and Tompkins, 2019
Educational endowment	Human capital index	Human capital index, based on years of schooling and returns to education.	1950-2014	PWT; Tselios and Tompkins, 2019
Income inequality	Net-income inequality	Gini index of net-income inequality.	1960-2016	SWIID; Tselios and Tompkins, 2019
Income inequality	Market-income inequality	Gini index of market-income inequality.	1960-2016	SWIID; Tselios and Tompkins, 2019

Table 2: Political determinants of disasters

Variable	Measurement	Description	Year	Source and key references
Government composition	Party orientation with respect to economic policy	a) Right: for parties that are defined as conservative, Christian democratic, or right-wing. b) Center: for parties that are defined as centrist or when party position can best be described as centrist (e.g. party advocates strengthening private enterprise in a social-liberal context). c) Left: for parties that are defined as communist, socialist, social democratic, or left-wing.	1975-2015	DPI2015; Tselios and Tompkins, 2017
Government composition	Cabinet posts of right-wing parties, center parties and left-wing parties	a) Right: Cabinet posts of right-wing parties in percentage of total cabinet posts. Weighted by the number of days in office in a given year. b) Center: Cabinet posts of center parties in percentage of total cabinet posts. Weighted by the number of days in office in a given year. c) Left: Cabinet posts of social democratic and other left parties in percentage of total cabinet posts. Weighted by the number of days in office in a given year.	1960-2015	CPDS
Government composition	Relative power position of right-wing parties, center parties and left-wing parties	a) Right: Relative power position of right-wing parties in government based on their seat share in parliament, measured in percentage of the total parliamentary seat share of all governing parties. Weighted by the number of days in office in a given year. b) Center: Relative power position of center parties in government based on their seat share in parliament, measured in percentage of the total parliamentary seat share of all governing parties. Weighted by the number of days in office in a given year. c) Left: Relative power position of social democratic and other left parties in government based on their seat share in parliament, measured in percentage of the total parliamentary seat share of all governing parties. Weighted by the number of days in office in a given year.	1960-2015	CPDS
Government composition	Parliamentary seat share of right-wing parties, center parties and left-wing parties	a) Right: Parliamentary seat share of right-wing parties in government. Weighted by the number of days in office in a given year. b) Center: Parliamentary seat share of center parties in government. Weighted by the number of days in office in a given year. c) Left: Parliamentary seat share of social democratic and other left parties in government. Weighted by the number of days in office in a given year.	1960-2015	CPDS
Quality of governance	Voice and accountability	Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	1996-2016	WGI
Quality of governance	Political stability and absence of violence	Political stability and absence of violence/terrorism measures perceptions of	1996-2016	WGI

		the likelihood of political instability and/or politically-motivated violence, including terrorism.		
Quality of governance	Government effectiveness	Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	1996-2016	WGI
Quality of governance	Regulatory quality	Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	1996-2016	WGI
Quality of governance	Rule of law	Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	1996-2016	WGI
Quality of governance	Control of corruption	Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests.	1996-2016	WGI
Federalism	Autonomous regions	Are there autonomous regions? An autonomous region is recorded if a source explicitly mentions a region, area, or district that is autonomous or self-governing. Furthermore, they must be constitutionally designated as "autonomous" or "independent" or "special". a) There are not autonomous regions. b) There are autonomous regions.	1975-2015	DPI2015
Federalism	Electoral level of the municipal governments	Are municipal governments locally elected? a) Neither local executive nor local legislature are locally elected. b) The executive is appointed, but the legislature elected. c) Both the executive and the legislature are locally elected.	1975-2015	DPI2015; Tselios and Tompkins, 2017
Federalism	Electoral level of the state/provincial governments	Are the state/province governments locally elected? a) Neither local executive nor local legislature are locally elected. b) The executive is appointed, but the legislature elected. c) Both the executive and the legislature are locally elected.	1975-2015	DPI2015; Tselios and Tompkins, 2017
Federalism	Authority of the state/provinces	Do the state/provinces have authority over taxing, spending, or legislating? a) The state/provinces do not have authority over taxing, spending, or legislating. b) The state/provinces have authority over taxing, spending, or legislating.	1975-2015	DPI2015
Federalism	Constituencies of the senators	Are the constituencies of the senators the states/provinces? a) The constituencies of the senators are not the states/provinces.	1975-2015	DPI2015

		b) The constituencies of the senators are the states/provinces.		
Federalism	Self-rule	It measures the authority a regional government exerts within its territory across the following five dimensions: a) institutional depth (i.e. the extent to which a regional government is autonomous rather than deconcentrated), b) policy scope (i.e. the range of policies for which a regional government is responsible), c) fiscal autonomy (i.e. the extent to which a regional government can independently tax its population), d) borrowing autonomy (i.e. the extent to which a regional government can borrow), and e) representation (i.e. the extent to which a region has an independent legislature and executive).	1950-2010	RAI; Tselios and Tompkins, 2017
Federalism	Shared-rule	It measures the authority a regional government or its representatives exerts in the country as a whole across the following five dimensions: a) law-making (i.e. the extent to which regional representatives co-determine national legislation), b) executive control (i.e. the extent to which a regional government co-determines national policy in intergovernmental meetings), c) fiscal control (i.e. the extent to which regional representatives co-determine the distribution of national tax revenues), d) borrowing control (i.e. the extent to which a regional government co-determines subnational and national borrowing constraints), and e) constitutional reform (i.e. the extent to which regional representatives co-determine constitutional change).	1950-2010	RAI; Tselios and Tompkins, 2017
Federalism	Rai-total	It measures the sum of the self- and shared-rule.	1950-2010	RAI; Tselios and Tompkins, 2017

