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# THE ROLE OF NATURAL HAZARD ON INCOME INEQUALITY

**Lucia Errico**

*University of Calabria, Department of Economics, Statistics and Finance "Giovanni Anania" – DESF*

*(e-mail: lucia.errico@unical.it)*

**Andrea Mosca**

*University of Bergamo, Department of Economics*

*(e-mail: andrea.mosca@unibg.it)*

**Sandro Rondinella**

*University of Calabria, Department of Economics, Statistics and Finance "Giovanni Anania" – DESF*

*(e-mail: sandro.rondinella@unical.it)*

**Carmela Ciccarelli**

*University of Calabria, Department of Economics, Statistics and Finance "Giovanni Anania" – DESF*

*(e-mail: carmela.ciccarelli@unical.it)*

**Info**
Via Pietro Bucci, Cubo **0/C**
87036 Rende (Cs) - Italia
tel. (+39) 0984 492434 / 492422

https://desf.unical.it

# The role of Natural Hazard on Income Inequality ♠

**Lucia Errico[a,*], Andrea Mosca[b], Sandro Rondinella[a] and Carmela Ciccarelli[a]**

[a] *Department of Economics, Statistics and Finance 'Giovanni Anania', University of Calabria, Rende (Italy)*

[b] *Department of Economics, University of Bergamo, Bergamo (Italy)*

**Abstract**

This study investigates the relationship between environmental risks and income inequality within Italian municipalities, utilising data spanning from 2010 to 2020. Specifically, leveraging a unique dataset drawing upon various sources, we analyse the impact of environmental hazards such as hydrogeological risks, landslides, volcanic zones, and earthquakes on income distribution. Our findings suggest that municipalities facing heightened environmental risks tend to exhibit increased income inequality, with results being driven by hydrogeological risks, landslides, and volcanic zones. On the other hand, earthquake risk appears to alleviate income inequality, particularly in the South of the country. Our results underscore the significance of preventive and communication measures not only in mitigating the impact of such natural hazards but also in managing the associated economic uncertainty.

***Keywords***: Income inequality, environmental risk, beta regression

***Jel Codes***: D31; I30; Q54

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♠ Even though the paper is the result of joint work by the authors, Lucia Errico, Andrea Mosca, and Sandro Rondinella are jointly responsible for all sections. Instead, Carmela Ciccarelli, along with other co-authors, is responsible for the literature review included in Section 1.

* Corresponding author. Address: Dipartimento di Economia, Statistica e Finanza "Giovanni Anania" – Università della Calabria, Ponte Pietro Bucci, Cubo 0/C, 87036 Arcavacata di Rende (CS) – Italy.
E-mail: lucia.errico@unical.it

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## 1. INTRODUCTION

Environmental risks and income inequality are interconnected challenges that pose significant implications for both the well-being of societies and countries' economies. This established relationship provides a compelling motivation for our analysis, which seeks to examine the influence of environmental risks on the income inequality of Italian municipalities. In the last decades, the frequency and severity of extreme climate events have drawn increasing attention to their extensive impacts on ecosystems, infrastructures, economic activity and human well-being (EPA, 2023; NASA, 2023). Between 1980 and 2022, damages from climate-related extremes amounted to an estimated EUR 650 billion (2022 prices) in the EU. According to the report on promoting safety from natural hazards, Italy is prone to earthquakes, landslides, and floods. These events have resulted in over 10,000 fatalities and an economic loss of approximately 290 billion over the past seven decades (Presidenza del Consiglio dei Ministri, 2017). In addition, due to its particular position in the geodynamic context of the Mediterranean, Italy is one of the countries with the greatest seismic danger in Europe. Therefore, seismic and geological-hydraulic hazards represent two critical issues for Italy (ISPRA, 2022).

Extreme events and natural disasters, by temporarily halting economic activities due to both direct and indirect damages, have a detrimental effect on economic growth, particularly evident in low-income countries and during severe natural disasters (Okuyama, 2003; Hochrainer, 2009; Felbermayr and Groschl, 2014; Hsiang and Jina, 2014; Botzen et al., 2019; Panwar and Seno, 2019). Furthermore, environmental hazards can create an atmosphere of uncertainty, impeding long-term investment prospects within a country. Yet, it adversely affects tourism, production in the agricultural and industrial sectors, and household income (Hsiang, 2010; Anttila-Hughes and Hsiang, 2013; Keen et al, 2003; Fiala, 2017; Hystad and Keller, 2006; Rossellò et al., 2020).

Exploring the influence of natural disasters and environmental uncertainty[1] on income inequality is a relevant subject, considering the significant impact of income distribution on various outcomes. Lower income inequality can yield numerous positive effects, such as poverty reduction, enhanced social cohesion, improved health outcomes, increased economic growth, strengthened human capital, and greater economic stability (refer to, among others, Subramanian and Kawachi, 2004; Wilson and Pickett, 2009; Wilson and Pickett, 2011; Stiglitz, 2015; Di Gioacchino et al., 2024). Focussing on the impact of natural disasters on income distribution varies widely across countries, regions, and individuals due to differing levels of exposure and susceptibility (Song et al., 2023). Various studies suggest that natural disasters – involving meteorological, geological or hydrological phenomena in nature – typically worsen poverty in the short term (Carter et al., 2007; Rodriguez-Oreggia et al., 2013; Zografos et al., 2016), thereby increasing income inequality (Yamamura, 2015), particularly affecting vulnerable groups, such as those employed in agriculture (Paglialunga et al., 2022; Tanir et al., 2024), which tolerate the most significant damages relative to their income (Wisner, 2004; Hallegatte et al., 2017; Brata, 2022).

Lower socioeconomic cohorts are more vulnerable to river floods, exacerbating financial disparities and worsening the economic status of affected populations (Fielding and Burningham, 2005; Erman et al., 2018; Araùjo, 2021; Bista, 2022). Also, volcanic eruptions pose a substantial threat to agricultural areas, impacting sector productivity and farmers' incomes, especially in regions with limited resources and adaptation technologies (Cronin et al., 1998; Annen and Wagner, 2003; Hsiang et al., 2019). Landslides disproportionately affect rural populations, leading to significant income losses among farmers and exacerbating income inequality (Msilimba, 2009; Mertens et al.,

[1] A natural disaster refers to the severe and detrimental consequences experienced by a society or community as a result of a natural hazard event. A natural hazard, on the other hand, is a naturally occurring phenomenon that has the potential to cause harm to humans, other animals, or the environment. These hazards are broadly categorized into geophysical and biological events. Additionally, natural hazards can be influenced or exacerbated by human activities such as changes in land use, drainage systems, and construction practices. The relationship between natural disasters and natural hazards, as explained by the US Federal Emergency Management Agency (FEMA), involves recognizing that while natural hazards represent the threat of adverse events, natural disasters occur when these hazards actually manifest and significantly impact a community. FEMA. (2023, April 18). "Glossary." https://training.fema.gov/programs/emischool/el361toolkit/glossary.htm#N.

2016; Bista, 2022). Studies on the socio-economic consequences of seismic events present conflicting results, with some indicating greater damage to disadvantaged groups due to a lack of preventive actions triggered by budget constraints (Reyes-Nunez and Jamienson, 2023) and struggle with recovery over time (Sapkota et al., 2021). On the other hand, others find no significant increase in income inequality following earthquakes (Feng et al., 2016; Mendoza and Jara, 2022). However, severe earthquakes have shown a negative impact on non-agricultural growth, highlighting the need for further exploration of post-seismic socio-economic dynamics (Panwar and Seno, 2019).

The argument posited in our work aims to explore the relationship between environmental risks and income inequality, focusing on Italian municipalities as a case study. The contribution of this article is threefold. Firstly, we provide empirical evidence exploiting a unique highly disaggregated dataset at the municipal level, covering a lengthy observation period from 2010 to 2020. To our knowledge, the topics explored in this study have not been previously investigated with such high-quality data. Second, the topics examined have been largely overlooked in existing literature across all Italian municipalities. However, its significance has been highlighted in recent studies focusing on Italy's varying levels of income inequality (Gallo and Pagliaccio, 2020; Bonanno et al., 2022) and environmental risk profiles (Oliviero et al., 2024), rendering it an ideal subject for investigation in this context. To bolster our investigation, we consider examining specific environmental risk factors such as earthquakes, floods, and landslides, and how they correlate with income inequality within Italian municipalities. Focusing on Italy is also motivated by its vulnerability to natural disasters, highlighted by the Disaster Risk Management Knowledge Centre (DRMKC) of the European Commission's Joint Research Centre (JRC), ranking it among the most susceptible countries, along with Bulgaria, Romania, and Greece.[2] Furthermore, the North-South divide in Italy, with distinct economic development and industrialization levels, offers a compelling opportunity to explore varied responses to environmental risks.

[2] https://drmkc.jrc.ec.europa.eu/risk-data-hub/#/vulnerability-in-europe

Lastly, we also contribute to the literature that examines the effects of economic uncertainty stemming from exposure to environmental risk, rather than only focusing on the impact of natural disasters *per se* on income distribution.[3] Indeed, there is limited understanding regarding the significance of uncertainty in terms of its effects on income distribution (Theophilopoulou, 2022). Specifically, as elucidated by Theophilopoulou (2022), economic uncertainty disproportionately affects higher-income households and individuals situated at the higher percentiles of income distributions, whereas those at the lower end of the spectrum are less affected. During uncertain times, affluent households, reliant on earnings and investments, face significant income reductions, while lower-income households, supported by social security benefits, experience milder impacts due to the countercyclical nature of these benefits. Economic uncertainty also affects the broader economy by prompting firms to adjust their investment and hiring practices, leading to a downturn in economic activity. This reduction in output can affect aggregate demand and prices, contributing to income inequality, as identified by various studies (Piketty and Saez, 2003; Roine et al., 2009; Coibion et al., 2017; Fischer et al., 2021).

Moving from these insights, on the methodological ground, we employ a Beta regression model suitable for both cross-sectional and longitudinal data as the outcome variable of our analysis is the income concentration index or the Gini Index. The latter is computed based on actual informative income data from the Ministry of Economy and Finance (MEF). Instead, information on environmental risk is provided by the Italian Institute of Statistics (ISTAT). Our findings suggest that municipalities facing elevated environmental risk levels demonstrate increased income inequality. Factors such as hydrogeological and landslide risks, along with the presence of volcanic zones, appear to contribute to this pattern. These environmental threats, consistent with the literature, exacerbate disparities by deteriorating the economic well-being of affected communities. Conversely, our findings suggest that earthquake risk alleviates income inequality. The latter finding seems to be

[3] Refer to footnote 3 for the definition of natural disasters and natural hazard.

driven by Mezzogiorno, as in Northern regions income inequality remains unaffected by the risk of earthquakes.

