



DOCTORAL THESIS IN URBAN STUDIES AND
REGIONAL SCIENCE

**Land, housing and work: the household issues in
the Post-Disaster. Market reactions and State
intervention in the Regions left behind**

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ABSTRACT

Disasters caused by natural phenomena represent a long-standing problem, which increases dramatically in frequency and cost in recent years. The economies are affected as a whole, but the most affected category is households. In an area prone to earthquakes, where risk exposure cannot be avoided, reducing the vulnerability of buildings has the most important role. Sometimes, for various reasons, prevention is not enough and a seismic event leads to catastrophic destruction of human settlements. There is no consensus in the literature on how to deal with a socio-natural disaster. The main parameters for assessing the territorial recovery are the local GDP and the employment rate, useful but not sufficient to evaluate the labour conditions. Decreases in house prices are seen as a private problem and seismic risk models are sometimes obsolete or imprudent. The theory has often neglected to analyse the micro implication of reconstruction subsidies and there are shortcomings in the various nuances that state intervention can have on post-disaster markets. The purpose of this thesis is to define the work, housing and vulnerability of the land as the three pillars on which to intervene in a post-disaster area, as well as for other territories that are still safe but risky and in decline, implicitly suggesting these as new parameters for local development. The thesis is a collection of papers, structured in three articles that analyse the dimensions of work, housing and seismic risk from a global perspective to a local one. The first chapter is a comparison between Ecuador, Chile and Italy regarding the regional post-earthquake labour market. The three short-term workforce surveys are compared, finding the different pre-shock determinants of having a job, an increase in wages or in working hours after the earthquake. Salary distributions are also compared in quantile estimations, including which segments of the population are losing or gaining purchasing power after the disaster. The results show that women and uneducated people suffer most from the state of emergency and, surprisingly, construction workers are not the ones who are gaining from the disaster. The second chapter explores the impact on housing prices of the double shock caused by the 2009 L'Aquila earthquake in Italy and the subsequent reconstruction process financed with public funds. The research adopts a difference in difference approach, using as controls for rural municipalities a Mahalanobis Distance Matching and a border control and a synthetic parametric control for the city of L'Aquila. The results show that the relationship between subsidies for reconstruction and housing prices is positive and quadratic. For rural municipalities that do not depopulate, the public spending more than absorb the shock of the

catastrophe, with several territorial disparities. The third chapter focuses on the local implication of risk perception on housing prices. Using only the municipality of L'Aquila as a case study, every single post-disaster housing transaction is analysed in a hedonic model. Each housing price is then broken down according to its vulnerability to the land, seismic damage and reconstruction funds. The results show an increasingly higher value for the non-reconstructed houses and for the low soil vulnerability. Building damage and all neighbourhood-related variables are inconsistent if adequate to the money spent on private reconstruction, the latter providing us ideas for a general positive confidence of homeowners in public-led reconstruction. Summarizing the results of each document, the state intervention can absorb much of the seismic shock but it is extremely expensive and the benefits are always strongly polarized within the local communities, increasing inequalities and causing expulsions from the original territories, in the short run as well as in the long term. Earthquakes like any other disaster can be an opportunity to regenerate a lagging territory only if the processes are well managed and well monitored. The best option, both in terms of public expenditure and household wealth, is always to prevent any possible risk and create solid endogenous growth.

“Nel terremoto morivano infatti ricchi e poveri, istruiti e analfabeti, autorità e sudditi. Nel terremoto la natura realizzava quello che la legge a parole prometteva e nei fatti non manteneva: l’uguaglianza. Uguaglianza effimera. Passata la paura, la disgrazia collettiva si trasformava in occasione di più larghe ingiustizie

In the earthquake, in fact, rich and poor, educated and illiterate, authorities and subjects died. In the earthquake, nature achieved what the law promised and in fact did not keep: equality. Ephemeral equality. Once the fear passed, the collective misfortune turned into occasion of wider injustices ”

Ignazio Silone

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[ENGLISH]

It is very hard for me writing these acknowledgements, mainly because I never wrote such page in my previous dissertation and because these are the last words of my PhD and of my experience here in L'Aquila. These three years have been for me the most important of all of my life, I can say. I came here as a messy student and I come out as a more mature man. Not everything went out as I was expecting it. In my first year here I felt like in an amazing laundry where I was washed and bumped all over dozens of different experiences, L'Aquila and the GSSI were under a big spotlight and I put all of my energies to make every place I was going a better place for future generations. I brought with me these energies in Chile, in Antofagasta mainly, where I tried again to be the best person I could be. I really think that one of the greatest achievements I got in these years was when, both in L'Aquila and Antofagasta, the "locals" gave me the explicit badge of being one of them. "Now you are Aquilano/Antofagastino, never forget it" they told me, and I will never forget.

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[ITALIANO]

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Dedicated to my People, all
the People, to my Cities and
my Love

1 Introduction.

The Earthquake as a mirror to understand our societies

1.1 Introduction to the Thesis

At 3:32 am on April 6th 2009, the city of L'Aquila (Abruzzo, Italy) was hit by a 6.3 magnitude earthquake, the highest of a long seismic swarm in those days. The casualties included 309 inhabitants, 1600 people were injured and about 100,000 were evacuated from L'Aquila and the surrounding municipalities during the following weeks. In the night of February 27th 2010, an earthquake of 8,8 Mw that lasted four minutes shook the Chile. The epicenter was located 17 km far from the town of Cobquecura, the magnitude and the distance induced a tsunami wave that hit the Chilean coast 35 minutes after the seismic shake. The final count of losses is of 525 deads and about 500,000 people without a shelter. At 6:58 pm of April 16th 2016, the Ecuadorian coast was shaken by an earthquake of 7.8 Mw, its hypocentre was located off the coast of Pedernales (Province of Manabí). The disaster left a total of 671 human lives lost, 113 individuals have been rescued alive and, in the three days after the earthquake, almost 4859 people have received medical aid.

Three earthquakes, three disasters, as many others occurred in the last decade all over the world, as in Nepal, Haiti, Japan, Pakistan, Indonesia, New Zealand and China. All of these affected by hundreds or thousands of losses, hundreds of thousands of people in a state of emergency and other millions directly or indirectly affected in other ways. Earthquakes, as many other natural events, bring devastation on physical environment and destruction of human communities. At the same time, while all of these natural phenomena are the same since millions years (with now some evidences of their increasing caused to global warming), in the last few thousands of years the human societies became more complex, larger in size and exploiting more the natural environment they are linked to (Pelling, 2003). This huge increasing of human footprint, instead of making us more prepared for disasters and harmonious with our natural environment, made us more vulnerable and fragile to the

changes in our planet. Nonetheless, not all the humans are exposed to the same risks. There is a geographical inequality due to some territories more prone than others as well as differences between populations living in the same dangerous area, someone is more prepared or more able to recover while someone else doomed to suffer more from catastrophes. Sadly, in the 21st century, these inequalities in risk are more and more related to wealth and income, both at the individual and territorial level. Institutions can adapt, firms can relocate, wealthy people can find a better place on their own, the great majority of people will suffer the consequences of a disaster, because they do not have means to do otherwise.

The scope of this dissertation is to understand what this vast majority of affected people react to a disastrous earthquake. The dissertation adopts a quantitative approach, in order to understand behaviours or patterns for a number of people sufficiently large, with a research focus large enough in time and space dimension. The preliminary research question is to identify the few parameters this thesis should work toward, in order to give a first quantitative assessment for the most important issues the post-disaster populations are dealing with. As the title of this thesis indicates, the aim is to identify these main issues: land, housing and work. The title is an homage to South American catholic and socialist social movements, one of whose main slogan is *Tierra, Techo y Trabajo* (indeed, Land, Housing – literally Roof - and Work) as the main rights the poor people fight for (Scannone, 2018). The theoretical and empirical justifications are explained throughout this section and the thesis. The only “poetic licence” adopted in this paper is a distortion of the original meaning of “Land”, used here not as the claim of some land to cultivate but as the right to live on a territory where the land is safe and it does not turn into a threat for the people survival.

