XLI CONFERENZA ITALIANA DI SCIENZE REGIONALI

# CITY RESILIENCE AND STUDENTS MOBILITY: HOW CITIES RESPOND TO NATURAL DISASTERS

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**ABSTRACT:**

This study examines the role of cities' human capital when geographical areas faced a natural disaster. It focuses on two important earthquakes in the last 16 years in Italy (Abruzzo, 2009 and Emilia-Romagna, 2012) in order to explain the linkage between students' mobility and city attraction post-natural disasters. Using the ordinary least-squares method (OLS), we evaluate students' mobility of more than 3.100.000 students enrolled in the bachelor's and master's degree programs in the aforementioned regions and focus on 1.280.000 students that move from one region to another one and 50.000 that move from another country to the cities taken into consideration. The result shows that human capital and knowledge flow inbound measured in terms of national and international students are strongly related to the natural event that affect the geographical area taken into consideration in the following period.

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## 1. Introduction

In the last few years, we have seen a notable increase in the number of studies investigating the effects of natural disasters in many dimensions (Baez, Fuente and Santos, 2010). These events affect the geographical area that has to react in terms of economic development (Skidmore and Toya, 2002), human capital (McDermott, 2012), social capital (Gotham and Powers, 2015a), and knowledge attraction (Boustan, Kahn and Rhode, 2012) in order to distribute and generate wealth for the affected area.

Previous studies demonstrated that it is necessary to lay the foundations for the growth of the entire geographical area by developing infrastructures and transport by improving the connection network with the territory (Mojtahedi, Newton and Von Meding, 2017), investing in economic expansion (Cummins and Mahul, 2009) and creating a welfare network that allows the affected area to react to the shock generated by the event (Chan, 2012). We posit that a central role in the relationship between territory and economic development in the period post-event is played by the human capital.

This study examines the role of the human capital in the cities in the period after the geographical areas faced a natural disaster. Relying on the research by Skidmore and Toya (2007) which affirms that "*natural catastrophes reduce the expected return to physical capital, rational individuals would shift their investment toward human capital*", we intend to analyse the relationship between a natural disaster and city attraction in terms of students' mobility, which is presented as an opportunity to attract new human capital.

We base our research on the city level due to the need to improve our understanding of the impact of natural disasters on human capital and the knowledge attraction of the geographical area in the period post-disaster. In particular, we focus on the ability of the city to react to a shock like a natural disaster (in our case an earthquake) and develop a process of growth in terms of innovation and knowledge attraction that allows the city itself to grow in the post-event period. This ability to attract knowledge in the post-event period represents the resilience of the city (as the capacity to recover quickly from troubles) that attracts and generates knowledge more markedly than it did previously. The term resilience provides a linking concept for understanding how both humans and urban ecosystems respond to traumatic events and what factors explain the pace and trajectory of human-ecosystem recovery and change (Gotham and Powers, 2015b).

In the past years, there has been a growing recognition that knowledge and highly skilled individuals as "carriers" of knowledge are a key driving force for regional development, growth and innovation (Lucas, 1988; Florida, 2004; Trippl and Maier, 2010) and in this area an important role is played by the university. There is a wide spectrum of literature that examines the role of universities related to economic growth. Previous studies demonstrated that universities play a key role as producers of creative and high human capital that is embodied in their graduates and their staff and therefore they have an impact on regional economic growth (Florida, 1995; Lee, Florida and Gates, 2010; Sedlacek, 2013). Besides, several researches have also argued that universities can be a contributor to growth as a source of knowledge spillovers (Coe et al., 2004; Goldstein and Drucker, 2006; Faggian and McCann, 2009). Universities are assumed to be important sources of localized knowledge spillovers due to their explicit focus on the generation and diffusion of knowledge.

In this paper, we focus on two important natural disasters in the last 16 years in Italy (Abruzzo, 2009 and Emilia-Romagna, 2012) and, to explain the linkage between students' mobility and city attraction post-natural disasters, our research sample is based on 13 Italian cities with universities that represent the main cities in the two geographical areas taken into consideration to the natural disaster. Besides, to understand the impact of human capital accumulation and knowledge spillover flow incoming, we evaluate the impact of students' mobility from other regions and other countries in the overall period in response to the following research question: *"How the natural disaster that occurs in the geographical area affect the attraction of national and international students to the area in the post-event period?"*.

Previous literature suggests that the effects of natural disasters on the economy are generally uncertain but confirms the fact that natural disasters are strongly correlated with economic growth and human capital

investment. The role played by natural disasters on city attractiveness in terms of knowledge flow incoming is already uncertain.

This is one of the first works that try to bridge the literature gap by investigating the relationship between the attractiveness of the city and natural disasters. The central role will be played by the attraction of the city, intended as a source of renewal and value creation in the medium-long term (Florida, 2002), which acts as a driver of growth and development of the city in the period following the event.

To test our conjunctures, we considered a sample of more than 3.100.000 Italian students and focused on 1.280.000 students that move from one region to another one and 50.000 that move from another country to the geographical area taken into consideration. Students' flow represents an uninterrupted channel for the transfer of scientific and technical knowledge among countries and regions (Trippl, 2013) and an opportunity to attract talent in the geographical area itself (Florida, 2004).

Our result shows that human capital and knowledge flow inbound measured in terms of national and international students are strongly related to the natural event that affects the cities taken into consideration in the post-disaster period. Natural disasters represent a great shock for the entire area affected but can also represent an opportunity for growth and economic development; the ability of the city to improve after these events represents a real resilience of the city itself to the events that occur. In this case, the possibility of attracting knowledge in the form of national and international students represents a starting point for post-event economic development.