A possible interpretation of this finding could be attributed to the significant uncertainty associated with this particular hazard phenomenon, given its unpredictability and severe consequences. Higher-income households, with greater exposure to labour and financial incomes, are primarily affected by heightened uncertainty, potentially mitigating income inequality (Theophilopoulou, 2022). Additionally, critical issues in the South, such as ageing buildings and delays in redevelopment (e.g., 50% of public schools needing urgent work compared to 20% in the North), exacerbate the impact of seismic events (Legambiente, 2024). Addressing seismic event uncertainty requires proactive measures, including incentives for building compliance with natural hazards and communication strategies to raise awareness and reduce exposure (Reyes-Nunez and Jamienson, 2023). Public policies aimed at containment and risk reduction, coupled with awareness campaigns across various channels (e.g., social media), play a crucial role in minimizing uncertainty and thereby marginally improving population well-being.[4] Our finding implies that addressing environmental risks and income inequality concurrently is crucial for sustainable development and inclusive growth. Policymakers can leverage this insight to craft targeted interventions that alleviate the detrimental impacts of environmental risks on vulnerable populations and foster equitable economic outcomes across regions.

The remainder of this work is organized as follows. The next section outlines the empirical strategy, while Section 3 illustrates the data used as well as the descriptive statistics. Section 4 discusses the results obtained. Section 5 concludes this paper.

## 2. EMPIRICAL STRATEGY

[4] An example of an information campaign at a national level is the "Terremoto - Io non rischio" initiative, which was launched in 2010 following the strong earthquake that struck L'Aquila. This initiative was promoted by the Department of Civil Protection and Anpas (National Association of Public Assistance), in collaboration with INGV (National Institute of Geophysics and Volcanology), ReLUIS (Consortium of the Laboratory Network for Earthquake Engineering University), and in agreement with the Regions and Municipalities involved.

This paper utilizes the income concentration index (i.e. the Gini Index) to measure economic inequality as it is the predominant measure for assessing income inequality.[5] The Gini Index is a continuous random variable within the interval (0,1) and is commonly analyzed using the Beta distribution (Bonanno et al., 2022). The probability density function (PDF) of the Beta distribution is parameterized based on mean and precision parameters, as outlined by Ferrari and Cribari-Neto (2004).[6] In line with the approach introduced by the latter authors, we employed a nonlinear regression model to estimate the mean, $\mu_{it}$, employing a logit transformation. Additionally, the precision parameter, $\phi_i$, was estimated using a log-linear link.

Given the characteristics of our dependent variable, we employ beta regression overcoming the limitations identified in existing literature concerning the assessment of the influence of different explanatory variables on the Gini Index using Gaussian linear models (Bonanno et al., 2022). To be more specific, we apply the beta mixed model or the generalized beta model with mixed effects (Beta GLMM), namely an expanded form of the Beta regression.[7] This methodology allows us to accommodate the longitudinal and multilevel hierarchical structure of the data. Specifically, this class of models involves incorporating random effects into a standard Beta regression model, effectively addressing the issue of dependence within clusters. When analyzing repeated measures for each subject or when subjects are grouped, observations linked to the same statistical unit often exhibit correlation, violating the assumptions of conventional regression models (Bonat et al., 2015).

We estimate a nonlinear regression model for the mean using a logit transformation. To account for the multilevel structure of the data, we include a random intercept for the region $j$ where the municipality is located ($j = 1, \ldots, 20$).

[5] This scalar metric evaluates the average deviations in income distribution, ranging from 0 (representing perfect equality) to 1 (indicating perfect inequality). Noteworthy for its desirable properties, the Gini coefficient exhibits mean independence, population size independence, and symmetry (De Maio, 2007; Coccorese and Dell' Anno, 2022).
[6] Refer to Ferrari and Cribari-Neto (2004) for a detailed description of the methodology related to the Beta distribution.
[7] Generalized linear mixed models (GLMMs) offer an advantage over traditional mixed linear models by accommodating response variables that do not follow a Gaussian distribution. Additionally, GLMMs allow for the inclusion of random effects among predictors, in addition to the typical fixed effects, thereby extending the hypotheses of generalized linear models (GLMs). However, it's important to note that the assumptions regarding the independence of sample units and homogeneity may be violated. For further details, refer to Lovison et al. (2011).

The following equation defines the model for the mean:

$$logit(\mu_{it}) = \beta_{0j} + \beta_1 RISK_i + \sum_X \beta_X X_{it} + \sum_Z \beta_Z Z_{jt} + \beta_t TIME\ TREND_t \quad (1)$$

where *i* denotes the *i*-th municipal, *t* refers to the temporal period and *j* represents the *j*-th region.

It is important to note that when applying this method, the intercept of the model ($\beta_{0j}$) is equal to $\beta_{0j} = \omega_{00} + \omega_{0j}$, which represents the sum of the overall mean of the Gini Index ($\omega_{00}$) and the random variation from the overall mean attributed to the *j*-th region ($\omega_{0j}$).

On the right side of the equation, RISK represents the key variable, measuring the environmental hazard of the municipality $i$. Following Oliviero et al. (2024), we define an aggregate variable of environmental risk at the municipality level which ranges from 0 to 4, where a value equal to 4 indicates exposure to all four sources of risk, while 0 indicates an absence of exposure to any source of environmental risk.[8] Specifically, the components of the aggregate risky measure are HYDRAULIC representing areas with high hydraulic hazard, scaled for municipality surface (both expressed in square kilometres), LANDSLIDE is the area with high landslide hazard divided by the municipality surface (both expressed in square kilometres),[9] VOLCANIC is a binary variable taking value equal to one if a municipality belongs to a volcanic area.[10] Lastly, EARTHQUAKE is a dummy equal to one if the municipality is classified as a high seismic risk area.[11]

What is more, building upon existing literature on factors influencing income inequality at the country level (e.g., Furceri and Ostry, 2019; Nolan et al., 2019; Acemoglu and Robinson; 2020; Zhang et al., 2020; Dang and Nguyen, 2021), we examine various socioeconomic and demographic

[8] Summary statistics are reported in Table 1.
[9] In defining the variable RISK for the continuous variables, LANDSLIDE and HYDRAULIC, we construct dummy variables at the municipal level that take a value equal to one when their values are above their respective median.
[10] It is should be noticed that all volcanic areas in Italy are in South.
[11] Natural occurrences that pose potential hazards can be classified into two primary categories, distinguished by their underlying mechanisms. The first category, genetic phenomena, encompasses those arising from within the Earth (e.g., volcanic eruptions, earthquakes), stemming from internal Earth processes. The second category, exogenous phenomena (e.g., floods, landslides, avalanches), occurs on the Earth's surface. These phenomena vary significantly in their magnitude and frequency, often on a vast scale (ISPRA, 2022).

characteristics at the municipality level as in Gallo and Pagliacci (2020), Mastronardo and Cavallo (2020), and Bonanno et al. (2022). In particular, the vector of covariates $X$ includes the average taxable income (INCOME) to account for the economic development of the municipality and the number of hospitality businesses (BUSINESS) that are integral to the vitality and prosperity of a municipality (Rosselló et al., 2020). Moreover, we control for the institutional context by adding TAX REVENUE, which represents the tax capacity of the municipality, and variables capturing the characteristics of the mayor (MAYOR AGE, MAYOR BACHELOR, and MAYOR FEMALE). Municipal management significantly influences income distribution as local administrators' preferences shape redistribution efforts, impacting income inequality (Einstein and Glick, 2018; Nitschke and Roesel, 2023). Mayors can address local income inequality by promoting policies such as housing density near transit hubs and supporting education voucher programs. Encouraging minority-owned small businesses and enhancing their access to capital are also effective strategies (Stajkovic and Stajkovic, 2024).

To capture the effect of technological advancement, we employed a proxy for innovation. Specifically, we introduced a dummy variable, UNIVERSITY, which takes the value of one if a municipality hosts a university and zero otherwise. The rationale behind this hypothesis, which suggests that the presence of a university fosters knowledge spillovers, is widely recognized in the literature (Bonaccorsi et al., 2014; Muhamad et al., 2022; Rukanyangira and Oidu, 2021).

Furthermore, the population density (POP DENSITY) and the senior index (SENIOR INDEX) are inserted in the model to control for the demographic characteristics of the territory. The former indicates urbanization and rurality levels, informing settlement characteristics in Italy's diverse territories (Mastronardo and Cavallo, 2020). The senior index allows for control of the population composition and the redistributive effect of pensions (Mastronardo and Cavallo, 2020; Bonanno et al., 2022). Finally, the TIME TREND captures the temporal effect on the Gini Index.

As far as the dispersion model is concerned, the equation for the precision parameter is defined by the following equation:

$$log(\phi_i) = \gamma_0 + \gamma_1 RISK_i \qquad (2)$$

where only $i$ subscript denotes that variable $RISK_i$ is time-invariant. By estimating the dispersion model, we gain insight into how the Gini coefficient reacts to changes within the middle range of income levels, highlighting its sensitivity to such variations.

A more detailed description of all the variables employed in our estimations and their main statistics are shown in Table 1. Table 2 provides a correlation matrix, showing no higher correlation among the variables included in the estimated model is detected.

[TABLES 1 AND 2]

## 3. DATA AND DESCRIPTIVE STATISTICS

### 3.1 Data

Our data collection involved accessing fiscal declarations at the municipal level spanning the years 2010–2020 from the Ministry of Economy and Finance (MEF – Department of Finance) website.[12] These declarations offer comprehensive information regarding taxpayers' income and assets within consistent income brackets for each municipality. The data originates from tax returns submitted during the specified timeframe. The calculation of the Gini Index relies on municipality-specific tabulated data concerning declared gross income segmented into seven income brackets.[13]

Environmental risk data at the municipal level is available from the Italian National Institute of Statistics (ISTAT) website,[14] along with other characteristic information (e.g., the number of hospitality businesses, population density, senior index). Financial data on the local authorities is

[12] https://www1.finanze.gov.it/finanze/pagina_dichiarazioni/public/dichiarazioni.php. This source is also used for the average taxable income variable.

[13] Consistency in income intervals is preserved both over time and across municipalities to facilitate comparability. The defined income brackets, denominated in thousands of euros, are as follows: (i) 0–10,000; (ii) 10,000–15,000; (iii) 15,000–26,000; (iv) 26,000–55,000; (v) 55,000–75,000; (vi) 75,000–120,000; and (vii) exceeding 120,000. To compute the Gini Index for each municipality and year, we follow the procedure used by Rubolino (2023).