This iconic motto used for summarise this thesis, leaves open the question of why, from an economic point of view, the focus of this thesis should be about the household as an economic unit. Households are the first necessary economic unit, the consumption of good and services is the pillar of any economy and the households are, by definition, net consumers. In order to assess which is the best aspect to evaluate when studying households, it is useful to look at the literature on poverty. For any individual, are considered three “basic needs” (in addition to many others) for the survival: food, clothing and shelter/housing (Streeten and Burki, 1978). Food is surely the most basic need and there is a strong literature considering this as a correct proxy to

evaluate households behaviours (Vecchi, 2011). At the same time food, as clothing, is a need linked to a huge amount of very volatile markets and finding a coherent aggregate index, especially for geolocated studies, can be a difficult process. Instead, the housing market, even with its volatility and peculiarities, can be considered a more stable proxy for evaluating households preferences and change in behaviours after a shock (Meyer et al., 2013). The best proxy to evaluate changes in firms behaviours is more easy to define. According to the main economic literature, any production process needs labour and capital as inputs (Arrow et al., 1961). Now, while the capital is a very volatile input and its main evaluation proxy, the interest rate, is generally linked with global processes, locally difficult to analyse, the labour market is easier and more related to population movements market (Smart, 1974). Generally, the government is seen as a complete third part from the previous two economic units, a sort of *deus ex machina* who could improve the situation from the outside (Greenwald and Stiglitz, 1986). In this research it is not completely possible to remove this “government as exogenous shock” approach, mainly because of the huge amount of national public spending for the reconstruction, but there will be an attempt for considering even the endogenous causes of public intervention. However, the market objects of this research in order to assess the change in a local economy after a natural disaster are the housing market, the labour market and the post disaster government intervention for both systems. In this thesis the labour dynamics are called with the mainstream term “market”. While acknowledging the importance of the term, it is important to note that in literature has been highlighted that “Labour is not a commodity” (Evju, 2013), indeed it is a human right and a trait of each individual’s dignity. For simplicity, this thesis still use the term “labour market”, with the hope to not use it again.

The introductory chapter is structured as follows: section 2 introduces the literature advancements on disaster studies and explain the reasons why to study earthquakes from an economic point of view. Section 3 put the attention on the regional science, where the disaster studies can be an opportunity for regions to recover at their best from an earthquake and to open a regeneration process but it can be an opportunity for the rethinking of the regional development itself as a concept. Section 4 illustrates the case study of L’Aquila and its strict relevance with all the theoretical topics in this dissertation. Section 5 concludes the chapter, summarising the following chapter of the thesis.

1.2 Why earthquakes?

Humans live in contact with potential harmful natural phenomena since the beginning of history (Pelling, 2003). Events such earthquakes, rarely release their force over urban settlements so strongly to reshape their social order, it is what we call a disaster. Catastrophic events caused by a natural phenomenon (natural disasters) are an increasing problem of our societies. The expansion of urban settlements, the population growth, the soil consumption as well as climate change, are exposing more and more a larger share of population to dangerous events year by year, in all the side of the world (IPCC 2011; 2015; 2019). Nevertheless, natural disasters are not catastrophic by themselves. They become catastrophic when the human settlements facing them are not prepared or excessively vulnerable. This is why they can be considered as “social in nature” (Quarantelli, 1989). For this reason, a new stream of literature prefers the term “socio-natural disasters” (Arteaga and Ugarte, 2015). The etymology of the term indicates a moment “against the star” (dis-aster, from latin), so against the constituted order. It can be courageously assessed that “a natural disaster is not a natural event” (Hallegatte, 2014, p. 9) because the nature forces can be followed and even the strongest event can cause very few casualties. It is the case for many disaster cases, moreover, the hardest time was the medium term after the tragedy, when the institutions were not able to rearrange a new harmonic situation and many conflicts arise (Alexander, 2000). How to define when a phenomenon becomes a disaster is all related to the human perspective. Or, by an economic point of view, “a natural disaster can be defined as a natural event that causes a perturbation to the functioning of the economic system, with a significant negative impact on assets, production factors, output, employment, or consumption” (Hallegatte, 2014, p. 9). Earthquakes are a particular and very interesting cases of natural phenomena causing disasters: when they do not induce tsunamis or landslides, the greatest problem are the damage derived from the land shaking, not directly hurting human lives but easily destroying buildings and other human infrastructure (Cassidy, 2013). Our abilities to predict precisely the earthquake incidence are increasing but still not sufficient to evacuate and protect the population. The optimal way to be protected from this, the most harmful, natural phenomenon is the prevention through seismic codes, safe buildings and a proper information to the exposed populations (Pelling, 2003; Cassidy, 2013).

Unfortunately, most of the times it is still not possible to completely prevent

the destruction coming from natural events. The history of humankind is full of cases of entire civilisations destroyed or reshaped from such events. This continuous reshaping of the physical environment and human settlements pushed the societies to live their post-disaster times as a moment of proper “social catalyst” (Kreps, 1995). In the last decades, with the increasing in social science literature of the *Disaster Research* stream, scholars identified these historical moments of social reshaping as great accelerators of political dynamics already in act or, sometimes, the rise of minoritarian elites pushing the processes towards their interests, it is the famous concept of “Shock Doctrine” introduced by Naomi Klein (2007). With some virtuous exception, as the Friuli (Italy) earthquake in 1976, sociological studies of the Disaster Research suggest that most of the historical shocks of 20th century, natural induced or not, the first mid term outcome has been always a shift of economic and political power from the lower classes to the upper ones (Finch et al., 2010). The methods with the emergency and the reconstruction phases are managed and determined by the national and local governments is crucial to undermine these risks (Gotham and Greenberg, 2014)

One of the empirical method can define this linkage between catastrophic phenomena and political spheres is what is here defined as the reconstruction culture: the set of laws, institutions, practices and dynamics a particular society, mainly a nation-state, has as endowment or develops when it deals with a disaster. Reconstruction cultures after a natural disaster can be categorised in three ways: The first one is belonging to countries with a strong vocation for free market, like the United States, that would mostly let the private sector to pay for the reconstruction. Great part of the last California earthquakes reconstruction, for example, has been paid using households’ savings, insurances or state granted low-interest loans, while only 7% has been directly paid by public sector (Wu and Lindell, 2004). The second reconstruction culture, like the Japanese or Iranian, is more balanced, with a parity between public (often just as granted low-interest loans) and private funds (Ghafory-Ashtiany and Hosseini, 2008; Hayashi, 2012). The reconstruction processes of the so-called developing countries, here considered as “balanced”, are quite interesting, because they highly depend on international aid. In these countries, not only in case of disaster, the high volatility of aids can produce severe stability problems and often became a sort of “bubble” (Bulir and Hamann, 2003; Arellano et al., 2009). The last reconstruction culture is the one belonging to countries where State has a strong role in markets, as in Italy or in China. Chinese housing is mostly based on state-ownership and market movements are marginal

(Ge et al., 2010). In Italy, 73% of households own their home (Eurostat, 2015) and, nevertheless, there is a strong culture of publicly-funded reconstruction in case of disaster (Alexander, 2009). These two simultaneous phenomena make the study of the Italian case very important to assess the relationship between State, community and free market movements in the housing sector after a natural disaster.

An earthquake, as all the natural disasters, can be a particular economic shock. The complete exogeneity of this phenomenon affects all the aspects of a human local system. The economic environment could just prevent the damage, react in order to come back to the pre-existent situation or evolve to a new economic arrangement. Generally speaking, there are three different ways to deal with these harmful phenomena: first of all, there is the prevention, then the reconstruction “where it was, as it was” and, at the end, the regeneration process (Faggian et al., 2017). The prevention, in the earthquake case, seems surely the best and safer technique to alleviate the negative economic shock. Differently to other kind of natural disasters, as hurricanes or fires, earthquakes do not induce, in general, a natural direct damage to living beings; all the damages are historically related to building sustainability. So, in theory, should be possible to create an urban system 100% earthquake safe just perfecting building sustainability or, *per absurdo*, living in a society without buildings. Unfortunately, history of mankind has proven a strong correlation between economic and urban development and exposure to earthquake damages. The common, intuitive, way to react is the proper reconstruction, the so called “bouncing back”. To reconstruct every building where it was as it was. In this case, the only effort for the community is to find the resource in order to restore the pre-existent situation. This was a common practice in all the world and particularly in the Eastern Asia, where the building culture was, even in not seismic areas, very conservative. The other approach is the regeneration process. After a consistent destruction of residential, productive and public buildings, it can be useful to transform the past damage in an opportunity for the social environment for rebuilt the local system in a different way. In general, it's quite rare to encounter a reconstruction process that has been completely bounced back or completely renewed, but the mixed planned or spontaneous process could tend more to one or another side. An important historical case in which the reconstruction process completely renewed the region, even with important social implication, is the earthquake in Val di Noto (Sicily, Italy) in 1693. The former city of Noto was situated on a plateau, all the population was living, quite distant from the farmland. After the earthquake,

the duke Giuseppe Lanza decided to rebuilt the new city eight kilometres southern. The new place was no more on the plateau but on a declivity above the fields, in order to let the landowners supervise the workers staying at home. The working classes were disagreeing this change, but their claims have been unheard, the town was rebuilt in the new place (Piazza, 2012).

Every year, the our planet is affected by, on average, fifteen earthquakes with magnitude over 7.1, one hundred with magnitude over 6.1 and several thousands of less powerful shakes. Most of these are in uninhabited land but we are still facing disastrous earthquakes every year, all over the world. It is therefore possible to create a disaster-free world? The answer was obvious until few years ago, now, in parallel with the increasing of catastrophic phenomena, many scholars assess there is space for an (almost) zero risk society (Clarke and Dercon, 2016). It is about preparedness before these phenomena occur as well as the ability to respond and alleviate the disaster. This thesis is structured to bring a contribution in this direction.