## 2. Theoretical background

Natural disasters represented an unexpected factor in the economy and the development of a country. Consequently, there has been an explosion of studies investigating the effect of a natural disaster on many economic dimensions. Natural disasters such as earthquakes, tsunamis, and hurricanes have a destructive impact on economic growth (Cavallo et al., 2013a), urban development (Wesener, 2015) and social capital (Pelling, 2012). Natural disasters consequently have a great impact on the territory in terms of the attractiveness of human capital (Baez, Fuente and Santos, 2010).

Scholars attempted to understand the ways to deal with natural disasters in terms of economic growth and regional development. In related literature, Khan (2005) and Kellenberg & Mobarak (2008) studied the relationship between economic development and vulnerability to natural disasters and argue that behavioural changes at the micro-level in response to increasing income may lead to a non-linear relationship between aggregate incomes and disaster damages, where the risks increase with income before they decrease. Yang (2011) studied the impact of hurricanes on international financial flows, he focuses on hurricanes (one of the most common and destructive types of disasters) and examines the impact of hurricane damages on resource flows to affected countries. Furthermore, Sargiacomo, Ianni, & Everett (2014) examines the role of accounting and other calculative practices in the context of a natural disaster and subsequent emergency-relief effort. Relying on document analysis and interviews with key participants, the study chronologically examines when, how, and with what effects accounting and other associated practices were mobilized in the follow-up to an earthquake that occurred in the Abruzzo region of central Italy in 2009. The Abruzzo region represents a part of the sample taken into consideration.

There is, however, a large body of research that has examined the effect of natural disasters on economic variables in the short (usually up to five years) and long-term effects (anything beyond that horizon).

The empirical literature on the economic effects of natural disasters has traditionally concentrated on the short-run effects of catastrophic events. In the short-term, Gotham & Powers (2015a) provide a summary of the recent studies that assess the immediate repercussions of natural disasters on economic activity. The empirical findings in this literature (Goshay, Dacy, and Kunreuther, 1970; Bista, 1989; Albala-Bertrand, 1993; Cummins and Mahul, 2009) confirm that gross domestic product (GDP) is generally found to increase in the periods immediately following a natural disaster. Rawls & Turnquist (2012) study the dynamic delivery planning for a short-term response following a natural disaster using shelter locations in North

Carolina and a set of hurricane threat scenarios is used to illustrate the model and how it supports an emergency relief strategy.

Other important aspects regard the long-run effects. Skidmore and Toya (2002) find that in a cross-sectional, long-run perspective, output growth is positively correlated with natural disaster frequency. They look at how disaster risk correlates with growth in the long run, not at what the causal impact of a given disaster is. Cavallo, Galiani, Noy, & Pantano (2013b) show that only very large disasters, whereby "large" is defined in relation to the distribution of direct damages caused by the natural event, display an impact on GDP growth in the affected countries in both the short and the long-runs. In a comprehensive study of the effect of cyclones on economic growth over the short and long-term, Hsiang and Jina(2014) combine a country-year panel on GDP growth rates for almost every country over the 1950–2008 period with each country's exposure to cyclones. They find robust evidence that national incomes decline, relative to their pre-disaster trend, and do not recover within twenty years.

### *2.1 Natural disaster and human capital*

The human consequences of disasters may be significant for economic growth through their effects on human capital accumulation, which has come to be seen as a crucial determinant of long-run development potential in the so-called new economic geography literature (Barro, 1991; Masters and McMillan, 2001; Sachs and Warner, 2001).

While natural disasters have affected our lives, our economy and our economic development, relatively little are known about the welfare losses of human capital accumulation arising from such traumatic events (Caruso and Miller, 2015). The role of human capital and knowledge in economic development has been widely studied by economists and geographers. One of the most important theories was made by Romer (1986, 1990, 1994) who first formally examined the role of knowledge in growth from the perception of the public good aspect of knowledge spillovers. Moreover, the role played by knowledge externalities linked with human capital was also supported by Lucas (1988).

Existing literature tries to explain the link between natural disasters and human capital. Previous research analyses the effect of natural disasters on human capital in terms of children and primary school. Baez (2010) seeks to review and assess available empirical evidence on the ex-post microeconomic effects of natural disasters on the accumulation of human capital. Paudel (2017) tries to demonstrate that male infants born in earthquake-affected districts perform significantly better than the female counterparts, and also provides evidence that negative health shocks possibly influenced the long-term educational attainment of infants exposed to the earthquake at an early age. Furthermore, Toya, Skidmore, & Robertson(2010), suggests that endogeneity is significant and finds that natural disasters are a good instrument for changes in schooling. It is also important to evaluate the impact of investment in education and knowledge after natural disasters. These types of arguments aim at unveiling the role of natural disaster risk as a determinant of cross-country differences and urban development. In this sense, these theoretical explanations refer to the long-run effects of natural disasters on education investments. Short-run effects on human capital accumulation associated with the actual occurrence of the disaster could be extremely important as well.

In terms of students' enrolment, Cuaresma (2017) highlights strong evidence of the negative effects of geologic natural disaster risk on secondary school enrolment rates. The effects tend to be homogeneous across countries and do not depend on income or the degree of human capital accumulation within a country. Although, McDermott (2012) investigates the effects of disasters on human capital accumulation. He used an extensive panel dataset on natural disasters, covering 170 countries over 25 years and shows that disasters have both a direct, contemporaneous effect and a long-term, indirect effect on human capital.