[14] This information is available at https://www.istat.it/it/mappa-rischi.

obtained from the Bureau van Dijk's Aida PA.[15] Details about the mayor's characteristics come from the Italian Ministry of the Interior's website.[16] Finally, the Ministry of Education, University and Research (MIUR) is consulted to account for the presence of a university in a municipality.[17]

### 3.2 Descriptive statistics

Figure 1 depicts the geographical distribution of environmental risk in Italy, revealing that the municipalities most vulnerable to natural disasters are located in the Central-North regions, all the South excluding the Apulia region, and the Catania area in eastern Sicily.

[FIGURE 1]

When assessing landslide hazards, municipalities facing elevated risks are identified in the extreme North, along the Alps, in the central region along the Apennines, and in the Northern part of the Mezzogiorno (Campania region is strongly affected), with some areas in Sardinia also affected (see Figure A1 in Appendix). The hydraulic hazard is widespread across the country, except for the Northeastern part and the central region along the Apennines (see Figure A2 in Appendix). Similarly, municipalities with heightened earthquake risks (see Figure A3 in Appendix) are clustered around the Apennines, in Sicily (excluding central and extreme western parts), and in the Northern regions of Friuli Venezia Giulia and Veneto. Lastly, municipalities in volcanic areas (see Figure A4 in Appendix) are located near Vesuvius (Campania) and Etna (Sicily).

Table 3 reports the Gini Index values for different levels of environmental risk in Italy. There is a slight variation in the mean Gini Index across different levels of environmental risk, ranging from 0.3763 to 0.4298. The coefficients of variation (CV) are relatively consistent across different levels of risk, indicating a similar level of variability relative to the mean across the risk categories.

[15] https://www.bvdinfo.com/en-gb/our-products/data/national/aida-pa.
[16] https://dait.interno.gov.it/elezioni/open-data.
[17] https://ustat.mur.gov.it/

The Gini Index values are also presented for different levels of environmental risk in two broad regions: Centre-North and South and Islands. In both regions, there is a similar pattern of variation in the mean Gini Index across different levels of environmental risk. The coefficients of variation are relatively consistent within each region, suggesting similar levels of variability relative to the mean across different levels of risk within each region. When comparing the overall mean Gini Index for Italy (0.3808) with the mean values for the Centre-North (0.3746) and South and Islands (0.3941), it appears that the South and Islands region has a slightly higher Gini Index on average compared to the Centre-North region.

[TABLE 3]

**4. ESTIMATION RESULTS**

Table 4 shows regression results from a beta GLMM. The analysis is structured into various specifications, initially dedicated to the examination of overall environmental risk - column 1 - and then to the effects of individual risk components - columns 2 to 5. The table includes both the Conditional Mean Model and Dispersion Model results.

The coefficient on Environmental Risk (RISK), in column 1, consistently suggests a positive association with the Gini Index, implying that income inequality increases in municipalities exhibiting a greater intensive margin of environmental risk. Column 2 reveals that hydrogeological risk (HYDRAULIC) has a positive and statistically significant effect on income inequalities as in Araùjo et al. (2022) and Bista (2022).[18] A similar effect is observed for landslide risk and volcanic zones. Specifically, in Column 3, the coefficient associated with LANDSLIDE demonstrates a robust positive significance, in line with Bista (2022), and in Column 4, the coefficient related to volcanic areas (VOLCANIC) yields a similar result of Hsiang et al. (2019). Interestingly, we observe an opposite result in Column 5 for the earthquake-related coefficient (EARTHQUAKE), which is

[18] High hydrogeological risk exacerbates damage from floods and landslides. Thus, we connect the literature on floods to this risk, which, to our knowledge, has not yet been explored in relation to income inequality.

negatively associated with the Gini coefficient. The latter result might suggest that population groups more affected by this phenomenon are those with high incomes, which heavily depend on earnings and investments, and potentially are involved in non-agricultural incomes. Additionally, the level of uncertainty experienced by these groups may play a crucial role, leading to a reduction in wealth and potentially mitigating income inequality (Panwar and Seno, 2019; Theophilopoulou, 2022).

Turning now to the results of the control variables, the negative coefficient on INCOME suggests that an increase in income is associated with a decrease in the Gini Index, holding other variables constant. The positive values of the coefficients associated with BUSINESS indicate that as the number of hospitality businesses increases, the income concentration index tends to rise. Similarly, the income concentration index tends to increase with TAX REVENUE, MAYOR AGE, MAYOR BACHELOR. By contrast, MAYOR FEMALE is negatively correlated with the Gini Index. The positive values of coefficients on UNIVERSITY and POP DENSITY suggest that municipalities with universities and higher population densities tend to have a higher income concentration index. Instead, we find a negative relationship between the seniority index and income inequality. Lastly, a positive trend in the Gini Index over time emerges from the coefficient of TIME TREND.

The dispersion model, reported in Table 4, shows that environmental risk has a statistically significant impact on the precision parameter of the income concentration index. The positive coefficient on RISK suggests that higher environmental risk is associated with a decrease in the variability of the Gini Index. Moreover, these estimates highlight significant differences in the variability of the income concentration index across different environmental hazard components. In particular, according to columns 2 and 3, there is an increase in the variability of the Gini Index in municipalities affected by higher hydrologic and landslide risks. Conversely, when considering volcanic and seismic areas (columns 4 and 5), the dispersion of the income concentration index is reduced.

[TABLE 4]

In Tables 5 and 6, we provide estimates by splitting the sample in Central-North and South Italy, respectively.[19] Overall, the findings reported in Table 4 are confirmed, including those related to control variables. Indeed, columns 1 to 3 of both tables show positive coefficients on the composite indicator of environmental risk (RISK), HYDRAULIC and LANDSLIDE. A similar pattern is evidenced for volcanic risk, which is positively related to the Gini Index in the South.

Notable differences emerge when focusing on the seismic zone. According to Table 5 (column 4), EARTHQUAKE does not significantly affect income distribution in Central-Northern Italy, aligning with the findings of previous studies (e.g., Feng et al., 2016; Mendoza and Jara, 2022).[20] Instead, column 5 of Table 6 shows that earthquake risk is negatively associated with income inequality. These results highlight the presence of heterogeneous effects across Italian regions in terms of the relationship between environmental risks (i.e., seismic risk) and income disparities. Indeed, in Mezzogiorno, the uncertainty which characterizes the link under scrutiny could be influenced by issues such as ageing buildings and building redevelopment (Legambiente, 2024).

When focusing on the dispersion model, Tables 5 and 6 display dissimilar evidence on the influence of environmental risk and its components on the variability of the Gini Index. Indeed, for the Northern regions, results are in line with those described for the entire sample, with the only exception being volcanic areas (i.e., the variability of the Gini Index is negatively (positively) associated with RISK and EARTHQUAKE (HYDRAULIC and LANDSLIDE)). Instead, in Table 6, the negative coefficient on RISK suggests that higher environmental risk is associated with a rise in the variability of the Gini Index. The components HYDRAULIC and VOLCANIC are positively correlated with the precision parameter of the income concentration index, suggesting lower dispersion in municipalities with higher hydrological risk and those located in volcanic areas. Lastly, the negative coefficient on EARTHQUAKE suggests an increase in the variability of the Gini Index.

[19] The Chow-test, reported in Table A1, confirm that the differences between the risk measure (and the components) coefficients and their analogues in the two sub-samples are statistically significant.
[20] The specification including volcanic risk is not included due to the absence of volcanic zones in this area.

[TABLES 5 AND 6]

### 4.1 Robustness checks

Table 7 reports the output of several robustness checks performed by changing the benchmark specification through the inclusion of additional control variables. More specifically, column 1 shows the estimation results when the econometric model is augmented with the share of female municipal employees (GENDER) and the education of municipal employees (EDUCATION). The figures in column 2 are obtained when the estimated equation includes the disaggregation of the inner area as defined by the National Strategy for Inner Areas (NSIA) classification (INTERMEDIATE, PERIPHERAL, ULTRAPERIPHERAL).[21] Lastly, results in columns 3, 4 and 5 are obtained by including regional variables such as the institutional quality indices (IQI REG),[22] the unemployment rate (UNEMPLO REG) and a measure of social capital (SOCCAP REG).[23] All these sensitivity checks leave our results for both conditional and dispersion models unchanged.

Tables 8 and 9 present the same robustness checks for the North Central and South samples, respectively. These findings reinforce the evidence discussed earlier.

[TABLES 7, 8 AND 9]

## 5. CONCLUDING REMARKS

The intertwining challenges of environmental risks and income inequality have significant implications for societal well-being and economic stability. The increasing frequency and severity of extreme climate events have highlighted their extensive impacts on ecosystems, infrastructure,

[21] Insights into Italian inner areas, classified according to the NSIA in 2014, are obtained from the National Agency for Territorial Cohesion website. This classification is based on the concept that certain territories are spatially peripheral, which impacts their access to essential services (such as education, health, and mobility), and may affect citizens' quality of life and, consequently, their economic potential and the level of social inclusion.

[22] The Institutional Quality Index, provided by Nifo and Vecchione (2014) is a composite index based on the following sub-indicators: endowment of social structures, endowment of economic structures, regional health deficit, separate waste collection, and urban environment index.

[23] The social capital measure is defined as the regional number of blood donors to the 18-65 regional population (measure employed, among others, by Guiso et al., 2004 and Bigoni et al., 2016; Mocetti and Rizzica, 2023).

economic activities, and human welfare. These events, coupled with environmental hazards, not only disrupt economic growth but also create an atmosphere of uncertainty, hindering long-term investment prospects and adversely affecting various sectors such as tourism, agriculture, and household income. Exploring the influence of extreme events and environmental uncertainty on income inequality is crucial, given the significant impact of income distribution on poverty reduction, social cohesion, health outcomes, economic growth, and stability.

In this regard, this study contributes to the existing literature by empirically examining the relationship between environmental risk and income inequality in Italian municipalities. Utilizing data on environmental risk and income concentration, we find that municipalities facing higher environmental risk levels tend to exhibit greater income inequality. By contrast, earthquake risk appears to alleviate income inequality, particularly in the South, highlighting regional disparities. A possible interpretation of this evidence may involve the uncertainty associated with seismic risk, which, by damaging higher-income individuals and households, might lead to a reduction of income inequality. Mezzogiorno, characterized by older buildings and delays in building redevelopment, may be more affected by this mechanism than more advanced northern regions.

Therefore, this research underscores the importance of addressing environmental risks and income inequality in tandem to foster sustainable development and inclusive growth. By understanding the complex interplay between environmental factors and income distribution, policymakers can develop targeted interventions to mitigate the adverse effects of environmental risks on vulnerable populations and promote equitable economic outcomes across regions. The limitations of this analysis may inspire future research of further economic dynamics caused by natural disasters to further investigate impacts on income inequality.