Table 3: Regression results: Socioeconomic factors for disasters

a. All disasters

		(1) 1961-2016	(2) 1961-2016	(3) 1961-2016	(4) 1961-2016	(5) 1991-2016	(6) 1972-2016
Economic development	GDP per capita (ln)	-0.6389***		-0.5472***		-0.3978*	-0.4719
Economic growth	Annual growth	-0.0031	-0.0046	-0.0049	-0.0069	-0.0055	-0.0041
Agglomeration economies	Population density (ln)	0.8418***	1.2068***	1.2784***	1.5584***	1.0385***	1.0672**
Urbanisation economies	Urban population		-0.0101				
Sectoral composition	- Agriculture				-0.0208		
	- Industry			-0.0040	-0.0317		
	- Services			0.0027	-0.0234		
Unemployment	Unemployment rate					0.0033	
Public sector	Tax revenue						0.0030
	Log likelihood	-3198.488	-3289.2236	-2371.3956	-2400.2255	-1493.1828	-1150.9962
	LR chi2	1590.70	1565.05	1012.20	1013.69	121.91	271.17
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	7,946	8,136	5,963	6,009	3,699	3,070

		(7) 1972-2016	(8) 1961-2014	(9) 1961-2014	(10) 1961-2016	(11) 1961-2016
Economic development	GDP per capita (ln)	-0.3855	-1.4437***		-1.0145***	-1.0286***
Economic growth	Annual growth	-0.0030	0.0064	-0.0010	0.0022	0.0019
Agglomeration economies	Population density (ln)	0.9937*	0.6042	1.2289***	0.7763*	0.6274
Public sector	Expense	0.0132				
Investment	Capital stock (ln)		0.4211			
Technological change	tfp		0.2684			
Educational endowment	Human capital index			-0.6615**		
Income inequality	Gini (disposable)				-1.2420	
	Gini (market)					-2.5545
	Log likelihood	-1076.743	-1760.7654	-2320.1097	-1543.985	-1543.5239
	LR chi2	249.99	949.50	1392.23	484.28	485.20
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	2,878	4,577	6,051	4,294	4,294

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

b. Natural disasters

		(1) 1961-2016	(2) 1961-2016	(3) 1961-2016	(4) 1961-2016	(5) 1991-2016	(6) 1972-2016
Economic development	GDP per capita (ln)	-0.7871***		-0.6302***		-0.5143**	-0.6787**
Economic growth	Annual growth	0.0007	-0.0012	-0.0035	-0.0056	-0.0000	0.0028
Agglomeration economies	Population density (ln)	0.1524	0.7039***	0.4642	0.8552***	0.3438	0.1857
Urbanisation economies	Urban population		-0.0135*				
Sectoral composition	- Agriculture				-0.0219		
	- Industry			0.0015	-0.0331		
	- Services			0.0038	-0.0264		
Unemployment	Unemployment rate					-0.0005	
Public sector	Tax revenue						-0.0036
	Log likelihood	-3334.0143	-3426.332	-2531.6688	-2562.3512	-1655.8894	-1216.8403
	LR chi2	1354.12	1308.11	866.34	857.02	160.00	276.21
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	7,956	8,146	6,038	6,084	3,952	3,131

		(7) 1972-2016	(8) 1961-2014	(9) 1961-2014	(10) 1961-2016	(11) 1961-2016
Economic development	GDP per capita (ln)	-0.6690**	-1.3346***		-0.8679***	-0.8697***
Economic growth	Annual growth	0.0004	0.0122	0.0041	0.0070	0.0069
Agglomeration economies	Population density (ln)	-0.0339	-0.2169	0.5207*	-0.0083	-0.1029
Public sector	Expense	-0.0040				
Investment	Capital stock (ln)		0.2094			
Technological change	tfp		0.1729			
Educational endowment	Human capital index			-1.1905***		
Income inequality	Gini (disposable)				0.3240	
	Gini (market)					-0.8447
	Log likelihood	-1141.4874	-1881.7652	-2465.9467	-1751.6736	-1751.6046
	LR chi2	252.31	849.34	1216.11	473.06	473.19
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	2,966	4,619	6,072	4,470	4,470

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

c. Technological disasters

		(1)	(2)	(3)	(4)	(5)	(6)
		1961-2016	1961-2016	1961-2016	1961-2016	1991-2016	1972-2016
Economic development	GDP per capita (ln)	-0.1540		-0.3796**		-0.3949*	-0.1313
Economic growth	Annual growth	-0.0014	-0.0016	-0.0031	-0.0036	-0.0030	-0.0078
Agglomeration economies	Population density (ln)	2.6533***	2.6510***	2.9531***	3.1223***	2.1731***	3.0959***
Urbanisation economies	Urban population		0.0127				
Sectoral composition	- Agriculture				-0.0241		
	- Industry			0.0133*	-0.0093		
	- Services			0.0120	-0.0127		
Unemployment	Unemployment rate					-0.0034	
Public sector	Tax revenue						0.0321***
	Log likelihood	-2631.9252	-2650.2982	-2004.8583	-2018.016	-1587.2915	-1177.6693
	LR chi2	1565.69	1591.98	1221.73	1229.91	106.45	315.27
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	7,627	7,728	5,819	5,865	3,876	3,161