### *2.2 Cities resilience and natural disasters*

Recent years have witnessed the growth of interdisciplinary literature that seeks to identify the indicators, measures, and processes of resilience in communities affected by disasters. The term resilience provides a linking concept for understanding how both humans and urban ecosystems respond to traumatic events and what factors explain the pace and trajectory of human-ecosystem recovery and change(Gotham and Powers, 2015b).Rather, resilience implies the capacity for renewal, regeneration, and re-organization when faced with disturbance (Walker et al., 2004; Folke, 2006).

The most effective strategies for regional resilience rely on acquired levels of civic capital and the existing endowment of regional institutions to chart new paths forward. Among the factors that determine their effectiveness is the ability to build on specialized regional assets, including public and private research infrastructure, the presence or absence of 'civic capital' at the regional and local level; and the ability of local firms and entrepreneurs to adjust their business strategies in response to changing economic circumstances(Wolfe, 2010).

In the social sciences, more generally, however, the term regional resilience has become popular because of its association with regional adaptation and so has strong connections with evolutionary economics and evolutionary economic geography. Regional resilience is made by strong partnerships between local community-based organizations, external non-governmental and governmental organizations, public and private sectors and between the city and national government to build a sense of community (Pelling, 2012; Aldrich and Meyer, 2015; Gotham and Powers, 2015a; Agrawal, 2018). In terms of a sense of community, resilience has been closely allied with enhanced self-reliance and the desire for greater regional closure (Hudson, 2010).The intersection of an economic crisis and an environmental crisis has enhanced the perceived sense of vulnerability and, hence, stimulated the search for new paths to 'resilience'(Hudson, 2010; Gotham and Powers, 2015a). In opposition to that concept, Hassink (2010) rejects the concept of regional resilience altogether as leading to a misapprehension of the processes of regional change because of its neglect of the long-run in regional adaptation. Pooley, Cohen, & Pike(2005) are also highly critical of equilibrium approaches but distinguish the concept of resilience and they confirm the positive relationships in the short-run.

In terms of human capital and regional resilience, scholars have eschewed a notion of resilience as a measurable outcome or social-ecological condition and examined how communities and elites deploy various framing strategies and symbols about 'recovery' to respond to a disaster situation. In a comparison of post-disaster recovery in New York and New Orleans, Gotham and Greenberg(2014) draws attention to the framing strategies that particular groups and organized interests use to construct and deploy different meanings of resilience – for example, resilience as the return of original residents, repopulation of new residents, or physical rebuilding and reinvestment. Also, (2019)examines the long-run effects of natural disasters on population density growth across US counties from 1960 to 2000. Results also indicate that disasters have negligible indirect effects on county population density growth through impacting the county characteristics.

Previous literature suggests that the effects of disasters on the economy are generally uncertain but confirms the fact that natural disasters are strongly correlated with economic growth and human capital investment. Relying on the research by Skidmore and Toya (2007) which affirms that "natural catastrophes reduce the expected return to physical capital, rational individuals would shift their investment toward human capital", we intend to analyze the relationship between a natural disaster and city attraction in terms of students' mobility, which is presented as an opportunity to attract new human capital. We base our research on the city level due to the need to improve our understanding of the impact of disasters on human capital and the attraction of the cities post-disaster. Thus, we posit:

*HII The natural disaster that occurs in the geographical area positively affects the attraction of national students to the city in the post-event period.*

*HII The natural disaster that occurs in the geographical area positively affects the attraction of international students to the city in the post-event period.*

We assume that natural disasters represent an important shock in terms of cities and regional development and the actual literature suggests that natural disaster does not necessarily have negative impacts on long-term economic growth and labor market outcomes (Albala-Bertrand, 1993; Toya and Skidmore, 2007; Hallegatte and Dumas, 2009; Cavallo et al., 2013b).In particular, Toya (2007) demonstrates that the positive relationship between climatic disasters and growth is the result of improvements in technology and increased human capital investment spurred on by climatic disasters. Besides, to understand the impact of human capital accumulation and knowledge spillover flow incoming, we evaluate the impact of students' mobility from other regions and other countries in the overall period in response to the following:

*HIII The natural disaster that occurs in the geographical area positively impacts the national students' flow in the overall period pre and post event.*

*IV The natural disaster that occurs in the geographical area positively impact the international students flow in the overall period pre and post event.*

The effects of natural disaster risk on human capital accumulation have not received enough attention in the academic literature. This article aims to evaluate the effects of natural disasters on students' mobility and city attraction in terms of human capital. The heterogeneity of the students from other regions and other countries represents an important mechanism of knowledge transfer (Tödtling and Kaufmann, 2001). We assume that a large and heterogeneous flow of the knowledge and human capital inbound would promote and support the development process and the possibility to impact on economic growth post event.

## 3. Methodology

In this paper, we focus on two important natural disasters in the last 16 years in Italy (Abruzzo, 2009 and Emilia-Romagna, 2012) in order to explain the linkage between students' mobility and city attraction post natural disasters. Our database includes data on the students' mobility of more than 3.100.000 students enrolled in the bachelor's and master's degree programs in the aforementioned regions. In order to evaluate the impact of students' mobility, we considered the cities with universities in both regions, Abruzzo and Emilia-Romagna, as a sample of this research. We evaluate the population, the students' flow and the economic characteristics of each region during a 16-year period from (2004 - 2019) to understand the impact of the natural disaster on the students' mobility and cities' attraction pre and post event.

### *3.1 The natural disasters*

The natural disaster taken into consideration regards the 2009 earthquake in L'Aquila (Abruzzo) and the 2012 earthquake in Emilia-Romagna.