Before moving on to the next section, on the regional perspective of the economic analysis, it is important to refer to the recent scholar debates on resilience. In this dissertation, the term resilience will be used as less as possible. The author understands the importance of all the concepts belonging to the big framework of "resilience theory", as the adaptivity, the recovery, the resistance or the "bouncing back". The concept of resilience would have been perfect for this dissertation, connecting the vulnerability to earthquakes, the adaptivity of housing and labour market and the evolution of regional economies to a wider framework. Because of the plurality of these terms, although acknowledging the many efforts of the field on find a proper definition (Pike et al., 2010; Urso et al., 2019), the choice for this dissertation is to avoid the direct use of the word "resilience" and the implementation, case by case, of its synonyms, in order to not create confusion when the term could be used to define two different concepts in the same dissertation (i.e.: the resilience of the Chilean agricultural sector in the sense of resistance to changes and the resilience of the L'Aquila housing market in sense of regeneration). Lastly, the debate on resilience can be potentially dangerous when it causes the need to quantify resilience, where the subjectivity is not easily avoidable (Faggian et al., 2017), inducing real rankings between territories or cities, with winners and losers, as is the "100 Resilient Cities" project, funded by the Rockefeller Foundation.

In conclusion, the disaster studies, and earthquakes in particular, are an

important topic to deal with explicitly and implicitly. Explicitly, because catastrophic events are increasing and our societies should care more about them, in order to prevent or to reduce any damage as much as possible. Implicitly, because studying these moments of external shock it is possible to better understand the economic and political dynamics our societies enact in the moment of emergency, as a real summary of longer term dynamics.

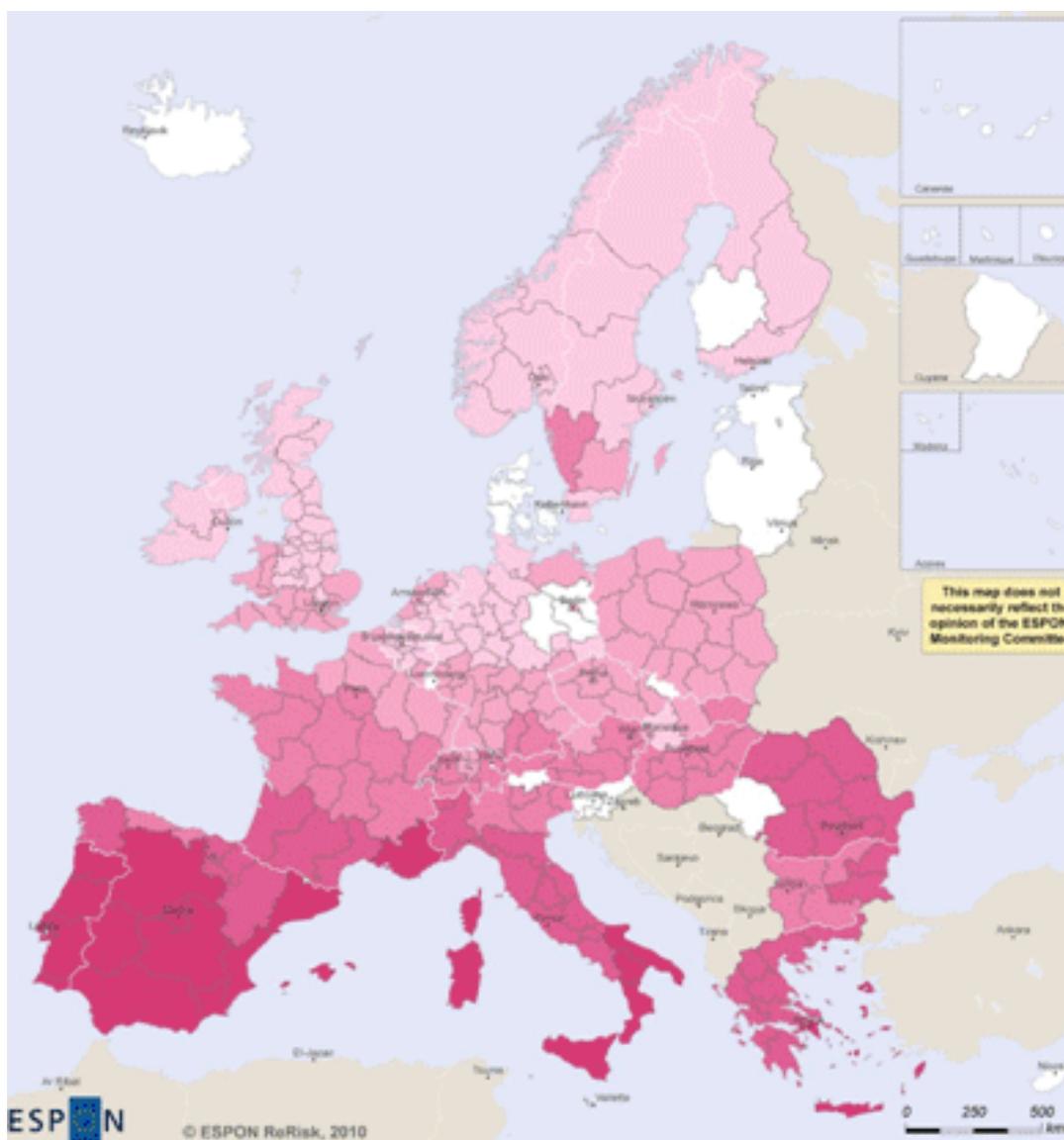
1.3 Why regions?

The second literature branch we rely on is the regional science theory. Considering that "In brief, regional science as a discipline concerns the careful and patient study of social problems with regional or spatial dimensions, employing diverse combinations of analytical and empirical research." (Isard 1975, p. 2), this subset of the economic theory is the best discipline to adopt when studying an economic system smaller than a national one, as a natural disaster affected area. So, not only regions in their strict meaning (as the NUTS-2 level for EU) but in a wider perspective. The scope of this thesis is not to indicate regions as the best substitute for the declining notions of nation-state in sense of sovereignty. The contemporary nation-state as we know it suffers of several crises in terms of effectiveness to respond to people's needs (Sassen, 2006; Moisio and Paasi, 2012) and there is an uprising political and academical thought suggesting regions, or city-regions, can take their place in Western Countries (Calzada, 2015). To simply reduce the size of the border of a sovereign institution can be an illusory move, when the challenges of our time require a wider perspective on how we define political and geographical borders. Considering the strong importance of this issue, this thesis is not directly facing it, accepting instead the principle of subsidiarity as defined by the Treaty on European Union (Art. 5) where "powers are exercised as close to the citizen as possible". Expanding the concept, every level of government (municipal, regional, national, supra-national or even global) should exercise its power in harmony with the other levels.

The European Union is one of the institutions that are omitted in this thesis, because its competences in case of natural disasters are not well defined (except for some financial coverage to Member States) and two case studies in Chapter 2 are outside the EU. At the same time, it is important to remark the role that EU had in the past decades to give importance to sub-national level of government and pushing decentralisation processes also outside its

borders. This important refocus from nations to regions brings sometimes the same errors that last century had when facing any comparison issue: the rush for Universalism (Maurice, 1989). The Universalism is the social science literature tendencies to avoid any kind of comparison because its scholars acknowledge an already identified benchmark to follow (the USA, mainly). Its contrary is the Culturalism that claims no need for comparison because every place is explained and justified in itself. When the barrier is moved a little away from the Universalism and comparison are accepted, it is easy to encounter (for sure in EU) maps very similar to the one below:

FIGURE 1.1: Almost every EU NUTS-2 Regions map



Of course it is a provocation but it illustrates clearly the lack in methodology of many EU Regional analysis. Where the reader already knows in advance

the final outcome. The map above can be about GDP, Unemployment, Education, Green Policies, etc. every European citizen sees that the North-West is the benchmark and the South and the East have to catch-up. It is very rare, fortunately not impossible, to find researches where the “better performing” territories have something to learn from the outliers. As better explained in Chapter 2, this thesis rejects territorial comparisons made to identify a benchmark and a group of followers, while the scope is to evolve the “place based approach” (Barca et al. 2011), where every territory not only has its own methods and valuable differences, but the outcome too can differ, understanding every territory has something to teach, something to learn and that the final goal can be different if this bring to a diffuse well-being and a reduction of inequalities ¹.

The study of disasters is a branch where this non-benchmarking way of looking at territorial economies takes place. Of course, there are some cases of ranking between nations about their exposure and preparedness to natural disasters, as the World Risk Index (2018), but in the main disaster research literature there is a slight multidisciplinary understanding for good practices all over the world, without necessarily creating dualisms between “developed” and “developing” countries for the process they adopt to deal with a disaster (Wu and Lindell, 2004; Alexander, 2005). Gerber and Robinson (2014), indicates a relevant stream of literature suggesting, both in theory and in practice, how sub-national level of government (i.e.: regions) are the most engaged in case of disaster. Their preparedness can be extremely unequal also according to the kind of disaster the regions have to face.