		(7)	(8)	(9)	(10)	(11)
		1972-2016	1961-2014	1961-2014	1961-2016	1961-2016
Economic development	GDP per capita (ln)	-0.0539	0.9314**		-0.4623**	-0.4778**
Economic growth	Annual growth	-0.0026	-0.0018	-0.0030	-0.0063	-0.0068
Agglomeration economies	Population density (ln)	3.0485***	3.3534***	2.8979***	3.3138***	3.0985***
Public sector	Expense	0.0197**				
Investment	Capital stock (ln)		-0.5990**			
Technological change	tfp		-1.3265**			
Educational endowment	Human capital index			0.4786		
Income inequality	Gini (disposable)				-1.3910	
	Gini (market)					-3.0190
	Log likelihood	-1100.5076	-1730.9623	-2199.6279	-1749.0976	-1748.1805
	LR chi2	293.44	1055.73	1452.01	651.58	653.41
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	2,949	4,687	6,150	4,509	4,509

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

Table 4: Regression results: Political factors for disasters

a. All disasters

i) Government composition

	(1)	(2)	(3)	(4)
	1975-2015	1961-2015	1961-2015	1961-2015
GDP per capita (ln)	-0.3765	0.8012	0.7924	0.7775
Annual growth	-0.0022	0.0434	0.0426	0.0431
Population density (ln)	1.9033***	-1.8855	-1.8202	-1.8557
Party orientation: right	-0.1504			
Party orientation: center	base			
Party orientation: left	-0.2065			
Cabinet posts: right		-0.0019		
Cabinet posts: center		-0.0016		
Cabinet posts: left		-0.0013		
Relative power position: right			-0.0038	
Relative power position: center			-0.0042	
Relative power position: left			-0.0040	
Parliamentary seat share: right				-0.0017
Parliamentary seat share: center				0.0007
Parliamentary seat share: left				-0.0020
Log likelihood	-1187.5316	-462.526	-462.4315	-462.49735
LR chi2	295.51	286.81	287.00	286.87
Prob>chi2	0.0000	0.0000	0.0000	0.0000
Observations	2,982	1,310	1,310	1,310

ii) Quality of governance

	(5)	(6)	(7)	(8)	(9)	(10)
	1996-2016	1996-2016	1996-2016	1996-2016	1996-2016	1996-2016
GDP per capita (ln)	-0.0885	-0.1263	-0.0373	-0.0204	-0.0624	-0.1157
Annual growth	-0.0071	-0.0089	-0.0069	-0.0069	-0.0075	-0.0070
Population density (ln)	0.7636	0.6665	0.7478	0.7214	0.6468	0.7322
Voice and accountability	0.6469**					
Political stability		0.1929				
Government effectiveness			0.2384			
Regulatory quality				0.1177		
Rule of law					0.1090	
Control of corruption						0.5444**
Log likelihood	-1044.0105	-1029.0384	-1035.3265	-1035.9815	-1048.0576	-1037.3716
LR chi2	59.39	55.41	55.58	55.26	53.92	60.67
Prob>chi2	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000
Observations	2,528	2,488	2,509	2,510	2,536	2,517

iii) Federalism

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	1975-2015	1975-2015	1975-2015	1975-2015	1975-2015	1961-2010	1961-2010	1961-2010
GDP per capita (ln)	-0.3673**	-0.3480*	-0.7602***	-0.1896	-0.3350	-0.1220	-0.0857	-0.1144
Annual growth	-0.0088	-0.0011	-0.0025	-0.0092	-0.0139	-0.0250*	-0.0248*	-0.0249*
Population density (ln)	1.6434***	1.2777***	1.0619***	0.5414	1.4927**	-0.2119	-0.2581	-0.2123
No – autonomous regions	base							
Yes – autonomous regions	-0.0076							
Municipal governments								
-No local elections		base						
-Legislature locally elected		-0.0996						
-Legisl. and exec. locally elected		-0.3891						
State/province governments								
-No local elections			base					
-Legislature locally elected			-0.4506					
-Legisl. and exec. locally elected			-0.0162					
No – local authority				base				
Yes – local authority				0.4538				
No – constit. of the senators					base			
Yes – constit. of the senators					-0.5073			
Self-rule (ln)						0.2140		
Shared-rule (ln)							0.0303	
Rai-total (ln)								0.1682
Log likelihood	-2183.2762	-1185.6372	-1530.3056	-657.15403	-652.39034	-1029.501	-1030.1683	-1029.6903
LR chi2	671.25	257.66	455.07	223.16	187.09	606.04	604.71	605.66
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	5,500	3,013	4,047	1,875	1,671	2,821	2,821	2,821

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

b. Natural disasters

i) Government composition

	(1) 1975-2015	(2) 1961-2015	(3) 1961-2015	(4) 1961-2015
GDP per capita (ln)	-0.5250*	0.4481	0.4589	0.4506
Annual growth	0.0140	0.0752**	0.0737**	0.0736**
Population density (ln)	1.1990**	-2.0216	-1.9584	-1.9467
Party orientation: right	-0.1713			
Party orientation: center	base			
Party orientation: left	-0.2433			
Cabinet posts: right		-0.0019		
Cabinet posts: center		0.0012		
Cabinet posts: left		-0.0009		
Relative power position: right			-0.0079	
Relative power position: center			-0.0059	
Relative power position: left			-0.0078	
Parliamentary seat share: right				-0.0044
Parliamentary seat share: center				0.0014
Parliamentary seat share: left				-0.0048
Log likelihood	-1289.4481	-454.80374	-454.43518	-454.62578
LR chi2	273.35	316.96	317.70	317.32
Prob>chi2	0.0000	0.0000	0.0000	0.0000
Observations	3,102	1,320	1,320	1,320