#### 3.1.1. 2009 L'Aquila earthquake in Abruzzo

When we talk about L'Aquila earthquake of 2009, we mean a series of seismic events, which began in December 2008 and ended in 2012, with epicentres in the entire area of the city, the Aquila basin, and in a part of the other provinces of Abruzzo. The name refers mainly to the mainshock, which occurred on April 6, 2009, at 3:32 am, which had a moment magnitude (Mw) of 6.3, with an epicentre in the area adjacent to the city of L'Aquila, affecting the other provinces of Abruzzo such as Pescara, Chieti and, Teramo and a large part of Central Italy to varying degrees. At the end of the event, the final death toll was 309, over 1,600 injured, and over 10 billion euros in estimated damage.

In the post-event period, the region and in particular, the city of L'Aquila has invested heavily in technology transfer aimed at supporting research and experimentation projects, supporting the creation of start-ups and promoting technology transfer to SMEs, on the issues of Blockchain, IoT and Artificial Intelligence. Funded by Ministry of Economic Development (MISE), it represents one of the ten most important centres in Italy. To date, the region, L'Aquila in particular, has invested heavily in technological

development, becoming one of the most developed centres and becoming attractive for international and transnational students that represents the major resource of the city of L'Aquila, constantly increasing from the date of the earthquake of 4 April 2009 to the academic year 2018-19 (Di Ludovico, D'Ovidio and Santilli, 2020).

As can be seen in the case of the city of L'Aquila, in the period following the event, the number of national (*Fig. 2*) and international (*Fig. 1*) students increased considerably. In particular, the number of international students, which up to the 78 units were constant up to the earthquake, increased considerably to 223 with a 179% increase compared to the pre-earthquake period. A similar situations regards the students from the rest of Italy which recorded a considerable increase in the subsequent period, recording the maximum growth in 2014 with 10800 students equal to 45% of the total number of students present in the city (in the pre-earthquake period the percentage was 26%. A percentage that is slowly flattening in the long run, returning to previous levels.

*[Insert Fig. 1 – L'Aquila – International Students - here]*

*[Insert Fig. 2 – L'Aquila – National Students - here]*

#### 3.1.2 2012 The Emilia-Romagna earthquake

The 2012 Emilia-Romagna earthquake was a seismic event including a series of earthquakes located in the seismic district of the Po valley in Emilia, mainly in the provinces of Modena, Ferrara, Mantua, Reggio Emilia, Bologna, and Rovigo, but also felt in a very large area including all of central-northern Italy and part of Switzerland, Slovenia, Croatia, Austria, south-eastern France, and southern Germany. In terms of economic impact, these natural disasters had cost more than 4 billion euros and caused damage to the economy: over 35,000 businesses damaged by the earthquake, the use of social safety nets, in particular layoffs, and affected at least 12,000-15,000 people. These data are the estimates presented by Confindustria to Parliament on the earthquake in Emilia.

After the event, the region made a total investment of 41 million destined to revive the historical centers and the economy in the territories affected by the earthquake of 2012. Almost seven years after the earthquake, the crater area has been halved and now it accelerates to revitalize and repopulate the historic centres, as well as supporting the creation of new start-ups and the research and innovation of small and medium-sized enterprises.

In terms of student attraction, in *Fig.3* and *Fig.4* we can see the example of Modena (the main area of the earthquake), has experienced a 122% increase from 107 international students to the current 237, marking a continuously growing trend in the period following the event. The same goes for students from other regions who have gone from more or less 3000 in the earthquake period to the current 5368, recording an 87% increase compared to the pre-event period.

*[Insert Fig. 3 – Modena - International Students - here]*

*[Insert Fig. 4 – Modena - National Students - here]*

### *3.2 Sample and Data collection*

Our research sample is based on 13 Italian cities that represent the main cities/provinces in the two regions taken into consideration in relation to the natural disaster. The cities taken into consideration are Piacenza, Bologna, Ferrara, Forlì, Modena, Parma, Ravenna, Reggio Emilia and Rimini in Emilia-Romagna and L'Aquila, Pescara, Chieti e Teramo in Abruzzo.

In terms of students' mobility and knowledge spillover, to evaluate the interconnection between cities, regions and other countries, the database of the National Student Clearinghouse has been used. NSC is an

administrative archive in which all the students enrolled in the Italian university system are registered. The data within the NSC database are sent monthly by the Italian universities and all the students enrolled in a university during a given academic year are taken into consideration, regardless of the year of the course. Our sample is based on more than 3.100.000 Italian students and focuses on 1.280.000 students that move from one region to another one and 50.000 that move from another country to the city taken into consideration. They represent an uninterrupted channel for the transfer of scientific and technical knowledge among countries and regions (Freeman, 2010; Trippl, 2013).

This study is conducted using the ordinary least-squares method (OLS) to verify the research framework and hypotheses using panel (i.e., longitudinal) data aggregated to the city-year, and city- level. The hypothesis testing was conducted using a panel data regression analysis model which aims to predict the extent of the strength of the effects of both independent variables on the dependent variable before and after the event in order to understand the impact of the event on the cities' development (Allison, 1994). A key advantage of panel data is that they allow for the inclusion of location (e.g., city) effects, which control the outcomes and thus can help control the effects of difficulty to quantify attributes of a location, such as geographic features, students' flow, and economic development (Botzen, Deschenes and Sanders, 2019). Since panel data regressions rely on within-location variation in disaster occurrence over time as the primary source of identification, these models allow the relationship between disasters and economic outcomes to be dynamic, and thus some studies allow for better understanding of lagged effects of natural disasters on human capital attraction measured in terms of students' mobility.