**Declarations**

**Competing interests:** The authors declare that they have no conflict of interest.

**Data availability:** The data that support the findings of this study are available upon reasonable request.

**REFERENCES**


Acemoglu, D., & Robinson, J. A. (2020). The narrow corridor: States, societies, and the fate of liberty. Penguin.

Annen, C. and Wagner, J.J., 2003. The impact of volcanic eruptions during the 1990s. *Natural Hazards Review*, *4*(4), pp.169-175.

Anttila-Hughes, J. and Hsiang, S., 2013. Destruction, disinvestment, and death: Economic and human losses following environmental disaster. *Available at SSRN 2220501*.

Araújo, R. S., Ohara, M., Miyamoto, M. and Takeuchi, K., 2022. Flood impact on income inequality in the Itapocu River basin, Brazil. *Journal of Flood Risk Management*, *15*(3), p.e12805.

Bigoni, M., Bortolotti, S., Casari, M., Gambetta, D. and Pancotto, F., 2016. Amoral familism, social capital, or trust? The behavioural foundations of the Italian North-South divide. *The Economic Journal*, 126 (594), 1318-1341.

Bista, R.B., 2022, October. Does disaster change income and wealth distribution toward extremity of inequality and poverty? Analysis of flood and landslides in the vulnerable locations of Nepal. In *Forum for Social Economics* (Vol. 51, No. 4, pp. 467-481). Routledge.

Bonaccorsi, A., Colombo, M.G., Guerini, M. and Rossi-Lamastra, C., 2014. The impact of local and external university knowledge on the creation of knowledge-intensive firms: Evidence from the Italian case. *Small Business Economics*, *43*, pp.261-287.

Bonanno, G., Domma, F. and Errico, L., 2022. Income Inequality And Inner Areas. A Study On The Italian Case (No. 202203).

Bonat, W. H., Ribeiro Jr, P. J., & Zeviani, W. M. (2015). Likelihood analysis for a class of beta mixed models. *Journal of Applied Statistics*, 42(2), 252-266.

Botzen, W.J.W., Deschenes, O. and Sanders, M., 2019. The economic impacts of natural disasters: A review of models and empirical studies. Review of Environmental Economics and Policy, 13 (2), 167–188.

Brata, A.G., 2022. The Impact of Natural Disasters on Income Inequality in Indonesia. *Journal of Disaster and Emergency Research*.

Carter, M.R., Little, P.D., Mogues, T. and Negatu, W., 2007. Poverty traps and natural disasters in Ethiopia and Honduras. *World development*, *35*(5), pp.835-856.

Coccorese, P. and Dell'Anno, R., 2022. The Role of Banks in Shaping Income Inequality: A Within-Country Study. *Review of Income and Wealth*.

Coibion, O., Gorodnichenko, Y., Kueng, L. and Silvia, J., 2017. Innocent Bystanders? Monetary policy and inequality. *Journal of Monetary Economics*, *88*, pp.70-89.

Cronin, S.J., Hedley, M.J., Neall, V.E. and Smith, R.G., 1998. Agronomic impact of tephra fallout from the 1995 and 1996 Ruapehu Volcano eruptions, New Zealand. *Environmental Geology*, *34*, pp.21-30.

Dang, H.A.H. and Nguyen, C.V., 2021. Gender inequality during the COVID-19 pandemic: Income, expenditure, savings, and job loss. *World Development*, *140*, p.105296.

De Maio, F.G., 2007. Income inequality measures. *Journal of Epidemiology & Community Health*, 61(10), pp.849-852.

Di Gioacchino, D., Sabani, L. and Usai, S., 2024. Public Versus Private Investment in Education in a Two Tiers System: The Role of Income Inequality and Intergenerational Persistence in Education. Italian Economic Journal, pp.1-32.

Einstein, K.L. and Glick, D.M., 2018. Mayors, partisanship, and redistribution: Evidence directly from US mayors. *Urban Affairs Review*, *54*(1), pp.74-106.

EPA, Environmental Protection Agency, 2023. "Climate Change Research" https://www.epa.gov/climate-research

Erman, A., Motte, E., Goyal, R., Asare, A., Takamatsu, S., Chen, X., Malgioglio, S., Skinner, A., Yoshida, N. and Hallegatte, S., 2020. The road to recovery the role of poverty in the exposure, vulnerability and resilience to floods in Accra. *Economics of Disasters and Climate Change*, *4*, pp.171-193.

Felbermayr, G. and Gröschl, J., 2014. Naturally negative: The growth effects of natural disasters. *Journal of development economics*, *111*, pp.92-106.

Feng, S., Lu, J., Nolen, P. and Wang, L., 2016. The effect of the Wenchuan earthquake and government aid on rural households. *IFPRI book chapters*, pp.11-34.

Ferrari, S. and Cribari-Neto, F., 2004. Beta regression for modelling rates and proportions. *Journal of applied statistics*, *31*(7), pp.799-815.

Fiala, O., 2017. *Natural disasters and individual behaviour in developing countries* (pp. 5-41). Springer.

Fielding, J. and Burningham, K., 2005. Environmental inequality and flood hazard. *Local Environment*, *10*(4), pp.379-395.

Fischer, M.M., Huber, F. and Pfarrhofer, M., 2021. The regional transmission of uncertainty shocks on income inequality in the United States. *Journal of Economic Behavior & Organization*, *183*, pp.887-900.

Furceri, D. and Ostry, J.D., 2019. Robust determinants of income inequality. *Oxford Review of Economic Policy*, *35*(3), pp.490-517.

Gallo, G. and Pagliacci, F., 2020. Widening the gap: the influence of 'inner areas' on income inequality in Italy. *Economia Politica*, *37*(1), pp.197-221.

Guiso, L., Sapienza, P. and Zingales, L., 2004. The role of social capital in financial development. *American economic review*, 94(3), 526-556.

Hallegatte, S. and Rozenberg, J., 2017. Climate change through a poverty lens. *Nature Climate Change*, *7*(4), pp.250-256.

Hochrainer, S., 2009. Assessing the macroeconomic impacts of natural disasters: are there any?. *World Bank policy research working paper*, (4968).

Hsiang, S.M. and Jina, A.S., 2014. *The causal effect of environmental catastrophe on long-run economic growth: Evidence from 6,700 cyclones* (No. w20352). National Bureau of Economic Research.

Hsiang, S.M., 2010. Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America. *Proceedings of the National Academy of sciences*, *107*(35), pp.15367-15372.

Hsiang, S., Oliva, P. and Walker, R., 2019. The distribution of environmental damages. *Review of Environmental Economics and Policy*.

Hystada, P. and Keller, P., 2006. Disaster management: Kelowna tourism industry's preparedness, impact and response to a 2003 major forest fire. *Journal of Hospitality and Tourism Management*, *13*(1), pp.44-58.

Keen, M.M., Freeman, M.P.K. and Mani, M., 2003. *Dealing with increased risk of natural disasters: challenges and options*. International Monetary Fund.

ISPRA, 2022. Ambiente in Italia: uno sguardo d'insieme - Annuario dei dati ambientali 2022. Available at https://indicatoriambientali.isprambiente.it/documenti.

Legambiente, 2024. XXIII Rapporto nazionale sulla qualità degli edifici e dei servizi scolastici. Available at: https://www.legambiente.it/rapporti-e-osservatori/rapporti-in-evidenza/ecosistema-scuola/

Lovison, G., Sciandra, M., Tomasello, A., & Calvo, S. 2011. Modeling Posidonia oceanica growth data: from linear to generalised linear mixed models. *Environmetrics*, 22(3), 370-382.

Mastronardi, L. and Cavallo, A., 2020. The spatial dimension of income inequality: An analysis at municipal level. *Sustainability*, *12*(4), p.1622.

Mendoza, C.A. and Jara, B., 2022. Post-earthquake short-run labor income shifts. What happens with the distribution of wages after an earthquake?. *International Journal of Disaster Risk Reduction*, *80*, p.103176.

Mertens, K., Jacobs, L., Maes, J., Kabaseke, C., Maertens, M., Poesen, J., Kervyn, M. and Vranken, L., 2016. The direct impact of landslides on household income in tropical regions: A case study from the Rwenzori Mountains in Uganda. *Science of the total environment*, *550*, pp.1032-1043.

Mocetti, S. and Rizzica, L., 2023. Organized crime in Italy: An economic analysis. *Italian Economic Journal*, pp.1-22.

Msilimba, G.G., 2010. The socioeconomic and environmental effects of the 2003 landslides in the Rumphi and Ntcheu Districts (Malawi). *Natural Hazards*, *53*(2), pp.347-360.

Muhamad, S., Kusairi, S., Aziz, N., Kadir, R. and Wan Kassim, W.Z., 2022. Economic and social impact of Malaysian higher education: stakeholders' perspectives. *Journal of Applied Research in Higher Education*, *14*(4), pp.1623-1636

NASA, National Aeronautics and Space Administration, 2023. Global Climate Change. Vital Signs of the Planet. https://climate.nasa.gov/

Nifo, A., Vecchione, G., (2014). Do institutions play a role in skilled migration? The case of Italy. Regional Studies, 48(10), 1628-1649.

Nitschke, R., & Roesel, F. (2023). Elite Persistence and Policy Persistence: Re-Installed Mayors from Weimar Germany.

Nolan B., Richiardi M. G., & Valenzuela L. (2019). The drivers of income inequality in rich countries. *Journal of Economic Surveys*, 33(4), 1285–1324.

Okuyama, Y., 2003. Economics of natural disasters: A critical review.