Inequalities in vulnerability to disasters are strictly correlated with other social vulnerabilities (Ikeda, 1995). For the European case, the maps of regional vulnerability to the several natural hazards are often overlapping with Figure 1.1, they present a greater vulnerability in Southern and Eastern regions (European Environment Agency, 2017). This correlation, extended also to developing countries, induced the concept of “territorial trap” (Bebbington et al, 2016). A territory, a region, is in “trap” when the inequalities in terms of poverty, vulnerability and opportunities are so high respect to the leading territories of their nations or continents that the possibilities of catching up are almost null. These territories present, all over the world, common traits of low education, depopulation, scarce urbanisation and higher proportion

¹For the records, the Figure 1.1 is the “Map of photovoltaic potential across Europe” (Espon, 2010), just the quantity of sunbeams every region is exposed to, a classic spurious correlation

of workers in the primary sector. Similar trends are not only related to poor countries, territorial inequalities are an increasing issue in the Global North too, as it is testified in the Italian Strategy for Inner Areas (Punziano and Urso, 2016). Territorial inequalities are not only dangerous from a justice perspective, as Amartya Sen argues (1990), but also in a general economic and political perspective, where the territories left behind can threaten the well-being of the other territories, through voting patterns (Rodríguez-Pose, 2018).

But, how to give more importance to the places left behind? "Societies measure what they care about." (Kušar and Černe, 2010, p 9). One solution, in addition to all the policy recommendation that this thesis will supply, is to update a critical background about regional development indicators. Posing always the attention on how much these territories are "underperforming" can bring a great sense of frustration and this should be avoided. Concluding, the importance of regional science in a moment of crisis of national state and economic theory is crucial. Reshaping our concept of territorial development through regions in theory and practice is something should be not underestimated. The study of natural disasters, in a regional science perspective, can help new theoretical approaches, indicators and measures about what do we mean an economic development is and to direct it towards the needs of the citizens.

1.4 Why L'Aquila?

The case studies of this thesis are more than one and all of them fit with the concept of territory left behind exposed in the previous section. Chapter 2 exposes the case of five regions in three countries, hit by three earthquakes: Manabì and Esmeraldas in Ecuador, Maule and Bio Bio in Chile and Abruzzo in Italy. Coming from different national scenarios, all the regions present similar traits of underdevelopment, scarce urbanisation (with the exception of Concepción in Chile) and lags respect to their national leading regions. A condition similar to many other earthquake vulnerable regions all over the world. This thesis has a main case study and it is the city of L'Aquila, the capital of Abruzzo in Italy. The city can be depicted as a summary of all the issues described in the previous sections and its detailed study can answer to many research question. Most of the data and analysis about L'Aquila are reported in the chapters, in this section is presented a brief overview about why the city is important for this thesis.

L'Aquila is a typical medium-size medieval Italian city. Founded in 1265 by the agglomeration of 99 villages and it is now the 70,000 inhabitants capital of its region, the Abruzzo. The city has been destroyed three times by earthquakes: in 1461, in 1703 and in 2009. As for many old cities, in L'Aquila history is not *magistra vitae* and, despite new Italian laws in 1981 and 2005 about seismic risk and building code, the biggest earthquake shake arrived at 3:32 am the 6th of April, finding an unprepared city, that completely collapsed. L'Aquila is a peculiar case for many disasters, especially in the peripheral Global North. Capital of a declining region before the earthquake, in the immediate post disaster it was the centre of a great national and global attention, like hosting the G8 Summit in 2009 (Alexander, 2010). The role of the state was massive in the emergency management and in the subsequent reconstruction, becoming the only city in Italy where real income per capita increased instead of decreasing in the decade 2008-2018. The contemporaneity with the great economic crises of 2008 and 2011 made L'Aquila a laboratory of disasters in time of crisis, where the narrations of a wonderful pre-disaster golden age and the hope for a future of renaissance were, and still are, both vivid. L'Aquila is also a political paradigm of many European peripheral regions. In L'Aquila, land, housing and work are the pillars of the post-disaster.

In the immediate before earthquake, L'Aquila was a small city with a decline in native population, an increasing in foreign migrants and a constant ageing of its inhabitants. The economy was mostly driven by the public administration, by the university (25.000 students in 2008, the highest ratio students/inhabitants after Pisa) and by few industrial sites in high-tech and pharmaceutical, in decline after the closure of many factories. Most of L'Aquila economic indicators were below the Italian average but above the Southern regions average. Tourism and student housing rents were the increasing activities generating income for local households. The city was living a great sprawling process started in the 1970s and accelerated with the displacement of many university departments in the outskirts, reducing the city centre population by a half (of whom half were students) in twenty years (Di Pietro and Mora, 2015). The 2009 earthquake changed everything, but it accelerated all the phenomena above. In peripheral Italy the role of the State is crucial for territorial development, large firms were pushed to locate there and the government was subsidising them, the subsidy for farmers were saving thousands of people and keeping low the food cost, the public administration created thousands of jobs in areas where free entrepreneurship was far from develop. In case of natural disasters, Italians strongly rely on the

State. There is a strong and diffuse acknowledgement for the State, in all of its level, of being the first actor in the post-disaster, in all of its aspect, from the emergency to the reconstruction to the economic development. It is like for Italy natural disaster are somehow a State “fault”. The aspect is not secondary because, differently from other cases where reconstructions are State-led, Italy is a country where house ownership is extremely high at national level (73%) and more in peripheral areas (more than 80%). The Italian productive system is also very diffuse in ownership, Italy is the country of micro and small firms, in 2009 like today, especially in peripheral regions. In 2009 like today, more than 90% of Italian firms have less than ten employers and half of Italian workers are employed in such firms. With such very granular and spread land ownership and enterprise systems the gravity pending on the State is peculiar (Contreras et al., 2015; Istat, 2019).

The earthquake of L'Aquila is sadly famous for the enormous amount of public scandals for the private and public manager involved in its emergency and reconstruction process, starting from the Civil Protection secretary laughing during the earthquake (imagining a wonderful future of profitable reconstruction) to all the cases of bribes and corruption involving the deviation of public money to one entrepreneur or another one. All of these while the displaced population was living in the emergency shelters and camps, militarised and managed with an explicit “command-and-control” method (Alexander, 2010). With the earthquake, and the controversial management of the emergency, L'Aquila became a great laboratory for progressive and social movements: the movement of the “wheelbarrows”, started in 2010 to free the city centre from rubble (and the military closure) triggered a sort of social renaissance in town, culminated with the victory in the court of justice for the “CaseMatte” trial (a social space born into the ruins of the former hospital) and the opening of the “Eco-village” in Pescomaggiore, these laboratories became examples for other post-disaster cases, as the Emidio di Treviri project for the Central Italy earthquake in 2016 (Forino, 2015; Emidio di Treviri, 2018). After this boom of the social movements, with the slow process of reconstruction public financed going on, the city started to turn more on the right wing, especially with the municipal elections in 2017, when for the first time the L'Aquila people elected a mayor explicitly neo-fascist. This turn to the far-right, common to many peripheral places in Europe it is interesting to investigate, although it is not strictly relevant for this thesis. As a synthesis of everything written above, L'Aquila is crucial to understand the importance of land, housing and work in the post-disaster, even considering its being part of a rich country.

Land, in its meaning of vulnerability, is a crucial topic since the days before the earthquake. L'Aquila was hit by a small earthquake swarm in the days preceding the 6th of April an expertise in an interview dated 25th of March, warned about the danger of a big earthquake in L'Aquila coming soon. Most of the authorities tries to silence him and to accuse him for procured alarm. Because of this fact, the people of L'Aquila tried to be as much aware as possible of the hazards coming from the land below their feet. So the risk perception related to land vulnerability is a pillar of the post-disaster in L'Aquila (Clemente et al., 2015). Housing is the pillar of L'Aquila post-disaster, a large majority of public financing was destined to private housing reconstruction, in a city where land ownership is above 85% of households. The housing constituted the main narrative of both the Berlusconi government (the narration of the "New Towns" and the CASE project) and the further Special Office for the Reconstruction (USRA), housing reconstruction was completely tracked on public websites (as opendataricostruzione.gssi.it) and it was the main topic in most of the newspaper articles about the reconstruction (Modica et al., 2019). As mentioned before, this is caused also by the large economic dependency of L'Aquila householders for the incoming rent due to the students housing. Work is the last and less highlighted pillar of the reconstruction. L'Aquila has been in the last decades always on the threshold of being an industrial city, situated in a strategical position between the two seas and the proximity to Rome, the cool climate is also peculiar for many sectors needing refrigeration for their production, as the high-tech. More important, the creation of jobs is one of the crucial way to understand the public involvement of the State in many peripheral areas and Italy is a relevant case to assess it. The Constitution itself depict the route to follow to judge the State involvement, as a unique case in the world, Italian Constitution starts in its first article saying: "Italy is a Republic founded on work" (Di Pietro and Mora, 2015).