### *3.3 Operationalization of the variables*

The students' mobility is our unit of analysis. Our model includes two dependent variables: National Students and International students. Both variables were measured by the interaction between the cities taken into consideration and the students' incoming flow from other regions and other countries. These variables consider the students enrolled in university courses at an Italian university. The sample analysed ranges from 18 to 35 years. A total of 3.100.00 students are analysed to understand the linkage between knowledge spillover and cities' attraction post natural disaster.

Our first dependent variable, National Students is measured by the students' flow incoming from other regions in the city taken into consideration. As proxies for the knowledge inbound from other regions, we use the number of students from other regions over the population of the cities themselves.

Our second dependent variable International students is measured by the students' flow incoming from another country to the city taken into consideration over the population of the city itself. They represent an uninterrupted channel for the transfer of scientific and technical knowledge among countries(Anselin, Varga and Acs, 2000). In the most advanced countries, the number of foreign students enrolled in higher education had a surprising growth rate over the last decade (González, Mesanza and Mariel, 2011; Guruz, 2011; Choudaha and Chang, 2012) influencing the regional development in terms of innovation (Siekierski et al., 2018) and human capital (Faggian and Mccann, 2009)

The independent variable is represented by the Gross Domestic product (GDP). The choice of GDP represents the economic indicator of each Italian region, considering the Gross Domestic Product (GDP) of every region that represented the city taken into consideration. GDP is a monetary measure of the market value of all the final goods and services produced in a specific period and represents one typical empirical approach to estimate econometrically how either climatic or geological disasters affect aggregate economic measures. For example, Skidmore and Toya (2002) conducted a cross-country analysis and conclude that, in some cases, disasters have important effects on investment decisions, hence growth. Looking at climatic disasters (e.g. typhoons), they find there is a positive relationship between such disasters and rates of human capital accumulation, total factor productivity and economic growth.

In our regression model, we control both region and economics' characteristics. More specifically, the model's specification includes as a control variable the following indicator. The Total Students considered

the total number of students in each city. Resident students regard the students that enrolled at the university in the city of residence. Expenditure in R&D considered the expenditure of each city in R&D over the population of the city itself. Moreover, regarding the R&D development, we are considering University R&D that considers the expenditure of the university in terms of R&D.

Table 1 reports the summary statistics of the variables used in the regressions and *Tab.2* and *Tab. 3* the correlation matrix related to this model.

*[Insert Tab.1 – Descriptive Statistics - here]*

## 4. Results

In this section, we present our estimates of the impact of natural disasters on human capital and knowledge flow attraction for countries that experienced such large disasters between 2004 and 2019 and that have the available data required to understand the pre and post phenomenal impact. Recall that for those countries we evaluate the relationship between economic growth and students' attraction as a driver of economic development in 3 different terms, pre, and post-natural disasters and overall, in case that we do not consider the event. The result shows that human capital and knowledge flow inbound measured in terms of national and international students are strongly related to the natural event that affects the cities taken into consideration in the following period.

*[Insert Tab 2: Correlation Matrix - here]*

*[Insert Tab 3: Correlation Matrix - here]*

The empirical results are presented in *Tab. 4* and *Tab.5*. *Tab. 2* and *Tab.3* report the correlation among variables and the descriptive statistics are presented in *Tab. 1*. No major collinearity issues are detectable. To assess potential multicollinearity, we computed the variance inflation factor (VIFs). For each model (*Tab. 4* and *Tab. 5*) the mean and maximum VIF are well below the thresholds of 3,4. We thus concluded that multicollinearity is not a threat to the validity of our results. Going beyond mere correlation, tab x reports the estimated result from regression.

*[Tab.4 – Regression model – National students - here]*

*[[Tab.5 – Regression model – International students - here]*

The models I, III, V, VII, and X in *Tab. 4* and *Tab. 5* refers to national students' flow and illustrate the result of a specification containing only control variable taken into consideration in 3 different periods. In terms of national students (*Tab. 4*) and international students (*Tab. 5*), Models II and IV show the effect on natural students' flow in the period pre-event, in this case, the result shows that we have a no correlation between GDP and human capital and knowledge flow. In the period post-event, models VI and VIII in *Tab. 4* provide support for the HI *(The natural disaster that occurs in the geographical area positively affects the attraction of national students to the city in the post-event period*) by showing a positive and statistically significant correlation between national students' mobility inbound and economic growth of the city itself measured by GDP per capita in the period post-event for both areas taken into consideration, in this case model VI for Abruzzo (*P= 0,005 β= 2,36)* and model VIII for Emilia Romagna (*P= 0,029 β= 2,18*). We got a similar result in terms of international students, the result pose the results presented in the model VI and VIII in *Tab. 4* and provides support for the second Hypothesis HII (*The natural disaster that occurs in the geographical area positively affects the attraction of international students to the city in the post-event period*) by showing a positive and statistically significant correlation in the period post-event even for the

international student. More specifically, as we can see in *Tab. 5*, Model VI for Abruzzo (*P= 0,006 β= 2,75*), and model VIII for Emilia Romagna (*P= 0,048 β= 1,85*).

As we can see in the *Tab. 4* in Model X, in the overall period, the relation between GDP and students inbound in the cities taken into consideration privileges the national students' flow from other regions and confirms the hypothesis III (*The natural disaster that occurs in the geographical area positively impacts the national students' flow in the overall period pre and post event*) in both areas in the overall time (*P= 0,009 β= 2,57*). Otherwise, model X in *Tab. 5* shows that there is no confirmation of the relationship with the attraction of international students if we are considering the total period taken into consideration; and the HIV (*The natural disaster that occurs in the geographical area positively impacts the international students' flow in the overall period pre and post event*) are not confirmed.