Oliviero, T., Rondinella, S. and Zazzaro, A., 2024. Green Firms, Environmental Hazards, and Investment. *Sustainability*, *16*(2), p.542.
Paglialunga, E., Coveri, A. and Zanfei, A., 2022. Climate change and within-country inequality: New evidence from a global perspective. *World Development*, *159*, p.106030.
Panwar, V. and Sen, S., 2019. Economic impact of natural disasters: An empirical re-examination. *Margin: The Journal of Applied Economic Research*, *13*(1), pp.109-139.
Piketty, T. and Saez, E., 2003. Income inequality in the United States, 1913–1998. *The Quarterly journal of economics*, *118*(1), pp.1-41.
Presidenza del Consiglio dei Ministri, 2017. Struttura di Missione Casa Italia. Rapporto sulla Promozione della Sicurezza dai Rischi Naturali del Patrimonio Abitativo. Available at: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.governo.it/sites/governo.it/files/Casa_Italia_RAPPORTO.pdf
Reyes-Nunez, R.L. and Jamieson, T., 2023. Who prepares? Seismic risk, household income, and individual earthquake preparedness in California. *Emergency Management Science and Technology*, *3*(1).
Rodriguez-Oreggia, E., De La Fuente, A., De La Torre, R. and Moreno, H.A., 2013. Natural disasters, human development and poverty at the municipal level in Mexico. *The Journal of Development Studies*, *49*(3), pp.442-455.
Roine, J., Vlachos, J. and Waldenström, D., 2009. The long-run determinants of inequality: What can we learn from top income data?. *Journal of public economics*, *93*(7-8), pp.974-988.
Rosselló, J., Becken, S. and Santana-Gallego, M., 2020. The effects of natural disasters on international tourism: A global analysis. *Tourism management*, *79*, p.104080.
Rubolino, E. (2023). Does weak enforcement deter tax progressivity?. Journal of Public Economics, 219, 104833.
Rukanyangira, N., & Oidu, M. K. (2021). Higher education institutions contribution to research and innovations through public private partnership (PPP), Muni University
Sapkota, J.B., Kurita, K. and Neupane, P., 2021. Progress after the 2015 Nepal Earthquake: Evidence from Two Household Surveys in One of the Hardest-Hit Mountain Villages. *Sustainability*, *13*(21), p.11677.
Song, Z., Hochman, G. and Timilsina, G., 2023. Natural disaster, infrastructure, and income distribution. *Development Research*.
Stajkovic, K., & Stajkovic, A. D. (2024). Ethics of Care Leadership, Racial Inclusion, and Economic Health in the Cities: Is There a Female Leadership Advantage?. *Journal of Business Ethics*, *189*(4), 699-721.
Stiglitz, J. E. (2012). The price of inequality: How today's divided society endangers our future. WW Norton & Company.
Stiglitz, J.E., 2015. The price of inequality: How today's divided society endangers our future.
Wilkinson, R.G. and Pickett, K.E., 2009. Income inequality and social dysfunction. *Annual review of sociology*, *35*, pp.493-511.
Subramanian, S.V. and Kawachi, I., 2004. Income inequality and health: what have we learned so far?. *Epidemiologic reviews*, *26*(1), pp.78-91.
Tanir, T., Yildirim, E., Ferreira, C.M. and Demir, I., 2024. Social vulnerability and climate risk assessment for agricultural communities in the United States. *Science of The Total Environment*, *908*, p.168346.
Theophilopoulou, A., 2022. The impact of macroeconomic uncertainty on inequality: An empirical study for the United Kingdom. *Journal of Money, Credit and Banking*, *54*(4), pp.859-884.
Wilkinson, R. and Pickett, K., 2011. The spirit level: Why greater equality makes societies stronger. Bloomsbury Publishing USA.
Wisner, B., Blaikie, P., Cannon, T. and Davis, I. (2004) At Risk: Natural Hazards, People's Vulnerability and Disasters, 2nd Edition. London: Routledge.
Yamamura, E., 2015. The impact of natural disasters on income inequality: analysis using panel data during the period 1970 to 2004. *International Economic Journal*, *29*(3), pp.359-374.
Zhang, M., Zhou, G., & Fan, G. (2020). Political control and economic inequality: Evidence from Chinese cities. *China Economic Review*, *61*, 101272.
Zografos, C., Anguelovski, I. and Grigorova, M., 2016. When exposure to climate change is not enough: Exploring heatwave adaptive capacity of a multi-ethnic, low-income urban community in Australia. *Urban Climate*, *17*, pp.248-265.

Table 1. Description and summary statistics

| | | Mean/ Relative frequency | Std. Dev. | Min | Max | Obs |
|---|---|---|---|---|---|---|
| GINI INDEX | Gini concentration Index | 0.38 | 0.04 | 0.16 | 0.76 | 88,099 |
| RISK | Municipality enviromental risk (see notes for a detailed description). | 1.40 | 0.87 | 0 | 4 | 91,437 |
| HYDRAULIC | Municipality surface (km2) at higher landslide hazard over total surface (km2) | 0.11 | 0.21 | 0.00 | 0.96 | 88,207 |
| LANDSLIDE | Municipality surface (km2) at higher hydraulic hazard over total surface (km2) | 0.03 | 0.08 | 0.00 | 0.86 | 86,123 |
| VOLCANIC | Dummy = 1 for municipality at higher earthquake hazard | 0.01 | 0.10 | 0 | 1 | 86,581 |
| EARTHQUAKE | Dummy = 1 for firm's municipality in a volcanic area | 0.37 | 0.48 | 0 | 1 | 87,472 |
| INCOME | The average taxable income (in euros) | 17744.85 | 4039.60 | 5097 | 63895 | 88,099 |
| BUSINESS | Number of hospitality businesses | 23 | 238 | 0 | 20270 | 88,246 |
| TAX REVENUE | The ratio between tax revenue and total tax revenue (tax revenue + income from contributions and current transfers + non-tax revenue) | 0.62 | 0.19 | 0.00 | 0.97 | 90,925 |
| MAYOR AGE | The age of the municipality's mayor | 52.00 | 11.00 | 19.00 | 96.00 | 86,280 |
| MAYOR BACHELOR | Dummy = 1 if the municipality's mayor has a bachelor degree or a greater education leve | 0.46 | 0.50 | 0 | 1 | 89,790 |
| MAYOR FEMALE | Dummy = 1 if the municipality's mayor is female | 0 | 0 | 0 | 1 | 90,274 |
| UNIVERSITY | Dummy = 1 if a University is located in the municipality | 0 | 0 | 0 | 1 | 90,218 |
| POP DENSITY | Population over surface (in square km) | 0.30 | 0.64 | 0.00 | 12.28 | 88,053 |
| SENIOR INDEX | The ratio between inhabitants >= 65 and inhabitants <= 14 | 2.10 | 1.50 | 0.22 | 56.00 | 87,025 |

RISK is a variable taking value from zero to four defined as the sum of the individual environmental risks affecting the municipality. For the variables LANDSLIDE and HIDRAULIC we consider a municipality risk if the value is above the median.

Table 2. Correlation matrix

| | RISK | HYDRAULIC | LANDSLIDE | VOLCANIC | EARTHQUAKE | INCOME | BUSINESS | TAX REVENUE | MAYOR AGE | MAYOR BACHELOR | MAYOR FEMALE | UNIVERSITY | POP DENSITY | SENIOR INDEX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RISK | 1 | | | | | | | | | | | | | |
| HYDRAULIC | 0.122 | 1 | | | | | | | | | | | | |
| LANDSLIDE | 0.2954 | -0.0832 | 1 | | | | | | | | | | | |
| VOLCANIC | 0.1496 | -0.0266 | 0.0162 | 1 | | | | | | | | | | |
| EARTHQUAKE | 0.593 | -0.12 | 0.0813 | 0.1097 | 1 | | | | | | | | | |
| INCOME | -0.2412 | 0.2275 | -0.1328 | -0.0279 | -0.3194 | 1 | | | | | | | | |
| BUSINESS | 0.0037 | 0.0627 | -0.016 | 0.0033 | -0.0008 | 0.0567 | 1 | | | | | | | |
| TAX REVENUE | 0.0735 | 0.1148 | -0.0312 | 0.0262 | -0.0418 | 0.2232 | 0.0086 | 1 | | | | | | |
| MAYOR AGE | -0.0049 | -0.0131 | -0.0021 | -0.0088 | -0.0321 | 0.0455 | -0.0027 | 0.0368 | 1 | | | | | |
| MAYOR BACHELOR | 0.0797 | 0.0072 | 0.017 | 0.0362 | 0.1048 | -0.0438 | 0.0191 | 0.0172 | -0.1471 | 1 | | | | |
| MAYOR FEMALE | -0.0395 | 0.0587 | -0.0284 | -0.0244 | -0.0484 | 0.0873 | -0.0017 | 0.0287 | -0.0692 | 0.0676 | 1 | | | |
| UNIVERSITY | 0.0333 | 0.0223 | -0.0147 | 0.022 | 0.0213 | 0.1112 | 0.1761 | -0.0081 | 0.0133 | 0.053 | -0.012 | 1 | | |
| POP DENSITY | -0.0731 | 0.0246 | -0.0581 | 0.2264 | -0.052 | 0.2833 | 0.0465 | 0.1648 | -0.0017 | 0.0956 | 0.0014 | 0.1635 | 1 | |
| SENIOR INDEX | 0.0762 | -0.0798 | 0.055 | -0.0613 | 0.0375 | -0.2171 | -0.0109 | -0.0994 | 0.0482 | -0.0645 | -0.0112 | -0.0129 | -0.1824 | 1 |

For the description of the variables see Table 1.

Table 3. The Gini Index by environmental risk

**ITALY**

| RISK | Mean | Minimum | Maximum | Coefficient of variation |
|---|---|---|---|---|
| 0 | 0.3779 | 0.2048 | 0.7520 | 0.1125 |
| 1 | 0.3763 | 0.1604 | 0.7452 | 0.1094 |
| 2 | 0.3846 | 0.2384 | 0.7629 | 0.1067 |
| 3 | 0.3883 | 0.2343 | 0.5363 | 0.0877 |
| 4 | 0.4298 | 0.3839 | 0.5057 | 0.0520 |
| | 0.3808 | 0.1604 | 0.7629 | 0.1076 |

**CENTRE-NORTH**

| RISK | Mean | Minimum | Maximum | Coefficient of variation |
|---|---|---|---|---|
| 0 | 0.3739 | 0.2048 | 0.7520 | 0.1210 |
| 1 | 0.3720 | 0.1604 | 0.7452 | 0.1109 |
| 2 | 0.3786 | 0.2384 | 0.7629 | 0.1149 |
| 3 | 0.3757 | 0.2843 | 0.5363 | 0.0817 |
| | 0.3746 | 0.1604 | 0.7629 | 0.1131 |

**SOUTH AND ISLANDS**

| RISK | Mean | Minimum | Maximum | Coefficient of variation |
|---|---|---|---|---|
| 0 | 0.3904 | 0.3111 | 0.4839 | 0.0752 |
| 1 | 0.3939 | 0.2678 | 0.5420 | 0.0796 |
| 2 | 0.3944 | 0.2507 | 0.6340 | 0.0882 |
| 3 | 0.3945 | 0.2343 | 0.5054 | 0.0859 |
| 4 | 0.4298 | 0.3839 | 0.5057 | 0.0520 |
| | 0.3941 | 0.2343 | 0.6340 | 0.0844 |

Source: Authors' elaboration.

Table 4: The role of the environmental risk and its components for the income concentation index (beta GLMM results).