1.5 Methodological assumptions in this Dissertation

The scope of this chapter is to introduce the empirical and intellectual framework of this thesis, settled around the centrality of households issues in the post-disaster. Each of three core chapters answer with its own empirical instruments to the research questions related to work, housing and land and it is not easy to draw a common methodological framework. In this brief

section are highlighted the preliminary reasons of the proper methodological assessment present in each chapter and presented in the previous section, delegating to them the proper methodological literature reviews.

However, it is possible to define some common trends between each proper chapter methodologies that underline the differences between this thesis and other similar works. These common traits can be seen as the empirical synthesis of the intellectual and theoretical assumptions depicted in this chapter. First of all, the thesis focuses on households: they are the most vulnerable economic agent after a natural disaster. Studying households implies to put the second main economic agent (firms) on the background. This thesis considers the overall productive system as ancillary and at the service of households needs, both in terms of jobs and goods supplier. The second focus and assumption is about territories: in this thesis the right to live in a disaster prone area is considered as given and not questionable. The issues of depopulation and relocation of workers are then considered as a negative outcome. The third assumption is related to the role of the third economic agent (Government) as a necessary and possibly good *deus ex machina* interfering in the economic affairs.

The empirical synthesis of these assumptions brought to a variety of econometric instruments with three common traits: the microfoundation of analysis, the evaluation of public policies and the reverse time-space analysis. The microfoundation of analysis bring to the common effort of having an econometric analysis set as much as possible on microdata at households level (as it is in Chapter 2 and 4) and, where it is not possible to use the smallest unit of observation available (neighbourhoods, as in Chapter 3). The theoretical support is given by original microeconomic models, based on households behavioural theories (in Chapter 3 and 4). The policy evaluation side is the most evident in all the thesis, natural disasters are mainly seen as a double effect of "natural" destruction (or scarce prevention) and public driven reconstruction. The judgemental evaluation of short, mid and long term public policies is the main common traits for all the chapters. The here called reverse time-space analysis is the assumption about the difficulty of analysing large territorial units for long time lapse and having not biased results. Having as object of analysis large strata of different population, spread all over the world for decades is an excessive exposure to the risk of non validity. For this reason, most of the worldwide large scale researches use aggregate data at regional level for cross country comparisons. In this thesis, the largest dataset

is analysed in a very short temporal term (Chapter 2: three countries analysed in one year) and the smallest datasets from a territorial point of view are then analysed from a larger time lapse (Chapter 3: 1000 small municipalities for 16 years; Chapter 4: 20,000 buildings in the same municipality studied over 8 years).

In this new section is summarised the multidimensional aspects of micro-data in use and how the double strains from a unidimensional dataset in a large geographical dimension (chapter 2) to a multidimensional dataset in a very small geographical dimension (chapter 4) can bring the largest opportunity to understand households dynamics. This section is not exhaustive to determine a common theoretical framework for all the thesis, because each following chapter needs its own specific methodology, but it prepares better to understand the following theoretical models and the final suggestions in the concluding chapter. Especially considering the policy recommendation for a better focus on wages and housing prices as main parameters for regional development after a disaster.

1.6 A brief review of papers in this Dissertation

This introductory chapter of the dissertation opens several questions: what are the effects of an earthquake on households behaviours? What can be learned from other countries experiences? Can there be a common understanding of seismic vulnerability? What are the practical implication of the state driven reconstruction in the short and long run? Is it suitable to study these effects on the sub-national level? The following chapters give answer to these questions. The thesis is organised in three chapters, written in form of academic papers, plus the introduction and the conclusion chapters. The focus is decreasing in geographical terms (from a global to a local perspective) and increasing in time length (from the short to the long run).

The first paper (Chapter 2) is a comparison between Ecuador, Chile and Italy regarding the regional post-earthquake labour market. The three short-term workforce surveys are compared, finding the different pre-shock determinants of having a job, an increase in wages or in working hours after the earthquake. Salary distributions are also compared in kernel quantiles, including which segments of the population are losing or gaining their purchasing power after the disaster. Natural disasters can generate ambiguous economic effects in the short and long run (Skidmore and Toya, 2002); probably the economic effects

depend of the country or region in which the natural disaster occur. Despite that countries are heterogeneous economically, culturally and institutionally, then it will make possible to have a broad vision of the local labor market transformations using three countries as a case study: Ecuador, Chile and Italy.

Earthquakes often destroy local productive infrastructure of the affected areas, causing severe damage to dwellings and public infrastructure as schools, hospitals, buildings, machinery, equipment, roads, electric transmission, etc. (Comité para Reconstrucción y Reactivación Productiva, 2016). Therefore, it is reasonable to think that the dynamics of the labor markets of the seismic zones will be affected; short run adjustments or transformations will occur, like increases in unemployment (Xiao and Feser, 2013), or the variation in the job seekers (Ohtake et al., 2012), or a mismatch between job offer and demand (Higuchi et al., 2012; Ohtake et al., 2012). The earthquakes could also cause structural changes in a medium or long run (Belasen and Polachek 2008, Mehregan et al., 2012). Some economic sectors linked to the reconstruction, will experience a boom during the reconstruction period (Chang and Rose, 2012); new industries born and replace the inefficient destroyed (Ohtake et al., 2012, and Xiao and Nilawar, 2013). In order to develop local labor markets transformations in the aftermath of the earthquakes, the paper uses individual labor surveys for each country, focusing in local labor markets short run transformation in three ways: 1) employment, 2) wage, and 3) worked hours. The aim is to unravel whether the individuals located in most seismic regions in each country had a positive or negative likelihood variation of been employed or increase their wages or increase their worked hours, making a cross-country comparison. The empirical strategy is a descriptive analysis for compare the post disaster dynamic of the local labor markets of the three countries, first presenting some descriptive statistics for labor markets of these countries and then estimating logit regressions for the three mentioned dimensions. For comparison between countries, we choose as affected areas: the provinces of Manabí and Esmeraldas for Ecuador, the region of Maule and Bío-Bío for Chile, the Abruzzo region for Italy.

The second paper (Chapter 3) explores the impact on housing prices of the double shock caused by the 2009 L'Aquila earthquake in Italy and the subsequent reconstruction process financed with public funds. The research adopts a difference in difference approach, using as controls for rural municipalities

a Mahalanobis Distance Matching and a border control and a synthetic parametric control for the city of L'Aquila. Housing is one of the most important issues to deal with after an earthquake (Beron et al., 1997). As for other types of disasters, in an earthquake the prevention is essential and the housing demand in a seismic area is strongly driven by safety and risk characteristics (Votsis and Perrels, 2016). A common approach is to assess the determinants of the housing price mainly in term of private insurance, where the occurrence of a harmful natural event can just change the risk perception and push downward the land values (Naoi et al. 2009). But there are circumstances where the effect of such events is not only restricted to the private market, the whole social and economic environment changes, sometimes forever, and these phenomena are defined as disasters (Alexander, 2000).

In case of a disaster, a strong State and community commitment is common, sometimes this is bound to the mere emergency stage, sometimes it goes beyond, helping to rebuild the infrastructure and taking care even of the many aspects of the post-disaster issues in the long run. Also in the case of housing, there are different post-earthquake strategies of intervention around the world. The majority of policies focuses on the housing demand side, hence they do not prevent prices from decreasing. This paper builds a theoretical framework where the collapse of house prices after a disaster are motivated by this oversupply. Private households cannot afford the reconstruction costs and so they are forced to sell their house to find a cheaper accommodation, or even leave the affected area. A policy directed at the small private supply side can prevent this. The empirical part of the paper looks at the changes in the characteristics of the housing market in the case of L'Aquila, Italy, which was severely hit by an earthquake in April 2009. Together the horrible death toll, the capital loss was enormous and remarkable, mainly in terms of housing (Alexander, 2010). After the earthquake, there was a significant flow of public money invested in the reconstruction process. Six billion euros were spent just for financing private buildings (OECD, 2012). The combination of these two external shocks, namely the earthquake and the reconstruction subsidies, are supposed to produce counterbalancing phenomena, where the possible negative impact from the earthquake is absorbed by the reconstruction policy. The methodology to estimate this possible displacement effect is a difference-in-difference model, where the area affected by the public reconstruction funds (157 municipalities) is matched to a group of municipalities with similar characteristics before the earthquake (identified with the Mahalanobis distance matching algorithm) and with the 83 municipalities outside the policy affected

area.