ii) Quality of governance

	(5) 1996-2016	(6) 1996-2016	(7) 1996-2016	(8) 1996-2016	(9) 1996-2016	(10) 1996-2016
GDP per capita (ln)	-0.1324	-0.1073	0.0984	0.0600	0.0375	-0.0857
Annual growth	-0.0021	-0.0037	-0.0013	-0.0013	-0.0024	-0.0012
Population density (ln)	-0.8626	-0.7982	-0.7457	-0.7068	-0.8123	-0.6207
Voice and accountability	0.4372*					
Political stability		0.2315				
Government effectiveness			-0.0557			
Regulatory quality				0.0393		
Rule of law					-0.1214	
Control of corruption						0.3691
Log likelihood	-1128.4439	-1115.6287	-1121.928	-1122.2068	-1130.9502	-1124.3558
LR chi2	59.94	59.59	56.56	56.81	57.56	59.74
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	2,773	2,733	2,754	2,755	2,781	2,762

iii) Federalism

	(11) 1975-2015	(12) 1975-2015	(13) 1975-2015	(14) 1975-2015	(15) 1975-2015	(16) 1961-2010	(17) 1961-2010	(18) 1961-2010
GDP per capita (ln)	-0.4918***	-0.7751***	-0.7069***	-0.3471	-0.6044*	-0.4770	-0.4395	-0.4757
Annual growth	-0.0051	0.0094	0.0003	0.0029	-0.0123	-0.0158	-0.0157	-0.0157
Population density (ln)	0.8696***	0.5435	0.5363	0.0067	0.5463	-0.7870	-0.7570	-0.7711
No – autonomous regions	base							
Yes – autonomous regions	0.3134							
Municipal governments								
-No local elections		base						
-Legislature locally elected		-0.1795						
-Legisl. and exec. locally elected		0.2463						
State/province governments								
-No local elections			base					
-Legislature locally elected			-0.3311					
-Legisl. and exec. locally elected			0.3727					
No – local authority				base				
Yes – local authority				0.3685				
No – constit. of the senators					base			
Yes – constit. of the senators					-0.5293			
Self-rule (ln)						0.1750		
Shared-rule (ln)							0.1692	
Rai-total (ln)								0.1708
Log likelihood	-2339.6642	-1268.0929	-1644.6312	-745.63066	-700.35959	-1080.3627	-1080.4212	-1080.3032
LR chi2	581.30	261.59	414.82	180.38	204.83	599.03	598.92	599.15
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	5,572	3,057	4,102	1,908	1,836	2,913	2,913	2,913

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

c. Technological disasters

i) Government composition

	(1)	(2)	(3)	(4)
	1975-2015	1961-2015	1961-2015	1961-2015
GDP per capita (ln)	0.5647*	0.3490	0.3294	0.3164
Annual growth	-0.0089	0.0679**	0.0656**	0.0662**
Population density (ln)	3.6265***	-0.5218	-0.6479	-0.6420
Party orientation: right	0.1268			
Party orientation: center	base			
Party orientation: left	0.0180			
Cabinet posts: right		-0.0062		
Cabinet posts: center		-0.0059		
Cabinet posts: left		-0.0067		
Relative power position: right			0.0008	
Relative power position: center			0.0002	
Relative power position: left			0.0001	
Parliamentary seat share: right				0.0031
Parliamentary seat share: center				0.0034
Parliamentary seat share: left				0.0028
Log likelihood	-1194.5531	-541.79653	-542.12059	-542.10555
LR chi2	311.97	155.22	154.57	154.60
Prob>chi2	0.0000	0.0000	0.0000	0.0000
Observations	3,139	1,365	1,365	1,365

ii) Quality of governance

	(5)	(6)	(7)	(8)	(9)	(10)
	1996-2016	1996-2016	1996-2016	1996-2016	1996-2016	1996-2016
GDP per capita (ln)	-0.3463	-0.2151	-0.3996	-0.3232	-0.2861	-0.4000
Annual growth	-0.0009	0.0002	-0.0017	-0.0013	-0.0008	-0.0019
Population density (ln)	1.3744**	1.3423**	1.3321**	1.3344**	1.3298**	1.2735**
Voice and accountability	0.4128					
Political stability		-0.2443				
Government effectiveness			0.1868			
Regulatory quality				-0.0450		
Rule of law					-0.0442	
Control of corruption						0.2871
Log likelihood	-1033.5876	-1026.4122	-1030.0959	-1030.4222	-1034.9032	-1030.9116
LR chi2	55.59	56.07	54.76	54.35	52.96	54.81
Prob>chi2	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001
Observations	2,621	2,575	2,594	2,595	2,621	2,600

iii) Federalism

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	1975-2015	1975-2015	1975-2015	1975-2015	1975-2015	1961-2010	1961-2010	1961-2010
GDP per capita (ln)	-0.0896	0.0138	-0.3848*	-0.2352	0.0463	0.3944	0.4829	0.4102
Annual growth	-0.0045	0.0041	0.0008	-0.0069	0.0083	0.0009	0.0017	0.0011
Population density (ln)	2.8041***	2.6884***	2.3510***	2.0652***	3.1894***	2.4777***	2.3211***	2.4959***
No – autonomous regions	base							
Yes – autonomous regions	-1.1412***							
Municipal governments								
-No local elections		base						
-Legislature locally elected		-0.2932						
-Legisl. and exec. locally elected		0.1263						
State/province governments								
-No local elections			base					
-Legislature locally elected			-0.4771					
-Legisl. and exec. locally elected			0.4017					
No – local authority				base				
Yes – local authority				-1.7807**				
No – constit. of the senators					base			
Yes – constit. of the senators					-0.4375			
Self-rule (ln)						0.4269**		
Shared-rule (ln)							-0.0277	
Rai-total (ln)								0.3279*
Log likelihood	-2136.9844	-1357.5753	-1688.0074	-793.00754	-694.41416	-1069.3882	-1072.0577	-1070.2758
LR chi2	773.93	266.82	486.19	251.72	177.42	529.40	524.06	527.62
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	5,663	3,304	4,304	2,045	1,880	2,856	2,856	2,856