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| **CONDITIONAL MODEL** | | | | | |
| RISK | 0.0160*** | | | | |
| | (0.0008) | | | | |
| HYDRAULIC | | 0.0133*** | | | |
| | | (0.0028) | | | |
| LANDSLIDE | | | 0.1159*** | | |
| | | | (0.0093) | | |
| VOLCANIC | | | | 0.0331*** | |
| | | | | (0.0045) | |
| EARTHQUAKE | | | | | −0.0043*** |
| | | | | | (0.0016) |
| INCOME | −0.0010*** | −0.0010*** | −0.0010*** | −0.0010*** | −0.0011*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| BUSINESS | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| TAX REVENUE | 0.1116*** | 0.1128*** | 0.1087*** | 0.1119*** | 0.1078*** |
| | (0.0045) | (0.0045) | (0.0045) | (0.0045) | (0.0043) |
| MAYOR AGE | 0.0008*** | 0.0007*** | 0.0007*** | 0.0007*** | 0.0007*** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| MAYOR BACHELOR | 0.0170*** | 0.0167*** | 0.0170*** | 0.0176*** | 0.0167*** |
| | (0.0011) | (0.0011) | (0.0011) | (0.0011) | (0.0011) |
| MAYOR FEMALE | −0.0117*** | −0.0127*** | −0.0122*** | −0.0126*** | −0.0108*** |
| | (0.0016) | (0.0016) | (0.0016) | (0.0016) | (0.0016) |
| UNIVERSITY | 0.1282*** | 0.1304*** | 0.1351*** | 0.1359*** | 0.1362*** |
| | (0.0067) | (0.0069) | (0.0068) | (0.0068) | (0.0066) |
| POP DENSITY | 0.0269*** | 0.0251*** | 0.0264*** | 0.0224*** | 0.0243*** |
| | (0.0009) | (0.0009) | (0.0009) | (0.0009) | (0.0009) |
| SENIOR INDEX | −0.0050*** | −0.0048*** | −0.0049*** | −0.0048*** | −0.0049*** |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0004) |
| TIME TREND | 0.0034*** | 0.0034*** | 0.0033*** | 0.0033*** | 0.0035*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Intercept | −0.6182*** | −0.5936*** | −0.5947*** | −0.5923*** | −0.5883*** |
| | (0.0131) | (0.0129) | (0.0126) | (0.0126) | (0.0126) |
| **DISPERSION MODEL** | | | | | |
| RISK | 0.1007*** | | | | |
| | (0.0059) | | | | |
| HYDRAULIC | | −0.3529*** | | | |
| | | (0.0204) | | | |
| LANDSLIDE | | | −0.6760*** | | |
| | | | (0.0687) | | |
| VOLCANIC | | | | 0.5533*** | |
| | | | | (0.0501) | |
| EARTHQUAKE | | | | | 0.5125*** |
| | | | | | (0.0102) |
| Intercept | 5.0326*** | 5.2112*** | 5.1922*** | 5.1638*** | 5.0010*** |
| | (0.0095) | (0.0055) | (0.0053) | (0.0049) | (0.0062) |
| AIC | −316323 | −315939 | −315427 | −315396 | −317950 |
| Log Likelihood | 158176 | 157984 | 157728 | 157713 | 158990 |
| Num. obs. | 83541 | 83541 | 83359 | 83379 | 83538 |
| Num. groups: region | 20 | 20 | 20 | 20 | 20 |
| Var: region (Intercept) | 0.0031 | 0.0030 | 0.0028 | 0.0028 | 0.0028 |

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. The dependent variable is the Gini Index.
The reported standard errors are enclosed in parentheses, and the estimated coefficients are reported.

Table 5: The role of the environmental risk and its components for the income concentation index in the Centre-North (beta GLMM results).

| | Model 1 | Model 2 | Model 3 | Model 4 |
|---|---|---|---|---|
| **CONDITIONAL MODEL** | | | | |
| RISK | $0.0231^{***}$ | | | |
| | (0.0010) | | | |
| HYDRAULIC | | $0.0112^{***}$ | | |
| | | (0.0030) | | |
| LANDSLIDE | | | $0.1996^{***}$ | |
| | | | (0.0146) | |
| EARTHQUAKE | | | | 0.0005 |
| | | | | (0.0021) |
| INCOME | $-0.0010^{***}$ | $-0.0010^{***}$ | $-0.0011^{***}$ | $-0.0011^{***}$ |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| BUSINESS | $0.0000^{***}$ | $0.0000^{***}$ | $0.0000^{***}$ | $0.0000^{***}$ |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| TAX REVENUE | $0.1020^{***}$ | $0.0995^{***}$ | $0.0887^{***}$ | $0.0889^{***}$ |
| | (0.0062) | (0.0062) | (0.0063) | (0.0060) |
| MAYOR AGE | $0.0007^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ | $0.0006^{***}$ |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| MAYOR BACHELOR | $0.0172^{***}$ | $0.0174^{***}$ | $0.0167^{***}$ | $0.0168^{***}$ |
| | (0.0015) | (0.0015) | (0.0015) | (0.0014) |
| MAYOR FEMALE | $-0.0152^{***}$ | $-0.0164^{***}$ | $-0.0143^{***}$ | $-0.0142^{***}$ |
| | (0.0020) | (0.0020) | (0.0020) | (0.0019) |
| UNIVERSITY | $0.1277^{***}$ | $0.1300^{***}$ | $0.1338^{***}$ | $0.1369^{***}$ |
| | (0.0099) | (0.0101) | (0.0098) | (0.0094) |
| POP DENSITY | $0.0406^{***}$ | $0.0369^{***}$ | $0.0387^{***}$ | $0.0405^{***}$ |
| | (0.0015) | (0.0015) | (0.0015) | (0.0015) |
| SENIOR INDEX | $-0.0022^{***}$ | $-0.0020^{***}$ | $-0.0021^{***}$ | $-0.0012^{**}$ |
| | (0.0005) | (0.0005) | (0.0005) | (0.0005) |
| TIME TREND | $0.0020^{***}$ | $0.0020^{***}$ | $0.0020^{***}$ | $0.0019^{***}$ |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Intercept | $-0.6423^{***}$ | $-0.6089^{***}$ | $-0.6094^{***}$ | $-0.6009^{***}$ |
| | (0.0171) | (0.0154) | (0.0152) | (0.0145) |
| **DISPERSION MODEL** | | | | |
| RISK | $0.0752^{***}$ | | | |
| | (0.0077) | | | |
| HYDRAULIC | | $-0.1917^{***}$ | | |
| | | (0.0212) | | |
| LANDSLIDE | | | $-1.4477^{***}$ | |
| | | | (0.0940) | |
| EARTHQUAKE | | | | $0.6629^{***}$ |
| | | | | (0.0138) |
| Intercept | $4.9255^{***}$ | $5.0391^{***}$ | $5.0538^{***}$ | $4.8692^{***}$ |
| | (0.0111) | (0.0067) | (0.0064) | (0.0069) |
| AIC | −206148 | −205662 | −205937 | −207620 |
| Log Likelihood | 103089 | 102846 | 102983 | 103825 |
| Num. obs. | 56650 | 56650 | 56633 | 56650 |
| Num. groups: regione | 12 | 12 | 12 | 12 |
| Var: regione (Intercept) | 0.0031 | 0.0025 | 0.0024 | 0.0022 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. The dependent variable is the Gini Index.
The reported standard errors are enclosed in parentheses, and the estimated coefficients are reported.

Table 6: The role of the environmental risk and its components for the income concentation index in the South (beta GLMM results).

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| **CONDITIONAL MODEL** | | | | | |
| RISK | 0.0023** | | | | |
| | (0.0010) | | | | |
| HYDRAULIC | | 0.0218*** | | | |
| | | (0.0055) | | | |
| LANDSLIDE | | | 0.0200** | | |
| | | | (0.0100) | | |
| VOLCANIC | | | | 0.0376*** | |
| | | | | (0.0043) | |
| EARTHQUAKE | | | | | −0.0067*** |
| | | | | | (0.0018) |
| INCOME | −0.0004*** | −0.0004*** | −0.0004*** | −0.0004*** | −0.0005*** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| BUSINESS | 0.0007*** | 0.0007*** | 0.0007*** | 0.0007*** | 0.0007*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| TAX REVENUE | 0.1228*** | 0.1226*** | 0.1229*** | 0.1193*** | 0.1210*** |
| | (0.0057) | (0.0057) | (0.0057) | (0.0057) | (0.0057) |
| MAYOR AGE | 0.0006*** | 0.0008*** | 0.0007*** | 0.0008*** | 0.0007*** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| MAYOR BACHELOR | 0.0135*** | 0.0141*** | 0.0142*** | 0.0145*** | 0.0142*** |
| | (0.0015) | (0.0015) | (0.0015) | (0.0015) | (0.0015) |
| MAYOR FEMALE | −0.0016 | 0.0002 | −0.0003 | −0.0001 | −0.0005 |
| | (0.0026) | (0.0026) | (0.0026) | (0.0026) | (0.0025) |
| UNIVERSITY | 0.0538*** | 0.0477*** | 0.0494*** | 0.0488*** | 0.0547*** |
| | (0.0082) | (0.0080) | (0.0081) | (0.0081) | (0.0079) |
| POP DENSITY | 0.0107*** | 0.0116*** | 0.0118*** | 0.0092*** | 0.0117*** |
| | (0.0010) | (0.0010) | (0.0010) | (0.0010) | (0.0010) |
| SENIOR INDEX | −0.0139*** | −0.0138*** | −0.0141*** | −0.0139*** | −0.0140*** |
| | (0.0007) | (0.0007) | (0.0007) | (0.0007) | (0.0007) |
| TIME TREND | 0.0057*** | 0.0058*** | 0.0058*** | 0.0058*** | 0.0058*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Intercept | −0.5621*** | −0.5656*** | −0.5650*** | −0.5636*** | −0.5535*** |
| | (0.0124) | (0.0122) | (0.0121) | (0.0120) | (0.0124) |
| **DISPERSION MODEL** | | | | | |
| RISK | −0.2039*** | | | | |
| | (0.0101) | | | | |
| HYDRAULIC | | 0.3687*** | | | |
| | | (0.0688) | | | |
| LANDSLIDE | | | −0.1268 | | |
| | | | (0.1159) | | |
| VOLCANIC | | | | 0.1327** | |
| | | | | (0.0504) | |
| EARTHQUAKE | | | | | −0.4081*** |
| | | | | | (0.0181) |
| Intercept | 6.0597*** | 5.6722*** | 5.6956*** | 5.6886*** | 5.9571*** |
| | (0.0195) | (0.0093) | (0.0100) | (0.0087) | (0.0140) |
| AIC | −114993 | −114638 | −114576 | −114662 | −115088 |
| Log Likelihood | 57511 | 57334 | 57303 | 57346 | 57559 |
| Num. obs. | 26729 | 26729 | 26726 | 26729 | 26729 |
| Num. groups: regione | 8 | 8 | 8 | 8 | 8 |
| Var: regione (Intercept) | 0.0010 | 0.0009 | 0.0009 | 0.0009 | 0.0010 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. The dependent variable is the Gini Index.
The reported standard errors are enclosed in parentheses, and the estimated coefficients are reported.