The third paper (Chapter 4) focuses on the local implication of risk perception on housing prices. Using only the municipality of L'Aquila as a case study, every single post-disaster housing transaction is analysed in a hedonic model. Each housing price is then broken down according to its vulnerability to the land, seismic damage and reconstruction funds. One of the pillars of the prevention from earthquake disasters is the Seismic Hazard (and risk) Assessment, the exhaustive study of the global and local determinants of a seismic events, both in terms of probability and magnitude of a possible earthquake in a particular area and in terms of direct effects on the inhabited lands affected by the seismic waves (Panza et al., 2011). There are not univocal methodologies to assess the seismic risk for an area, the most used one today is the Probabilistic Seismic Hazard Assessment, based on the probability a determinate seismic event occur with a 10% of probability in a time span of 50 years, following the assumption of 475 years seismic cycles (Nekrasova et al., 2013). This static assumption failed many times to predict an earthquake and it revealed itself as dangerous also in earthquake prone areas (Zuccolo et al., 2010). The Neo Deterministic Seismic Hazard Assessment (Panza, 2001) starts from the assumption of the PSHA but implements a more prudential approach, based on the Maximum Credible Earthquake and suggesting to update the hazard maps in a more risk-adverse methodology (Magrin et al., 2017), where the occurrence of an earthquake is taken as given. A derivative aspects of the Hazard Assessment is their effect on building safety (Clemente et al., 2015), where a too generous PSHA approach would induce builders to reduce their prevention expenses because an upcoming massive earthquake can be distant in time, while there are no empirical evidences of this cycles. This uncertainty about risk models and their effects on buildings in earthquake prone areas can lead to an ambiguous effect on the risk perception of the citizens living those areas, especially in already affected territories (Deng et al., 2015).

The most used method to understand these changes in behaviours is to use the housing price as a proper "thermometer" (Kaklauskas et al., 2015) for populations fears. Households may prefer to abandon areas they consider as too risky, reducing their housing prices as well for limited neighbourhoods as for entire cities (Önder et al., 2005; Timar et al., 2018). A commonly accepted methodology is the hedonic approach (Rosen, 1974; Zabel, 2015) with its price model that considers the final price as a linear vector of several variables, which may be correlated with characteristics related to earthquake risk

(Brookshire et al., 1985; Beron, 1997; Naoi et al., 2009).

Chapter 5 concludes the thesis, it summarises the results and indicates the possible new line of research, following three paradigms: a better preventive modelling for disaster prone areas, a more efficient post-disaster evaluation framework and a new method to understand regional development.

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2 Work.

Regional labour markets after an earthquake. Short-term emergency reactions in a cross-country perspective. Cases from Ecuador, Chile, Italy

ABSTRACT

Natural disasters can generate different economic effects in the short run in local economies. Our goal is to reveal how natural disasters reshaped local labor markets in three countries that faced massive earthquakes in the past decade: Italy, Chile and Ecuador. These three countries present a mix of heterogeneity and homogeneity in observable characteristics of the individuals, socio-economic structure of the affected areas, institutional factors and macroeconomic characteristics, as well as the actions and budget allocated by the different governments for reconstruction and recovery in the affected areas. The socio-natural disasters considered in this study were the 2009 L'Aquila earthquake in Italy, the 2010 Concepción earthquake-tsunami in Chile, and the 2016 Ecuadorian earthquake in the coast of Manabí. Using three short-run labor surveys and different regressions models, we found for Ecuador a positive variation in the likelihood of being employed and the likelihood of wage increase if the individuals were located in most seismic areas; while for Chile and Italy wages did not increase significantly for workers that were located in stricken areas. Additionally, we make a quantile comparison of wage differences before and after each earthquake, and found different distributional variations in each country. Our results suggest that spatial and socio-economic heterogeneity plays an important role in the short run labor market reaction.

2.1 Introduction

Humans live in contact with potential harmful natural phenomena since the beginning of history (Pelling, 2003), but events such an earthquake rarely release their force over urban settlements so strongly that end up reshaping their social order in what we call a disaster. Etymology suggests the term indicates a moment “against the star” (dis-aster, from latin), or against the constituted order. We can firmly assess that “a natural disaster is not a natural event” (Hallegatte, 2014, p. 9), because nature forces can be followed and even the strongest event can cause very few casualties. Moreover, in many cases that qualify as a disaster, the hardest time was the medium term after the tragedy, when institutions were are not always able to rearrange a new harmonic situation and many conflicts arise (Alexander, 2000). For these reasons, many scholars consider as more appropriate to define such disasters as “socio-natural” (Arteaga and Ugarte, 2015). The threshold defining when a

phenomenon becomes a disaster is completely related to human perspective. From an economic point of view, “a natural disaster can be defined as a natural event that causes a perturbation to the functioning of the economic system, with a significant negative impact on assets, production factors, output, employment, or consumption” (Hallegatte 2014, p. 9). When an earthquake or any other natural disaster occurs, there are two different kind of costs a region should support: direct and indirect. The direct costs are the ones showing an effect on the physical environment and the housing market in the affected areas; indirect costs are the ones that slow the productive system and the purchasing power, generating negative spillover effects. One of the most relevant markets influenced by indirect costs is the labor market (Meyer et al. 2013).

Natural disasters can generate ambiguous economic effects in the short and long run (Skidmore and Toya 2002); specific economic effects will depend of the country or region in which the natural disaster occurs. We know that many countries are heterogeneous (economically, culturally and institutionally), to have a broader vision of local labor markets we explore the short-term changes in three countries in this study: Ecuador, Chile and Italy. Earthquakes often destroy local productive infrastructure in the affected areas, as well as causing severe damage to dwellings, private and public infrastructure, e.g.: schools, hospitals, buildings, machinery, equipment, roads, electric transmission lines, among others (Comité para Reconstrucción y Reactivación Productiva, 2016). Therefore, it is reasonable to think that the dynamics of the labor markets of the seismic zones will be affected; short run adjustments or transformations will occur, like increases in unemployment (Xiao and Feser, 2014), how job seekers change their behavior (Ohtake et al., 2012), or a mismatch between job offer and demand (Higuchi et al., 2012; Ohtake et al., 2012). The earthquakes could also cause structural changes in a medium or long run (Belasen and Polachek 2008, Mehregan et al., 2012). Some economic sectors linked to the reconstruction, will experience a boom during the reconstruction period (Chang and Rose, 2012); new industries could be born and replace inefficient infrastructure (Ohtake et al., 2012, and Xiao and Nilawar, 2013).

Although the literature has already empirically determined some effects on labor markets from natural disasters, a large proportion of studies have focused on high income countries (Horwich 2000; Belasen and Polachek 2008; Di Pietro and Mora 2015), and few studies focused on how workers in developing and middle income countries cope with disasters (Mueller and Quisumbing 2009;

Rodríguez-Oreggia 2013; Gagnon 2013; Karnani 2016). To obtain a broader perspective of the post-disaster labor market adjustment, we develop a comparative analysis between three heterogeneous countries (Italy, Chile and Ecuador) in order to understand and systematize the main differences and similarities, as well as to assess whether the starting point or socio-economic characteristics are determining factors in any new dynamics. In order to unravel how local labor markets change in the aftermath of an earthquake, we use individual labor surveys for each country, focusing in three specific ways local labor markets adapted to new scenarios: 1) employment, 2) wage, and 3) worked hours. Our research question is to find out whether individuals located within the most seismic regions in each country had a positive or negative likelihood of being employed, increase their wages or increase their worked hours. Finally, one of the main focus of this paper is about gender issues after a natural disaster. A wide stream of recent literature underlines how the immediate post-disaster is often a moment where the, already high, gender gap in wages and work participation gets higher (Bradshaw, 2004; Dagsvik et al., 2013; Kirchberger, 2017). It is very important to not ignore this effect on labour market.

Our empirical strategy first performs a descriptive analysis to compare the post disaster dynamics of local labor markets in each country. First we present descriptive statistics to compare employment and wage structures, then we estimate logit regressions in each one of the three dimensions. To compare countries appropriately, we choose specific regions as areas affected by the corresponding earthquakes: i) the provinces of Manabí and Esmeraldas for Ecuador, ii) the region of Maule and Biobío for Chile, and iii) the Abruzzo region for Italy. We find significant associations between the earthquakes and labor market dynamics in the short term, for Ecuador there are positive (significant) variations in the likelihood of been employed and to have wage increases if individuals were located in the affected provinces; while for Chile and Italy the likelihood variation was negative (significant) if the workers are in highly seismic areas. Distributional differences show that the earthquakes probably had heterogeneous effects on wages (depending on the labor income quantile).

Our manuscript is divided in six sections, the next section introduce the relevant literature of regional labor markets after a disaster, section 3 describes our empirical cross-country comparison methodology, section 4 presents information of the three case studies and the dataset that we used in our

analysis, section 5 shows the results, and section 6 a discusses and concludes.

2.2 Regional labour markets after a socio-natural disaster

Skidmore and Toya (2002) use cross country data to show how ambiguous the economic effect of disasters could be, they find that geological disasters are negatively correlated with growth, but climatic disasters positively correlated with increases in total factor productivity, economic growth and human capital accumulation. The positive correlation is associated with "creative destruction" (Schumpeter, 1942); as pointed out by Ohtake et al. (2012) and Xiao and Nilawar (2013), it causes the birth of new industries by freeing resources, replacing less efficient infrastructure, and increasing productivity due to technological improvements. However, Crespo Cuaresma et al. (2008) indicates that in developing countries it is difficult to introduce and disseminate new technologies so that "creative destruction" would not fulfill its role.