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

Table 5: Regression results – Random Effects: Socioeconomic factors for disasters

a. All disasters

		(1)	(9)
		1961-2016	1961-2014
Economic development	GDP per capita (ln)	-0.5284***	
Economic growth	Annual growth	-0.0035	-0.0013
Agglomeration economies	Population density (ln)	0.1563*	0.1750*
Educational endowment	Human capital index		-0.5275***
	Log likelihood	-3924.216	-2858.5925
	Wald chi2	1079.68	941.07
	Prob>chi2	0.0000	0.0000
	Constant	0.1692	-2.6408***
	Observations	8,264	6,341

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

b. Natural disasters

		(1)	(2)	(9)
		1961-2016	1961-2016	1961-2014
Economic development	GDP per capita (ln)	-0.5718***		
Economic growth	Annual growth	0.0005	-0.0011	0.0048
Agglomeration economies	Population density (ln)	0.0526	0.0620	0.0381
Urbanisation economies	Urban population		-0.0132***	
Educational endowment	Human capital index			-0.7354***
	Log likelihood	-4055.0693	-4166.922	-3011.0275
	LR chi2	966.56	957.88	861.20
	Prob>chi2	0.0000	0.0000	0.0000
	Constant	0.4888	-3.2797***	-2.3122***
	Observations	8,264	8,455	6,341

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

c. Technological disasters

		(1)	(3)	(6)	(7)	(8)
		1961-2016	1961-2016	1972-2016	1972-2016	1961-2014
Economic development	GDP per capita (ln)	-0.3268***	-0.4081***	-0.2605**	-0.2651**	-0.7832***
Economic growth	Annual growth	-0.0005	-0.0031	-0.0013	-0.0001	0.0079
Agglomeration economies	Population density (ln)	0.3503***	0.2786***	0.1662	0.1367	0.0206
Sectoral composition	- Agriculture		base			
	- Industry		0.0165**			
	- Services		-0.0050			
Public sector	Tax revenue			0.0063		
Public sector	Expense				0.0064	
Investment	Capital stock (ln)					0.9147***
Technological change	tfp					-0.2992
	Log likelihood	-3334.7448	-2624.0763	-1643.188	-1549.5021	-2115.674
	LR chi2	900.27	651.35	214.05	202.72	0.0000
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000
	Constant	-3.9566***	-2.9076***	-1.3640	-1.1756	-8.0279***
	Observations	8,264	6,352	3,606	3,408	4,819

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

Table 6: Regression results – Random Effects: Political factors for disasters

a. All disasters

	Quality of governance	
	(5)	(10)
	1996-2016	1996-2016
GDP per capita (ln)	-0.5256***	-0.5006***
Annual growth	-0.0083	-0.0076
Population density (ln)	-0.1630	-0.1587
Voice and accountability	0.1434	
Control of corruption		0.0572
Log likelihood	-1545.6295	-1538.2139
LR chi2	73.65	75.30
Prob>chi2	0.0000	0.0000
Constant	5.8063***	5.5720***
Observations	3,369	3,358

b. Natural disasters

	Quality of governance
	(5)
	1996-2016
GDP per capita (ln)	-0.5865***
Annual growth	-0.0016
Population density (ln)	-0.1948*
Voice and accountability	0.3923**
Log likelihood	-1654.84
LR chi2	81.69
Prob>chi2	0.0000
Constant	5.8296***
Observations	3,369