## 5. Discussion and conclusions

Each year, natural disasters threaten the strength and stability of communities worldwide. Yet responses to the challenges of recovery vary greatly and in ways that aren't explained by the magnitude of the catastrophe or the amount of aid provided by national governments or the international community (Gotham and Powers, 2015a) but by the power of the city or the geographical area to react to this event and build self-resilience to react to the shock. An important indicator in the period after natural disasters is represented by human capital flow (McDermott, 2012).

The reported results show that disasters have important consequences for human capital and knowledge attraction. As we know, human capital is a key ingredient in economic development (Benhabib and Spiegel, 1994; Mathur, 1999). In this paper we examined the impact of natural disasters on human capital and knowledge attraction in the geographical area. Several studies look at the economic growth of areas affected by natural disasters (Shabnam, 2014) and on the relative mobility of human capital following these events (Nix-Stevenson, 2013), but a fundamental element is also the ability of cities within the affected areas to attract useful knowledge to generate innovation and economic development.

Our results show a strong attractiveness of the city in terms of national and international students in the post-event period. This attractiveness may concern post-event development policies (Noy, 2009), the opportunity to invest in innovation (Miao and Popp, 2014) that gives the possibility to the area to attract a strong heterogeneity of knowledge useful for generating development and innovation (Capuano and Grassi, 2019; Wu *et al.*, 2019). Very interesting is the case of L'Aquila which encouraged the foundation, in the post-earthquake period, of digital innovation hubs and research and innovation centres that have made it possible to attract students from all over the world. In conclusion, natural disasters represent a great shock for the entire area affected but can also represent an opportunity for growth and economic development, the ability of the city to improve after these events represents a real resilience of the city itself to the events that occur. In this case, the possibility of attracting knowledge in the form of national and international students represents a starting point for post-event economic development.

### *5.1 Research limits*

The first research limits are represented by the sample. In this paper, we focus on the main cities in the geographical area affected by natural disasters in the 2 Italian regions taken into consideration. This sample could also be extended to other countries. This extension would allow us to examine the connection between cities with different policies, different cultures, and different development. A second limitation concerns the period analysed (15 years). Temporal development that could be extended to have a more precise analysis of the phenomenon in the medium-long term. Following the Gotham and Greenberg works (2014; 2015b) an optimal time horizon could be 40 years, but this would not take into account the technological development in various sectors.

### *5.2 Practical implications*

Our results have practical and theoretical implications regarding the development and management policies of a city or region. The first recommendation concerns the role that development policies play in terms of the attractiveness of the city. Investing in innovation and in the developed economy is the basis of a post-natural disaster development policy. The role that the attractiveness of the city plays in the economic development process following the event is therefore highlighted (Lee, Florida and Gates, 2010; Florida, 2012). A second implication concerns the implementation of development programs to attract human capital. Unlike conventional approaches that focus on attracting businesses and forming industrial clusters (Masters and McMillan, 2001), cities investing in human capital and their attractiveness generate medium-long term development and trigger a mechanism of creation of human and intellectual capital which is the basis of the territory's resilience process (Toya and Skidmore, 2007).

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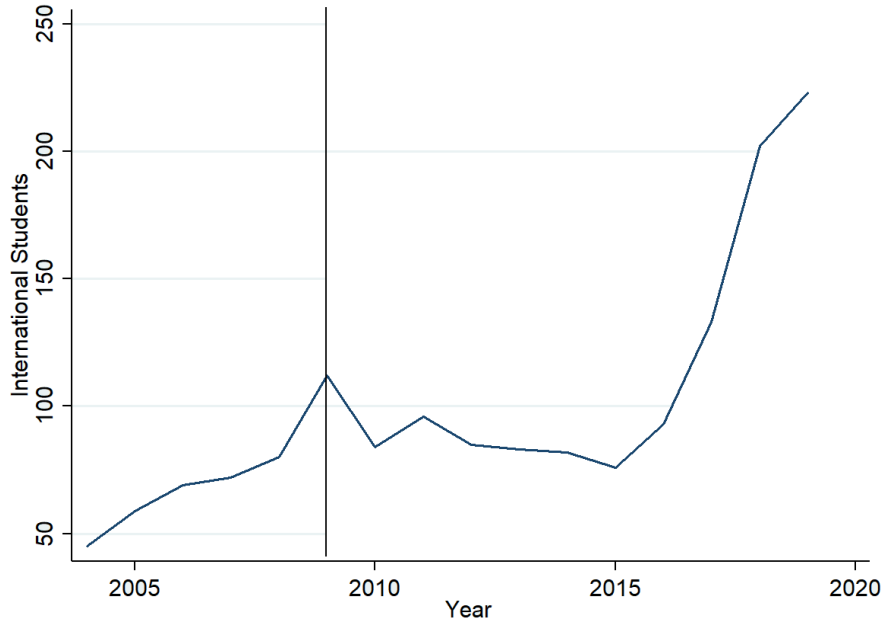
## 7. Figures and Tables:

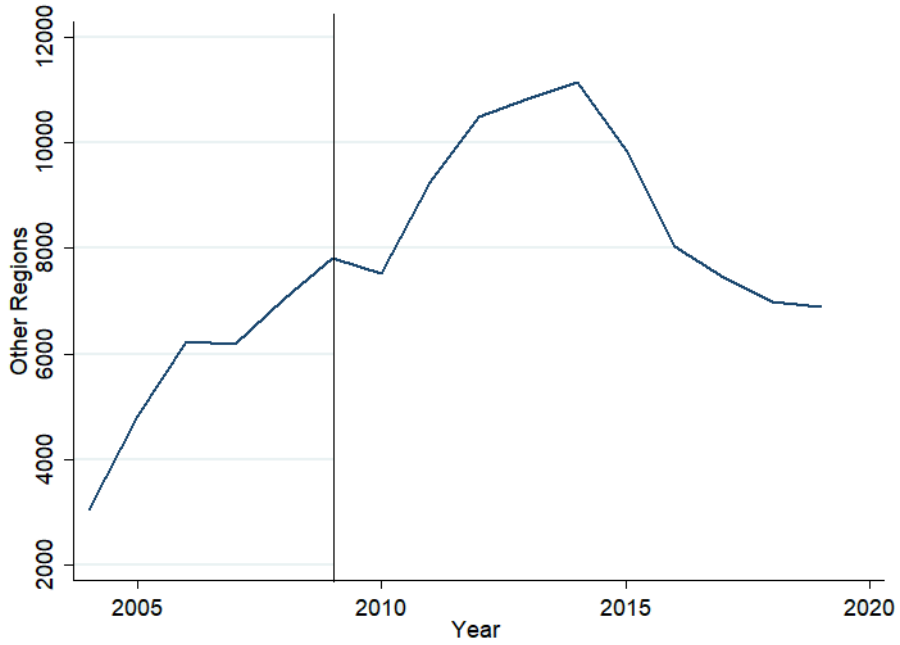
### *7.1 Figure*

*Fig. 1 – L'Aquila - International Students*




*Description: Number of students from other countries enrolled the bachelor and master's degree courses in L'Aquila 2004 – 2019 – Data source: NSC*

*Fig. 2 – L'Aquila - National Students*

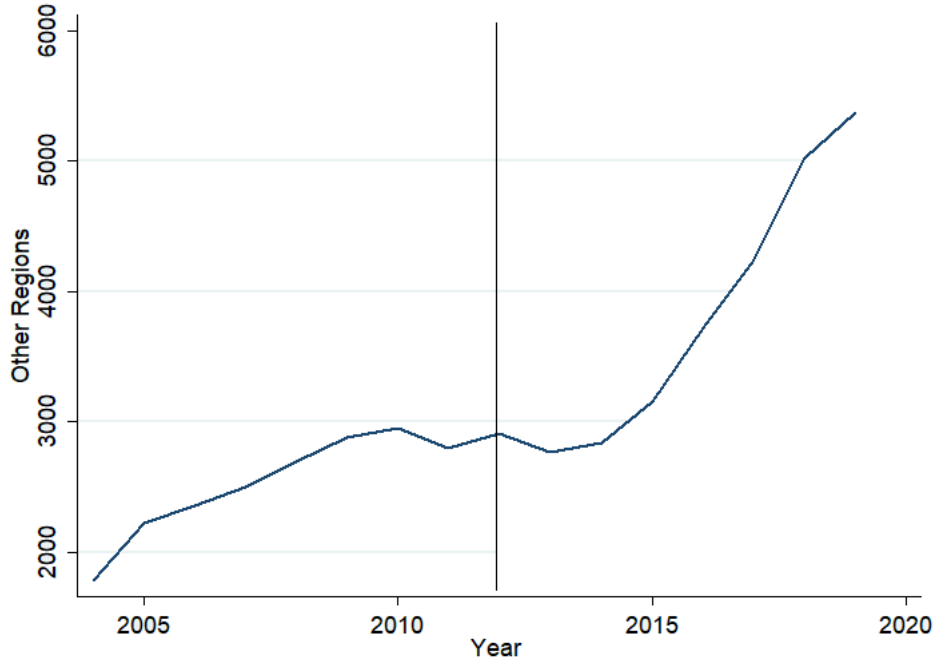



*Description: Number of students from other regions enrolled the bachelor and Master degree courses in L'Aquila 2004 – 2019 - Data source: NSC*

*Fig. 3 – Modena - International Students*


*Description: Number of students from other countries enrolled the bachelor and master's degree courses in Modena 2004 – 2019 - Data source: NSC*

*Tab. 4 – Modena - National Students*




*Description: Number of students from other regions enrolled the bachelor and master's degree courses in Modena 2004 – 2019 - Data source: NSC*

## *7.2 Tabs*

*Tab.1: Descriptive Statistics*

| *Variable* | *Obs.* | *Mean* | *Std. Dev.* | *Min* | *Max* |
|---|---|---|---|---|---|
| International Students | 208 | 0.001 | 0.001 | 0.001 | 0.006 |
| National Students | 208 | 0.048 | 0.047 | 0.003 | 0.201 |
| GDP | 208 | 0.793 | 0.338 | .0214 | 1.069 |
| Total Students | 208 | 0.115 | 0.092 | 0.011 | 0.382 |
| R&D Total | 208 | 0.001 | 0.001 | 0.001 | 0.001 |
| University R&D | 208 | 0.517 | 0.051 | 0.439 | 0.641 |
| Resident Students | 208 | 0.067 | 0.050 | 0.008 | 0.214 |

*Tab 2: Correlation Matrix*

| | *Variable* | *[1]* | *[2]* | *[3]* | *[4]* | *[5]* | *[6]* |
|---|---|---|---|---|---|---|---|
| [1] | International Students | 1 | | | | | |
| [2] | GDP | 0.140 | 1 | | | | |
| [3] | Total Students | 0.201 | -0.501 | 1 | | | |
| [4] | R&D Total | -0.019 | 0.672 | 0.349 | 1 | | |
| [5] | University R&D | 0.083 | -0139 | 0.204 | 0.204 | 1 | |
| [6] | Resident Students | 0.159 | -0.536 | -0.122 | -0.135 | 0.0202 | 1 |