Another important insight in this literature is the idea of economic resilience of scale (Xiao and Nilawar, 2013), which states that -in aggregate- an economy can be resilient since the destructive effect of a disaster disappears as you move away from its core, i.e., when the spatial unit of analysis is smaller, the negative effects of a disaster are perceived less, and the opposite happens when the affected area is larger. In the article by Ohtake et al. (2012), it is mentioned that some studies have determined that a large-scale disaster in the short run will produce a negative economic impact (Loayza et al., 2009, Raddatz, 2007; Noy 2009); a smaller scale natural disaster would have a positive economic impact given that the losses are less than the effects of reconstruction (Loayza, et al. 2009).

Many relevant findings of disaster literature focused in high income countries, Ewing, et al. (2005), evaluate changes in the labor market as a result of Hurricane Bret (1999) and recovery activity, in the city of Corpus Christi (Texas) using time series analysis, they found that the unemployment rate in the long run is reduced. Xiao and Drucker (2013), Xiao (2011), and Xiao and Feser (2014), studied the effects of the 1993 Midwest flood (USA), through time series econometrics and impact evaluation techniques, they found: i) on average the counties with greater economic diversity experienced a rapid

growth in employment, so economic diversity had an effect on resilience¹ ii) a negative effect on personal income in the short run; iii) in the short run and for the most affected counties, unemployment rates increased with the flood, over time this effect tended to disappear; iv) the effects of the flood seem to be long lasting for the agricultural sector only; v) apparently, local economies in aggregate seem to be resilient to natural disasters, being able to absorb the shock caused by the flood. Ohtake et al. (2012), study the effect on the Japanese labor market of the Great Hanshin-Awaji earthquake (1995) using time series econometrics. They found, in the short run, that the number of job placements was reduced for part-time workers, possibly due to a shortage of job offers (vacancies increase and job seekers decrease); for full-time workers, they found that growth in the number of job placements decreased abruptly, possibly due to a mismatch between labor supply and demand.

As mentioned before, Xiao and Drucker (2013) linked economic diversity with resilience, and explain this relation because: i) the industry represents only a portion of the economy therefore the risk is distributed and the effects of shocks in an industry are less extensive, this is the portfolio effect (Frenken et al., 2007; Malizia and Ke, 1993); ii) improves the matching between workers and employees, reduces labor search costs, and also increases productive efficiency (Duranton and Puga, 2004, Mion and Naticchioni, 2009); and iii) it facilitates the inter-industrial transfer of ideas and knowledge (Audretsch, 2003, Jacobs, 1969).

Several studies have focused on understanding what happens in the post-disaster labor market from a sectoral perspective. Belasen and Polachek (2008), find changes in the sectoral composition of employment and income in the counties of Florida affected by 19 hurricanes (1988-2005). A positive impact was found in construction and services; while a negative one in: manufacturing, commerce, transportation and utilities, and finance, investment and real estate. Ghafory-Ashtiany and Hosseini (2008) study the composition of the labor market in Bam (Iran) after the 2003 earthquake through a shift-share analysis. They found that agriculture lost participation in employment, while manufacturing, mining and services gained employment. Construction employment grew more than the regional and provincial average. Mueller and Quisumbing (2009) carry out a study of the effects on the labor market caused by the 1998 flood in Bangladesh, they find that non-agricultural labor markets

¹Understood as resistance and recovery. Diversity (measured in employment) helps the affected counties to return to their path of growth and employment in the long run.

are more affected in the long run (reduction of wages) possibly because they depend on the recovery of other markets, while on the other hand, agricultural labor markets had a negative effect in the short term. Sectoral changes seem to happen frequently after a disaster, at least in the short run, some economic sectors might be winners while others might be losers (Xiao and Nilawar, 2013).

A period of reconstruction, comes after a natural disaster. Chang and Rose (2012) review the literature that includes both empirical studies and formal models. Among the main findings cited by the authors are: i) a significant stimulus in the short run as a result of the reconstruction (Dacy and Kunreuther 1969, Chang 2010). Thus, sectors related to reconstruction showed significant gains (Chang and Rose, 2012); ii) during the recovery period, it has been shown that pre-disaster economic trends / performance (growth or economic decline) are usually accentuated (Chang 2000, Dahlhamer 1998, Alesch et al 2009, Chang 2010); iii) the more severe the disaster is, the more it can cause structural changes in the affected local economies in the long run: sectoral composition, competitiveness and business types (Alesch et al., 2009, Lam et al., 2009, Chang 2010). Ohtake et al. (2012), indicate that after the reconstruction period, the number of vacancies, job searches and jobs placements would be lower than pre-earthquake² levels if there were initial spillover effects.

In the end, a constant aspect worldwide studied about labour markets after a disaster is the gender inequality. Many United Nation reports started to underline the importance of this issue in the early 2000s (Bradshaw, 2004): in the post-disaster, women are more prone than man to lose their job or to have a decrease in their wages. This not desirable effect can occur in any kind of economic crises (Hallward-Driemer et al., 2017) but in case of natural disaster it is even more hateful, because of the public managed reconstruction process that should be aware of these gender issues. Women can lose their job because of a general market response (Kirchberger, 2017) but also because, in case of crises, households dynamics can lead women to be less encouraged to participate in labour market (Dagsvik et al., 2013). Men can sometimes ask (or command) to their wives to stay at home and to not look for a job, because that is mens primary role. These phenomena are not only driven by pure market reactions, Lewis (1992) gives some insights about how welfare regimes

²There will be a mismatch if job seekers are not willing to work in the construction sector, which limits the growth of job placements (in the reconstruction period, job vacancies increase).

can help or not women in work participation. Scope of this paper is, also, to determine how the institutional framework responding to earthquakes can change the gender gaps. Being aware that, especially in the first year after a disaster, households have to find their own way to restart their lives and the best way to get out from the "infantilisation trap" (Castorina and Pitzalis, 2019) of the earthquake victims is through labour.

2.3 Dataset and Methodology

It is important to reintroduce a debate often underestimated in literature: the correctness or not for a case comparison study. The question in the economic field is not obvious. John Stuart Mills started it in 1843 illustrating for social sciences the method of agreement (regression) vs method of differences (Ragin 1987). But, while Alford 1963 suggests the "most similar nation", Maurice 1989 warn about a too much fund comparison of "like with like". The need for comparison emerges when the two opposite of literature tendencies such as Universalism (there is no need for comparison because there is one best case) or the Culturalism (there is no need for comparison because every place is explained and justified in itself) are not sufficient. The in between stream of literature approves the concept of comparison (Maurice, 1989). In the end, Grootings (1986) talks about not only National scale, while Hantais (1990) suggests, before any comparison, a clear overview of any relevant context should be made. The discussion about why to adopt cross-country comparison almost ended in the 1990s, with little exceptions (George 2018). After that, the number of cross-country academic papers increased, focusing more on how do it better, trying to find cases comparable and with similar data or methods of evaluation (Maddison, 2005; Jilke et al. 2014). Because of the relative new field of study, without a clear benchmark or structured ideological currents, the post-disaster studies are strongly relying on cross-country comparisons.

To compare similar cases, it is very important to compare coherent and similarly taken data and to process them with the same methodology (Smith, 2001; Maddison, 2005). The identification of the three cases is not trivial. Jowell (1998) and Maddison (2005) introduce some schemes about the selection of case studies in cross country comparison for social sciences: The cases should present a right mix of similarities and differences, their number should be not too large but possibly more than two, in order to be able to describe them in depth and to prevent possible syncrasies, finally, the authors should not be

completely alien from their context. The three selected cases are Ecuador, Chile and Italy, in order from the latest to the oldest disaster in analysis. The similarities identified in advance are: all three are earthquake vulnerable across the whole country (no feasible self-selection in earthquake-free areas); they have comparable size and population (the biggest one is no more than three times the smallest) and morphology, they had a similar independent State history (independence in 1800s, liberal and authoritarian regimes, democratic transitions and a slow ongoing process from a centralized to a decentralized State in the late decades), same majority religion, similar languages and legal system (civil law), relative currency stability. Their main differences are their geopolitical role, their gross and per capita GDP (Italy 2009: 2.391 trillion USD – 40,640 per capita. Chile 2010 172.4 billion – 10,243 per capita. Ecuador 2015 99.29 billion - 6,150 per capita, according to World Bank).