c. Technological disasters

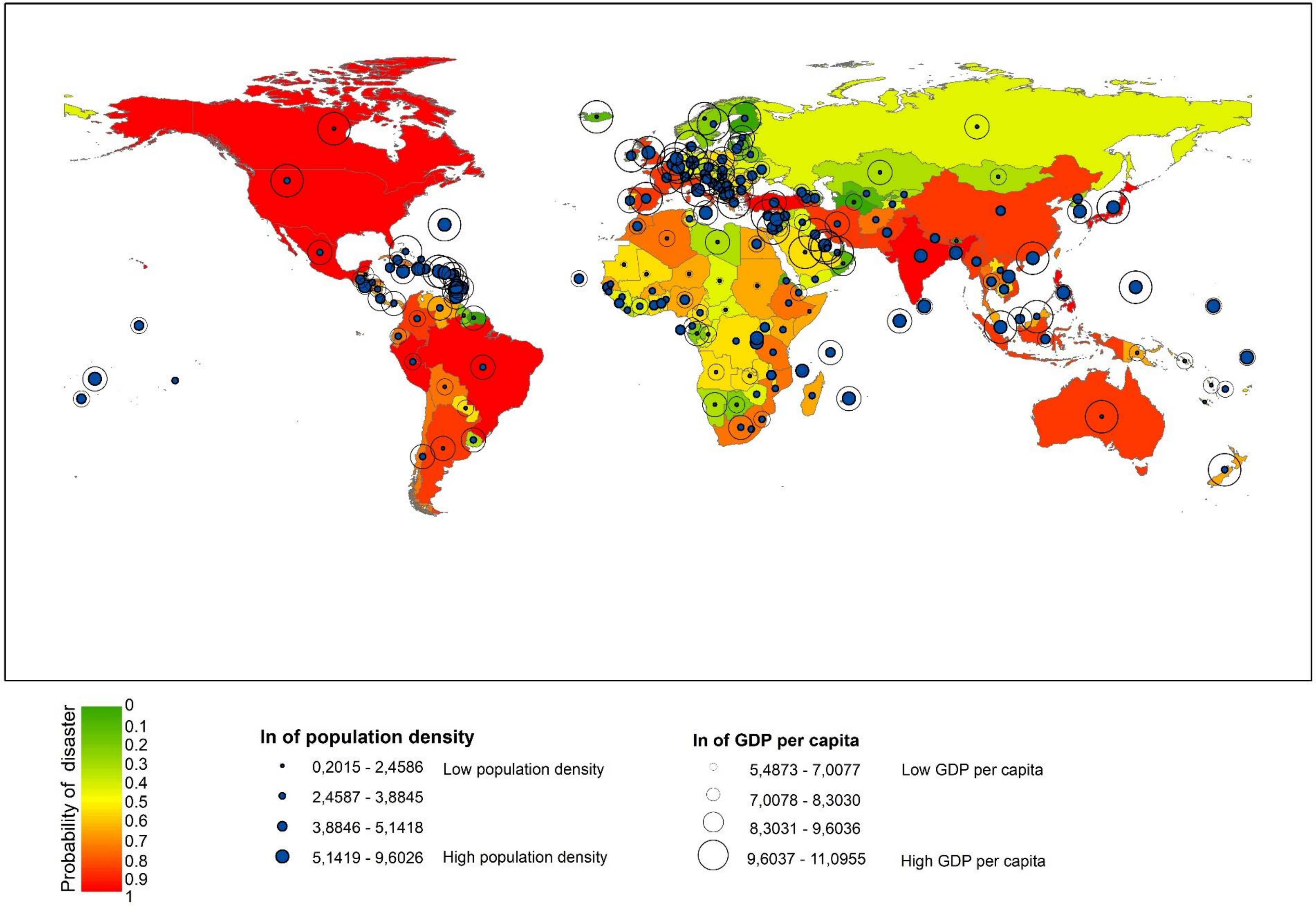
	iii) Federalism			
	(11)	(14)	(16)	(18)
	1975-2015	1975-2015	1961-2010	1961-2010
GDP per capita (ln)	-0.2434***	-0.2136	-0.3159**	-0.2833**
Annual growth	-0.0034	-0.0087	-0.0021	-0.0011
Population density (ln)	0.4845***	0.5152***	0.2351**	0.2389**
No – autonomous regions	base			
Yes – autonomous regions	-0.7225***			
No – local authority		base		
Yes – local authority		0.2656		
Self-rule (ln)			0.9824***	
Rai-total (ln)				0.8776***
Log likelihood	-2760.4955	-1032.2699	-1321.9764	-1324.3534
LR chi2	485.73	179.48	383.53	380.92
Prob>chi2	0.0000	0.0000	0.0000	0.0000
Constant	-3.1224***	-3.1811**	-3.3328***	-3.5876***
Observations	5,988	2,169	3,003	3,003

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

Appendix 1: Descriptive statistics

Variable	Measurement / Proxy	Obs	Mean	Std. Dev.	Min	Max
Disasters	All	12789	0.4217	0.4939	0	1
	Natural	12789	0.3704	0.4829	0	1
	Technological	12789	0.2041	0.4030	0	1
Economic development	GDP per capita (ln)	8554	8.1938	1.5154	4.7518	11.6412
Economic growth	Annual growth	8553	2.0844	6.4914	-64.9963	172.7522
Agglomeration economies	Population density (ln)	11003	3.9374	1.5609	-0.4585	9.9711
Urbanisation economies	Urban population	11443	48.9907	25.2875	2.0770	100
Sectoral composition	- Agriculture	6630	18.5820	15.8511	0.0000	94.8464
	- Industry	6594	28.8900	13.9334	1.8821	213.6904
	- Services	6604	52.8739	15.6843	2.4284	104.3466
Unemployment	Unemployment rate	4805	9.0377	6.4191	0.1000	39.3000
Public sector	Tax revenue	3724	16.9997	8.7528	0.0000	144.1203
	Expense	3508	25.7607	12.9553	0.0000	210.2051
Investment	Capital stock (ln)	8718	11.3957	2.3620	3.4288	18.0290
Technological change	tfp	5423	0.9597	0.2826	0.2218	4.3693
Educational endowment	Human capital index	7243	2.0582	0.7155	1.0070	3.7343
Income inequality	Gini (disposable)	5098	0.3820	0.0873	0.1833	0.6106
	Gini (market)	5098	0.4532	0.0673	0.2109	0.6846
Government composition	Party orientation: right	3961	0.3555	0.4787	0	1
	Party orientation: center	3961	0.1174	0.3219	0	1
	Party orientation: left	3961	0.5271	0.4993	0	1
	Cabinet posts: right	1602	39.3482	37.6639	0	100
	Cabinet posts: center	1602	23.5037	31.3510	0	100
	Cabinet posts: left	1602	32.4636	36.3641	0	100
	Relative power position: right	1602	40.9192	39.6148	0	100
	Relative power position: center	1602	24.0643	32.3152	0	100
	Relative power position: left	1602	33.8714	38.1460	0	100
	Parliamentary seat share: right	1602	23.0170	22.3814	0	78.5
	Parliamentary seat share: center	1602	13.8267	18.0955	0	67.8
	Parliamentary seat share: left	1602	18.7102	20.1883	0	67.52
Quality of governance	Voice and accountability	3579	-0.0329	0.9915	-2.3134	1.8010
	Political stability	3558	-0.0272	0.9824	-3.3149	1.7601
	Government effectiveness	3578	-0.0181	0.9902	-2.4459	2.4370
	Regulatory quality	3579	-0.0178	0.9927	-2.6450	2.2605
	Rule of law	3607	-0.0299	0.9935	-2.6064	2.1003
	Control of corruption	3587	-0.0193	0.9953	-1.8687	2.4700
Federalism	No – autonomous regions	6689	0.8689	0.3375	0	1
	Yes – autonomous regions	6689	0.1311	0.3375	0	1
	Municipal governments					
	-No local elections	3977	0.2421	0.4284	0	1
	-Legislature locally elected	3977	0.2406	0.4275	0	1
	-Legisl. and exec. locally elected	3977	0.5172	0.4998	0	1
	State/province governments					
	-No local elections	5058	0.4553	0.4980	0	1
	-Legislature locally elected	5058	0.2912	0.4544	0	1
	-Legisl. and exec. locally elected	5058	0.2535	0.4350	0	1
	No – local authority	2331	0.5401	0.4985	0	1
	Yes – local authority	2331	0.4599	0.4985	0	1
	No – constit. of the senators	2242	0.4688	0.4991	0	1
	Yes – constit. of the senators	2242	0.5312	0.4991	0	1
	Self-rule (ln)	3336	1.5505	1.0913	0	3.3082
	Shared-rule (ln)	3336	0.5644	0.8853	0	2.7730
	Rai-total (ln)	3336	1.6697	1.1873	0	3.6373