*Tab.3: Correlation Matrix*

| | *Variable* | *[1]* | *[2]* | *[3]* | *[4]* | *[5]* | *[6]* |
|---|---|---|---|---|---|---|---|
| [1] | National Students | 1 | | | | | |
| [2] | GDP | 0.328 | 1 | | | | |
| [3] | Total Students | .8600 | -0501 | 1 | | | |
| [4] | R&D Total | 0.012 | 0.6726 | -0.160 | 1 | | |
| [5] | University R&D | 0.196 | -0.139 | 0.205 | 0.205 | 1 | |
| [6] | Resident Students | 0.855 | -0583 | -0.122 | -0.122 | 0.201 | 1 |

*Tab.4 – Regression model – National students*

| | *Pre - Natural Disaster* | | | | *Post - Natural disaster* | | | | *Overall* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Abruzzo* | | *Emilia Romagna* | | *Abruzzo* | | *Emilia Romagna* | | *Total* | |
| Variable | *Model I* | *Model II* | *Model III* | *Model IV* | *Model V* | *Model VI* | *Model VII* | *Model VIII* | *Model IX* | *Model X* |
| National Students | | | | | | | | | | |
| | | 0.013 | | 0.001 | | 0.174** | | 0.026* | | 0.024* |
| GDP | | [0.147] | | [0.008] | | [0.063] | | [0.012] | | [0.009] |
| | 0.610*** | 0.487 | 0.515*** | 0.517*** | -1.025*** | -0.033 | 0.591*** | 0.451*** | 0.557*** | 0.556** |
| Total Students | [0.030] | [0.055] | [0.025] | [0.026] | [0.136] | [0.125] | [0.090] | [0.084] | [0.017] | [0.017] |
| | 1468.221* | -317.020 | -31.912 | -45.788 | -932.368** | -2230.400*** | -107.127 | -292937 | 139.352*** | 17.692 |
| R&D Total | [697.975] | [1599.064] | [73.515] | [105.352] | [291.701] | [578.322] | [85.015] | [137.865] | [40.560] | [61.725] |
| | 0.053 | 0,041 | 0.002 | -0.001 | -0.181 | -0154 | 0.034 | 0.031 | 0.010 | 0.009 |
| University R&D | [0.032] | [0.148] | [0.008] | [0.004] | [0.115] | [0.107] | [0.023] | [.0.025] | [0.009] | [0.008] |
| | -0.852*** | -0.214*** | 0.001 | 0.554 | 1.506*** | 0.415 | -0.925*** | 0.641** | 0.001 | 0.001 |
| Resident Students | [0.001] | [0.001] | [0.0081 | [0.005] | [0.291] | [0.272] | [0.013] | [0.015] | [0.003] | [0.003] |
| No. Of Observation | 24 | 24 | 72 | 72 | 40 | 40 | 72 | 72 | 208 | 208 |
| R-squared | 0.812 | 0.798 | 0.456 | 0.752 | 0.821 | 0.785 | 0.545 | 0.863 | 0.465 | 0.412 |

Notes: International Students, dependent variable. $P < 0.100$; *P < 0.050; ** $P < 0.010$; ***$P < 0.001$

*Tab. 5: – Regression model – International students*

| | *Pre - Natural Disaster* | | | | *Post - Natural disaster* | | | | *Overall* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Abruzzo* | | *Emilia Romagna* | | *Abruzzo* | | *Emilia Romagna* | | | |
| *Variable* | *Model I* | *Model II* | *Model I* | *Model II* | *Model III* | *Model IV* | *Model III* | *Model IV* | *Model IX* | *Model X* |
| International Students | | | | | | | | | | |
| | | 0.002 | | -0.001 | | 0.172** | | 0.019* | | 0.001 |
| GDP | | [0.001] | | [0.002] | | [0.062] | | [0.010] | | [0.001] |
| | 0.002** | 0.002** | -0.00 | -0.011*** | -1.025*** | -1.031*** | -0.445*** | -0.731*** | 0.003* | 0.004* |
| Total Students | [0.001] | [0.001] | [0.011] | [0.011] | [0.136] | [0.125] | [0.0.089] | [0.0.069] | [0.002] | [0.002] |
| | -8.602* | -27.501* | 35.086** | 47.855 | -932362*** | -2317.144** | -74.134 | -183.831 | -6.574 | 18.067*** |
| R&D_Total | [3.508] | [12.538] | [12.288] | [19.005] | [291.701] | [570.997] | [85.264] | [148.361] | [4.519] | [4.661] |
| | 0.001 | 0.001 | 0.001 | 0.001 | -0.182 | -0.152 | 0.039 | .043 | 0.001 | 0.001** |
| University_R&D | [0.001] | [0.001] | [0.001] | [0.0.001] | [0.115] | [0.106] | [0.024] | [0.027] | [0.002] | [0.001] |
| | 0,001 | 0,001 | 0.045 | 0.045 | 0.094*** | 1.421** | 0.137 | 0.656*** | 0.001 | -0.002 |
| Resident_Students | [0.002 | [0.002 | [0.001] | [0.001] | [0.662] | [0.269] | [0.195] | [0.016] | [0.003] | [0.005] |
| No. Of Observation | 24 | 24 | 72 | 72 | 40 | 40 | | 72 | 208 | 208 |
| R-squared | 0,712 | 0,461 | 0.456 | 0.771 | 0,821 | 0,842 | 0.851 | 0.863 | 0.465 | 0.412 |

Notes: International Students, dependent variable. $P < 0.100$; *P < 0.050; ** $P < 0.010$; ***$P < 0.001$