Table 7: The role of the environmental risk and its components for the income concentation index (beta GLMM results). Robustness check.

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| **CONDITIONAL MODEL** | | | | | |
| RISK | 0.0165*** | 0.0168*** | 0.0160*** | 0.0159*** | 0.0158*** |
| | (0.0008) | (0.0008) | (0.0008) | (0.0008) | (0.0008) |
| INCOME | −0.0010*** | −0.0010*** | −0.0010*** | −0.0010*** | −0.0010*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| BUSINESS | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| TAX REVENUE | 0.1069*** | 0.1126*** | 0.1112*** | 0.1094*** | 0.1097*** |
| | (0.0044) | (0.0045) | (0.0045) | (0.0046) | (0.0046) |
| MAYOR AGE | 0.0007*** | 0.0007*** | 0.0008*** | 0.0008*** | 0.0008*** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| MAYOR BACHELOR | 0.0209*** | 0.0170*** | 0.0170*** | 0.0170*** | 0.0170*** |
| | (0.0011) | (0.0011) | (0.0011) | (0.0012) | (0.0012) |
| MAYOR FEMALE | −0.0102*** | −0.0124*** | −0.0117*** | −0.0123*** | −0.0122*** |
| | (0.0016) | (0.0016) | (0.0016) | (0.0017) | (0.0017) |
| UNIVERSITY | 0.1345*** | 0.1240*** | 0.1283*** | 0.1301*** | 0.1301*** |
| | (0.0067) | (0.0068) | (0.0067) | (0.0070) | (0.0070) |
| POP DENSITY | 0.0284*** | 0.0270*** | 0.0269*** | 0.0267*** | 0.0267*** |
| | (0.0009) | (0.0010) | (0.0009) | (0.0010) | (0.0010) |
| SENIOR INDEX | −0.0041*** | −0.0046*** | −0.0050*** | −0.0049*** | −0.0048*** |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0004) |
| GENDER | −0.0034 | | | | |
| | (0.0031) | | | | |
| EDUCATION | 0.0612*** | | | | |
| | (0.0039) | | | | |
| INTERMEDIATE | | 0.0021 | | | |
| | | (0.0014) | | | |
| PERIPHERAL | | −0.0017 | | | |
| | | (0.0017) | | | |
| ULTRAPERIPHERAL | | −0.0142*** | | | |
| | | (0.0026) | | | |
| IQI REG | | | −0.0737*** | | |
| | | | (0.0152) | | |
| UNEMPLO REG | | | | −0.0022*** | |
| | | | | (0.0003) | |
| SOCCAP REG | | | | | 0.0006** |
| | | | | | (0.0002) |
| TIME TREND | 0.0033*** | 0.0034*** | 0.0035*** | 0.0033*** | 0.0024*** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0003) |
| Intercept | −0.5974*** | −0.6331*** | −0.5752*** | −0.5926*** | −0.6403*** |
| | (0.0152) | (0.0404) | (0.0149) | (0.0146) | (0.0168) |
| **DISPERSION MODEL** | | | | | |
| RISK | 0.0991*** | 0.0967*** | 0.1004*** | 0.1052*** | 0.1057*** |
| | (0.0058) | (0.0059) | (0.0059) | (0.0061) | (0.0061) |
| Intercept | 5.0537*** | 5.0382*** | 5.0333*** | 5.0331*** | 5.0318*** |
| | (0.0095) | (0.0095) | (0.0095) | (0.0100) | (0.0100) |
| AIC | −315223 | −316333 | −316344 | −288038 | −288001 |
| Log Likelihood | 157628 | 158184 | 158188 | 144035 | 144016 |
| Num. obs. | 83123 | 83541 | 83541 | 75930 | 75930 |
| Num. groups: regione | 20 | 20 | 20 | 20 | 20 |
| Var: regione (Intercept) | 0.0022 | 0.0283 | 0.0025 | 0.0036 | 0.0032 |

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$. The dependent variable is the Gini Index.
The reported standard errors are enclosed in parentheses, and the estimated coefficients are reported.

Table 8: The role of the environmental risk and its components for the income concentation index in the Centre-North (beta GLMM results). Robustness check.

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| **CONDITIONAL MODEL** | | | | | |
| RISK | $0.0235^{***}$ | $0.0222^{***}$ | $0.0231^{***}$ | $0.0229^{***}$ | $0.0229^{***}$ |
| | (0.0010) | (0.0011) | (0.0010) | (0.0011) | (0.0011) |
| INCOME | $-0.0010^{***}$ | $-0.0010^{***}$ | $-0.0010^{***}$ | $-0.0010^{***}$ | $-0.0010^{***}$ |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| BUSINESS | $0.0000^{***}$ | $0.0000^{***}$ | $0.0000^{***}$ | $0.0000^{***}$ | $0.0000^{***}$ |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| TAX REVENUE | $0.0976^{***}$ | $0.1039^{***}$ | $0.1014^{***}$ | $0.0988^{***}$ | $0.1011^{***}$ |
| | (0.0062) | (0.0062) | (0.0062) | (0.0064) | (0.0065) |
| MAYOR AGE | $0.0007^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| MAYOR BACHELOR | $0.0167^{***}$ | $0.0174^{***}$ | $0.0172^{***}$ | $0.0172^{***}$ | $0.0171^{***}$ |
| | (0.0015) | (0.0015) | (0.0015) | (0.0016) | (0.0016) |
| MAYOR FEMALE | $-0.0155^{***}$ | $-0.0150^{***}$ | $-0.0152^{***}$ | $-0.0157^{***}$ | $-0.0159^{***}$ |
| | (0.0020) | (0.0020) | (0.0020) | (0.0021) | (0.0021) |
| UNIVERSITY | $0.1280^{***}$ | $0.1289^{***}$ | $0.1276^{***}$ | $0.1293^{***}$ | $0.1294^{***}$ |
| | (0.0098) | (0.0099) | (0.0099) | (0.0101) | (0.0102) |
| POP DENSITY | $0.0375^{***}$ | $0.0424^{***}$ | $0.0406^{***}$ | $0.0405^{***}$ | $0.0404^{***}$ |
| | (0.0015) | (0.0016) | (0.0015) | (0.0016) | (0.0016) |
| SENIOR INDEX | $-0.0016^{***}$ | $-0.0028^{***}$ | $-0.0023^{***}$ | $-0.0021^{***}$ | $-0.0020^{***}$ |
| | (0.0005) | (0.0005) | (0.0005) | (0.0005) | (0.0005) |
| GENDER | $-0.0040$ | | | | |
| | (0.0040) | | | | |
| EDUCATION | $0.0762^{***}$ | | | | |
| | (0.0050) | | | | |
| INTERMEDIATE | | $0.0056^{***}$ | | | |
| | | (0.0018) | | | |
| PERIPHERAL | | $0.0088^{***}$ | | | |
| | | (0.0023) | | | |
| ULTRAPERIPHERAL | | $0.0188^{***}$ | | | |
| | | (0.0045) | | | |
| IQI REG | | | $-0.1491^{***}$ | | |
| | | | (0.0218) | | |
| UNEMPLO REG | | | | $-0.0080^{***}$ | |
| | | | | (0.0006) | |
| SOCCAP REG | | | | | $0.0005^{*}$ |
| | | | | | (0.0003) |
| TIME TREND | $0.0018^{***}$ | $0.0020^{***}$ | $0.0020^{***}$ | $0.0017^{***}$ | $0.0009^{***}$ |
| | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) |
| Intercept | $-0.6519^{***}$ | $-0.6457^{***}$ | $-0.5294^{***}$ | $-0.5758^{***}$ | $-0.6646^{***}$ |
| | (0.0177) | (0.0167) | (0.0244) | (0.0172) | (0.0235) |
| **DISPERSION MODEL** | | | | | |
| RISK | $0.0822^{***}$ | $0.0724^{***}$ | $0.0752^{***}$ | $0.0835^{***}$ | $0.0826^{***}$ |
| | (0.0077) | (0.0077) | (0.0077) | (0.0080) | (0.0080) |
| Intercept | $4.9244^{***}$ | $4.9294^{***}$ | $4.9263^{***}$ | $4.9240^{***}$ | $4.9221^{***}$ |
| | (0.0112) | (0.0112) | (0.0111) | (0.0117) | (0.0117) |
| AIC | $-205077$ | $-206170$ | $-206194$ | $-187649$ | $-187496$ |
| Log Likelihood | 102555 | 103103 | 103113 | 93840 | 93764 |
| Num. obs. | 56242 | 56650 | 56650 | 51439 | 51439 |
| Num. groups: regione | 12 | 12 | 12 | 12 | 12 |
| Var: regione (Intercept) | 0.0033 | 0.0029 | 0.0034 | 0.0028 | 0.0033 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. The dependent variable is the Gini Index.
The reported standard errors are enclosed in parentheses, and the estimated coefficients are reported.

Table 9: The role of the environmental risk and its components for the income concentation index in the South (beta GLMM results). Robustness check.