Appendix 2: Distribution of economic development, population density and disaster probability



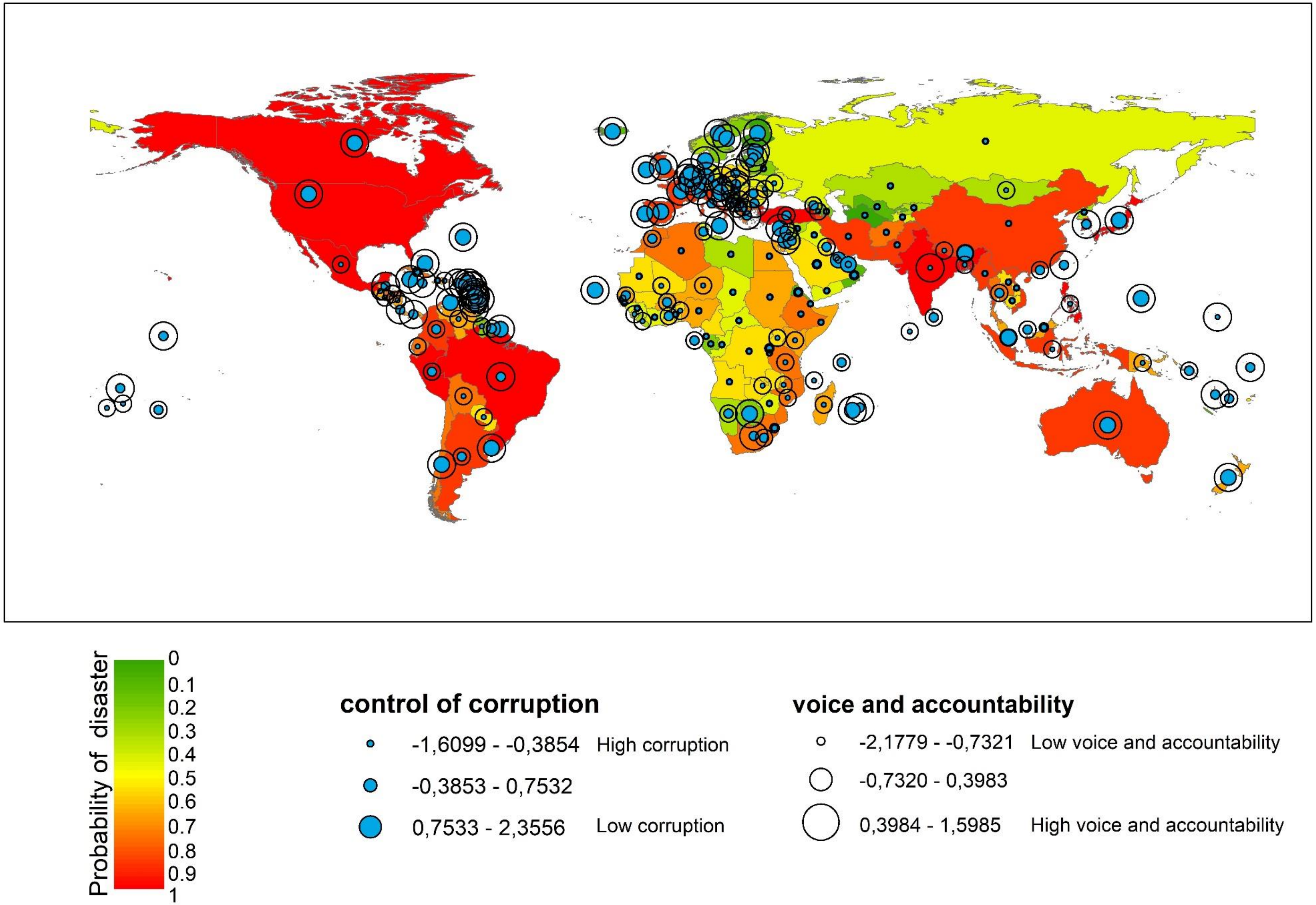
Appendix 3: Regression results: Socioeconomic factors for predictable disasters

		(1)	(2)	(3)	(4)	(5)	(6)
		1961-2016	1961-2016	1961-2016	1961-2016	1991-2016	1972-2016
Economic development	GDP per capita (ln)	-0.3934*		-0.0173		-0.7851	-0.6151
Economic growth	Annual growth	0.0189	0.0183	0.0154	0.0157	-0.0003	0.0342
Agglomeration economies	Population density (ln)	1.2196**	1.6608***	0.7867	0.8101	1.4899*	0.6417
Urbanisation economies	Urban population		-0.0255*				
Sectoral composition	- Agriculture				0.3484		
	- Industry			-0.0160	0.3313		
	- Services			0.0049	0.3522		
Unemployment	Unemployment rate					0.0473	
Public sector	Tax revenue						0.0153
	Log likelihood	-1145.9155	-1145.9541	-914.87943	-914.29973	-761.75033	-664.05705
	LR chi2	491.81	491.73	391.02	392.18	100.92	183.50
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	4,800	4,800	3,731	3,731	2,524	2,115

		(7)	(8)	(9)	(10)	(11)
		1972-2016	1961-2014	1961-2014	1961-2016	1961-2016
Economic development	GDP per capita (ln)	-0.5979	1.2934**		-0.9047***	-0.9249***
Economic growth	Annual growth	0.0430**	0.0096	0.0205	0.0222	0.0219
Agglomeration economies	Population density (ln)	0.6858	1.2169	1.2367**	0.1182	0.2131
Public sector	Expense	0.0076				
Investment	Capital stock (ln)		-1.3125***			
Technological change	tfp		-2.0051**			
Educational endowment	Human capital index			-0.8866		
Income inequality	Gini (disposable)				-1.1824	
	Gini (market)					0.2405
	Log likelihood	-623.82905	-850.90656	-1009.7182	-925.66024	-925.73074
	LR chi2	175.65	375.89	458.42	301.61	301.47
	Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000
	Observations	1,960	3,141	4,070	3,105	3,105

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies

Appendix 4: Distribution of voice and accountability, control of corruption and disaster probability



Appendix 5: Regression results: Political factors for predictable disasters

i) Government composition

	(1)	(2)	(3)	(4)
	1975-2015	1961-2015	1961-2015	1961-2015
GDP per capita (ln)	-0.0843	-3.5500**	-3.5041**	-3.5061**
Annual growth	0.0023	0.1201**	0.1226**	0.1220**
Population density (ln)	1.2116	-2.6771	-2.6513	-2.6234
Party orientation: right	-0.1144			
Party orientation: center	base			
Party orientation: left	0.1493			
Cabinet posts: right		0.0004		
Cabinet posts: center		0.0042		
Cabinet posts: left		0.0075		
Relative power position: right			-0.0042	
Relative power position: center			-0.0005	
Relative power position: left			0.0033	
Parliamentary seat share: right				-0.0054
Parliamentary seat share: center				0.0007
Parliamentary seat share: left				0.0084
Log likelihood	-601.56218	-273.45868	-273.04124	-272.99574
LR chi2	217.72	159.08	159.91	160.00
Prob>chi2	0.0000	0.0000	0.0000	0.0000
Observations	2,082	941	941	941

ii) Quality of governance

	(5)	(6)	(7)	(8)	(9)	(10)
	1996-2016	1996-2016	1996-2016	1996-2016	1996-2016	1996-2016
GDP per capita (ln)	-0.4289	-0.3839	-0.1674	-0.4562	-0.4857	-0.4646
Annual growth	-0.0159	-0.0170	-0.0131	-0.0134	-0.0137	-0.0154
Population density (ln)	2.4479*	2.7475**	2.5964**	2.7995**	2.8266**	2.8121**
Voice and accountability	0.8889**					
Political stability		0.3890				
Government effectiveness			-0.0386			
Regulatory quality				0.5180		
Rule of law					0.6531	
Control of corruption						0.6826*
Log likelihood	-538.03625	-539.35504	-540.59299	-539.56807	-539.60446	-539.20921
LR chi2	64.58	61.94	59.23	61.28	61.44	62.12
Prob>chi2	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	1,607	1,607	1,605	1,605	1,607	1,606

iii) Federalism

	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	1975-2015	1975-2015	1975-2015	1975-2015	1975-2015	1961-2010	1961-2010	1961-2010
GDP per capita (ln)	-0.3296	0.0170	-0.3108	-0.5332	-0.5616	-0.7901*	-0.6823*	-0.7563*
Annual growth	0.0140	0.0232	0.0096	-0.0060	-0.0118	0.0058	0.0057	0.0057
Population density (ln)	0.4740	0.3723	0.1986	-0.7415	0.6389	1.4213	1.2658	1.4347
No – autonomous regions	base							
Yes – autonomous regions	-0.2110							
Municipal governments								
-No local elections		base						
-Legislature locally elected		-0.5060						
-Legisl. and exec. locally elected		-0.2564						
State/province governments								
-No local elections			base					
-Legislature locally elected			-0.4216					
-Legisl. and exec. locally elected			-0.6190					
No – local authority				base				
Yes – local authority				13.6188				
No – constit. of the senators					base			
Yes – constit. of the senators					-1.1376			
Self-rule (ln)						0.2024		
Shared-rule (ln)							-0.2825	
Rai-total (ln)								0.1352
Log likelihood	-961.72383	-705.25178	-850.41129	-456.39223	-489.44196	-576.9147	-576.65148	-577.04674
LR chi2	270.39	181.51	204.53	128.37	150.57	320.36	320.88	320.09
Prob>chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	3,541	2,337	2,856	1,538	1,559	2,204	2,204	2,204

*** p<0.01, ** p<0.05, * p<0.1; all regressions include time-dummies