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| **CONDITIONAL MODEL** | | | | | |
| RISK | $0.0024^{**}$ | $0.0024^{**}$ | $0.0023^{**}$ | $0.0023^{**}$ | $0.0023^{**}$ |
| | (0.0010) | (0.0009) | (0.0010) | (0.0010) | (0.0010) |
| INCOME | $-0.0004^{***}$ | $-0.0003^{***}$ | $-0.0004^{***}$ | $-0.0004^{***}$ | $-0.0004^{***}$ |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| BUSINESS | $0.0007^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ |
| | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.0000) |
| TAX REVENUE | $0.1241^{***}$ | $0.1087^{***}$ | $0.1229^{***}$ | $0.1201^{***}$ | $0.1191^{***}$ |
| | (0.0057) | (0.0057) | (0.0057) | (0.0059) | (0.0059) |
| MAYOR AGE | $0.0006^{***}$ | $0.0006^{***}$ | $0.0006^{***}$ | $0.0007^{***}$ | $0.0007^{***}$ |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| MAYOR BACHELOR | $0.0132^{***}$ | $0.0132^{***}$ | $0.0135^{***}$ | $0.0137^{***}$ | $0.0137^{***}$ |
| | (0.0015) | (0.0015) | (0.0015) | (0.0016) | (0.0016) |
| MAYOR FEMALE | $-0.0011$ | $-0.0017$ | $-0.0016$ | $-0.0019$ | $-0.0019$ |
| | (0.0026) | (0.0025) | (0.0026) | (0.0027) | (0.0027) |
| UNIVERSITY | $0.0506^{***}$ | $0.0388^{***}$ | $0.0538^{***}$ | $0.0590^{***}$ | $0.0590^{***}$ |
| | (0.0082) | (0.0082) | (0.0082) | (0.0086) | (0.0086) |
| POP DENSITY | $0.0102^{***}$ | $0.0075^{***}$ | $0.0107^{***}$ | $0.0107^{***}$ | $0.0108^{***}$ |
| | (0.0010) | (0.0010) | (0.0010) | (0.0010) | (0.0010) |
| SENIOR INDEX | $-0.0132^{***}$ | $-0.0111^{***}$ | $-0.0139^{***}$ | $-0.0143^{***}$ | $-0.0143^{***}$ |
| | (0.0007) | (0.0007) | (0.0007) | (0.0007) | (0.0007) |
| GENDER | $0.0574^{***}$ | | | | |
| | (0.0047) | | | | |
| EDUCATION | $-0.0053$ | | | | |
| | (0.0059) | | | | |
| INTERMEDIATE | | $-0.0099^{***}$ | | | |
| | | (0.0021) | | | |
| PERIPHERAL | | $-0.0244^{***}$ | | | |
| | | (0.0022) | | | |
| ULTRAPERIPHERAL | | $-0.0510^{***}$ | | | |
| | | (0.0028) | | | |
| IQI REG | | | 0.0048 | | |
| | | | (0.0201) | | |
| UNEMPLO REG | | | | $-0.0019^{***}$ | |
| | | | | (0.0003) | |
| SOCCAP REG | | | | | $-0.0004$ |
| | | | | | (0.0003) |
| TIME TREND | $0.0056^{***}$ | $0.0055^{***}$ | $0.0056^{***}$ | $0.0064^{***}$ | $0.0060^{***}$ |
| | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0004) |
| Intercept | $-0.5828^{***}$ | $-0.5385^{***}$ | $-0.5637^{***}$ | $-0.5348^{***}$ | $-0.5422^{***}$ |
| | (0.0126) | (0.0124) | (0.0139) | (0.0137) | (0.0165) |
| **DISPERSION MODEL** | | | | | |
| RISK | $-0.2084^{***}$ | $-0.2097^{***}$ | $-0.2054^{***}$ | $-0.2022^{***}$ | $-0.2022^{***}$ |
| | (0.0101) | (0.0001) | (0.0118) | (0.0105) | (0.0105) |
| Intercept | $6.0733^{***}$ | $6.0835^{***}$ | $6.0658^{***}$ | $6.0638^{***}$ | $6.0626^{***}$ |
| | (0.0196) | (0.0195) | (0.0228) | (0.0205) | (0.0205) |
| AIC | −115093 | −115354 | −114992 | −104865 | −104838 |
| Log Likelihood | 57563 | 57695 | 57512 | 52448 | 52435 |
| Num. obs. | 26719 | 26729 | 26729 | 24332 | 24332 |
| Num. groups: region | 8 | 8 | 8 | 8 | 8 |
| Var: region (Intercept) | 0.0010 | 0.0009 | 0.0010 | 0.0010 | 0.0009 |

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$. The dependent variable is the Gini Index.
The reported standard errors are enclosed in parentheses, and the estimated coefficients are reported.

Table A1. Equality Test of the coefficients on the variable RISK and its components between geographical areas

| | | SOUTH = CENTRE-NORTH |
|---|---|---|
| RISK | $\chi(2)$ | 396.66 |
| | P-Value | 0.000 |
| HYDRAULIC | $\chi(2)$ | 5.30 |
| | P-Value | 0.021 |
| LANDSLIDE | $\chi(2)$ | 271.41 |
| | P-Value | 0.000 |
| VOLCANIC | $\chi(2)$ | 5.35 |
| | P-Value | 0.021 |
| EARTHQUAKE | $\chi(2)$ | 13.15 |
| | P-Value | 0.000 |

$H_0$: coefficients on variables are equal.

**Figure 1. Municipality environmental risk (aggregate measure)**

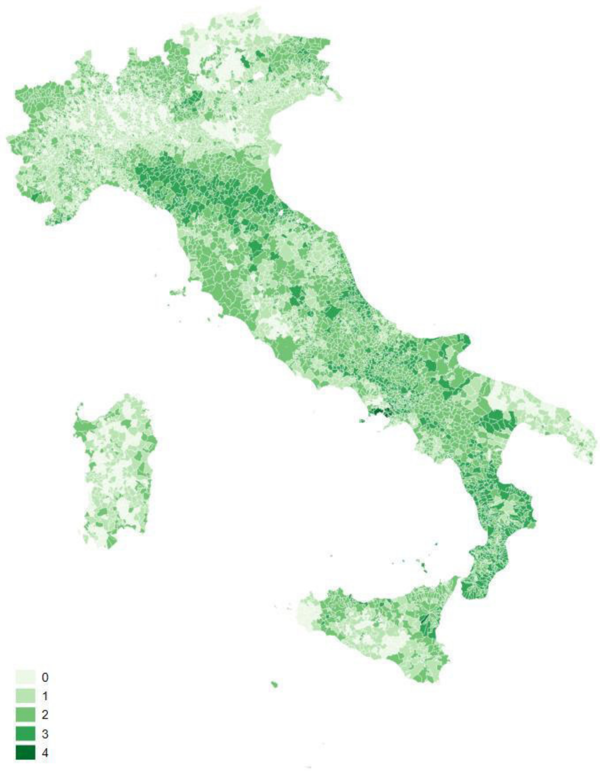


**Figure A1. Share of municipality surface (km2) at higher landslide hazard.**

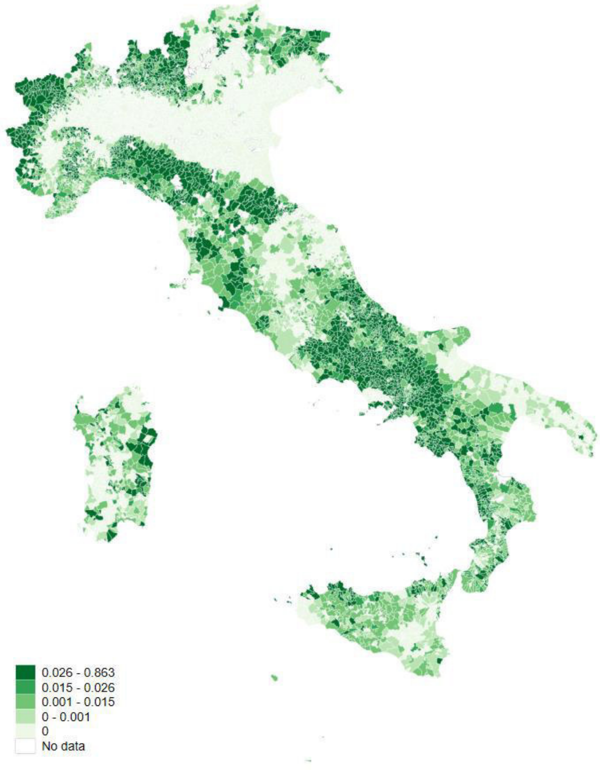

**Figure A2. Share of municipality surface (km2) at higher hydraulic hazard.**

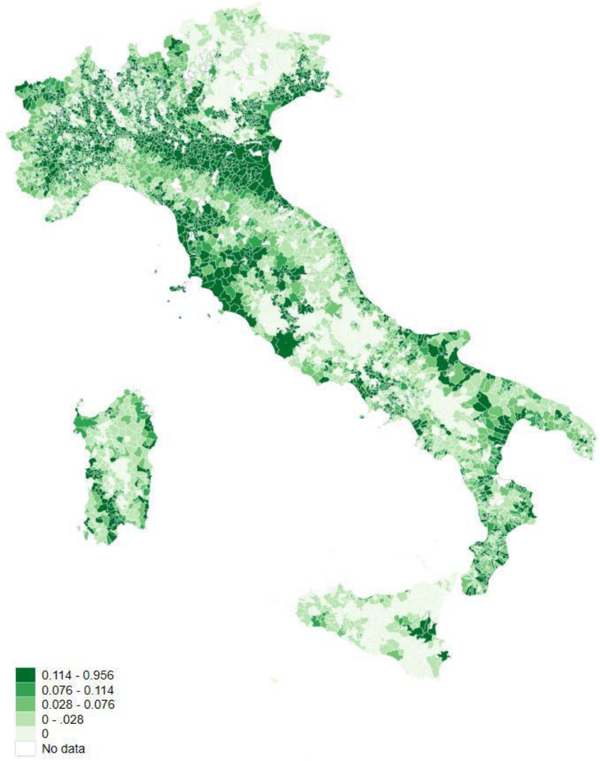


**Figure A3. Municipality at higher earthquake hazard.**

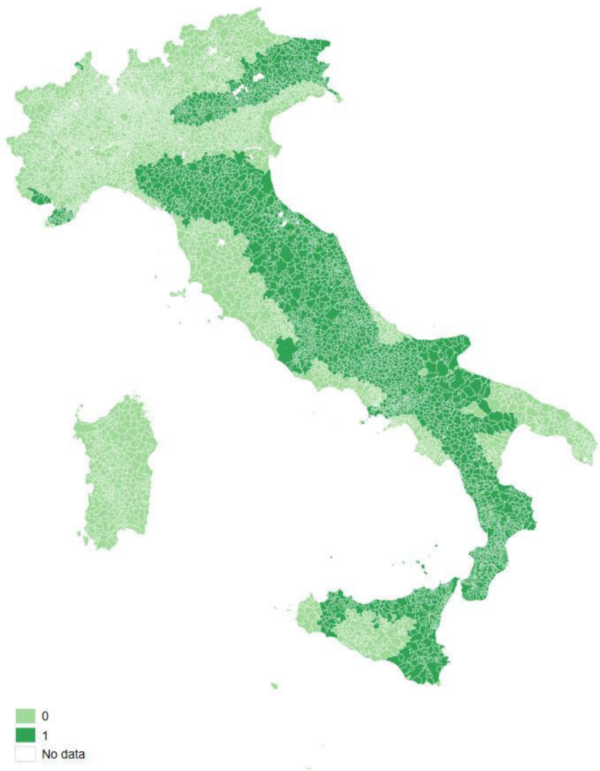

**Figure A4. Municipality in a volcanic area.**