They also experienced very different macroeconomic trends before and after the disaster in study: Italy was at its peak, since the earthquake it lived a severe crisis, mainly due to the European financial turmoil in 2008-2011. In Chile the reverse was happening, since 2009 was the middle of a rapid, yet volatile growth cycle. Ecuador was at the end of a sustained growth period that was becoming more flat. Their economic models of growth are also different, the Chilean one is very neoliberal, while the Italian and Ecuadorian are more balanced, the Indexes of economic freedom show this: Chile (18th) Italy (80th) Ecuador 170th. Most of these differences are given by government spending ³ (UN-SNA, 2017). Ecuador and Italy present similar characteristics with respect to Chile when workers rights are the center of analysis. Starting from a fundamental rights point of view, the Chilean Constitution recognizes to the workers the fundamental rights given by the human nature and the “freedom of work and its protection” (art 5 and 19). While Ecuadorian Constitution is explicitly considering the work as a “right and a social duty” (art 33), deeply articulated in its right and the State intervention (art. 34, 37, 38, 39, 47, 66, 276, 284, 319-333). Italian Constitution is even more explicit, starting with a clear “Italy is a democratic Republic founded on Labor” (Art. 1), with a clear stand of workers rights, the right to work and the role of the State actively promoting these (art. 4, 35-40, 46). All three States have their own Worker Statute Law, comprehending contract norms, workers securities and unions rights.

³This is negatively counted in the Index, which is very low for Chile at 25% of GDP, higher and similar for Italy and Ecuador (respectively, 50% and 44% of each GDP).

Regarding the role of the State in case of disaster, the Constitutional framework is different: the Italian text ignores the issue, mentioning only in a note the possibility of exceed the national budget (art.81) and so, forwarding to lower rank laws any protection from disaster hazards. The Chilean Constitution explicitly introduces the state of catastrophe (art. 32, 40 , 41) where the Government can exceed its normal powers, also restricting workers freedom, but there is no mention of any risk management. The Ecuadorian Constitution is widely introducing the concept of risk reduction, people's right in case of disaster and state of exception (art. 35, 38, 46, 164, 261, 389, 397). In all three nations, the norms of any rank about risk reduction and disaster management are numerous and prone to change after each occurring disaster (especially in Italy) so it is not easy to predetermine precisely how each State could have reacted to such disastrous events presented hereafter.

Data set

For all countries, we will use short-term micro data. For the Ecuadorian case we used a data panel of December 2015 (pre-earthquake) - December 2016 (post-earthquake) of the National Survey of Employment, Unemployment and Underemployment (ENEMDU), developed by the Ecuadorian Institute of Statistic and Censuses (INEC), sampling is done through a rotating panel (2-2-2), so the dwellings surveyed in December 2015 coincide with those surveyed in December 2016 (INEC, 2017). For Chile we use the post-earthquake National Socioeconomic Characterization Survey (CASEN) which was an extension of a cross-sectional survey taken in 2009, repeated in 2010 for the affected regions (six regions in central Chile); and for Italy the "Rilevazione sulle Forze di Lavoro - Dati trasversali trimestrali" make by the Istituto Nazionale di Statistica that contains information for 2009 (post-earthquake) and 2008 (pre-earthquake), the data was collected for Abruzzo and its neighboring regions.

The warning by Schuster (1987) opens the possibility of biases in population data comparison, due to a different data collecting. In order to have a clear and significant comparison, the variables we use are only the ones collected in the same way. In addition, because of a mismatch for the populations surveyed, the comparable group of analysis are not whole nations, but only the affected regions for each country. So, there are between 1.3 and 3 millions of people in the most affected areas (with the presence of both seaside and mountains) and about 15 millions of people in the overall population for all. The country capital cities (Roma, Quito and Santiago) are included in the

analysis. The most affected regions (provincias) for Ecuador are Esmeraldas and Manabí, ENEMDU does not investigate Galápagos Islands, but it does include all the other provinces. In Chile the most affected regions are Biobío and Maule, the others are O'Higgins, Valparaiso, Metropolitana and Araucanía. In Italy, the Abruzzo region was the most affected while Umbria, Marche, Lazio and Molise comprise the rest of the sample. After the reshaping and cleaning, the number of observations in the dataset for Ecuador are 42,775, for Chile 58,293 and for Italy 19,695. Because of several mismatches in survey design and in the inter-temporal construction, the number of independent variables are restricted to the comparable ones, such as occupational status, post-disaster wage, post-disaster working hours, sex, age, education, household size, a dummy for self-employment, a dummy for the household head and the economic sector (in 5 classes: 1 Agriculture, forestry and fishing; 2 Construction; 3 Manufacturing, mining and electricity; 4 Wholesale and retail trade, hotels and restaurants, transport and storage; 5 Other activities as the omitted category). The peculiarities of the Italian dataset forced us to identify pre-earthquake panel variables for wages and working hours using a quasi-panel joining (Bruno and Stampini, 2007), where the Istat LFS 2008 was matched with the 2009 one. The one by one matching for the most similar household created pseudo-id corresponding to 9 similar characteristics (corresponding to the covariates for the logistic regression in section 5) and a mismatch of only 23 observations. The quasi-panel approach is used for the Italian data only and only for the wages and working hours variables. Results are cross-validated with an accuracy of more than 80%.

Methodology

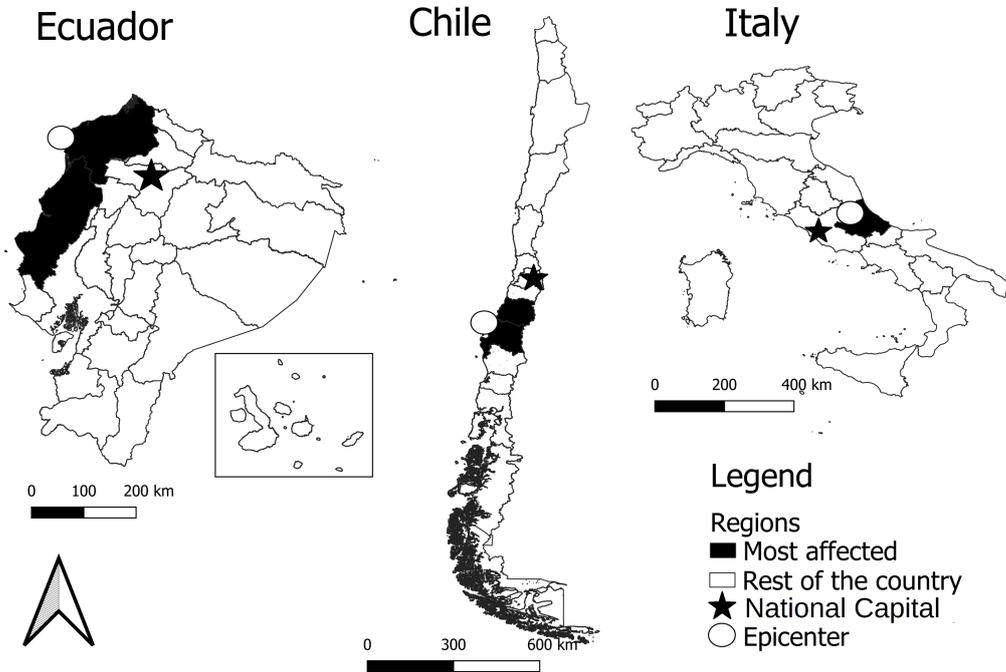
In order to compare the three countries, we consider the most affected seismic regions as a whole, since more disaggregate classifications are possible for Ecuador and Chile and identify affectation quantiles⁴, but this is not possible for the case of Italy. In Ecuador, we define the provinces of Manabí and Esmeraldas as highly seismic zones, because most of the counties that conform these provinces were stricken with high intensity during the April 2016 earthquake, and the government intervention was intended to focus to these territories. A similar situation occurred for the regions of Maule and Biobío in Chile which were the most affected in this country⁵ for Italy we define the Abruzzo region

⁴Cantons for Ecuador, and communes for Chile. This is equivalent to counties or districts in other countries and are the smallest geographical unit in these countries.

⁵Although significant impacts in poverty were found for the coastal areas of the O'Higgins region.

as the most affected area during the 2009 L'Aquila earthquake.

FIGURE 2.1: Regions affected for Ecuador, Chile and Italy



Once the affected regions were defined, we generate an affectation dummy variable using the labor surveys of each country, taking the value of 1 for individuals located in the most seismic regions, 0 otherwise. This allows us to determine the likelihood of show-run variations for workers that were employed, increased their salary or increased their worked ours in the aftermath of each earthquake. We estimate logistic regressions models for each country, to answer our research question:

$$Prob(z_i) = \frac{e^{\beta_i z_i}}{1 + e^{\beta_i z_i}} \quad (2.1)$$

Where z_i represents the vector of explanatory variables for each worker i .

We will use lagged variables (pre disaster period⁶) for the independent variables in order to minimize potential issues of endogeneity. We include explanatory variables typically seen in Mincerian equations (Mincer 1974) that are widely used in labor market literature. Our coefficients of interest are

⁶December 2015 for Ecuador, the year 2008 for Italy and for Chile the year 2009.

the ones associated to the dummy variables of affectation. The vector of the explanatory variables will be the following:

1. For the likelihood of being employed in the post-earthquake period⁷ (t): affectation dummy, sex dummy, wage in t-1⁸ (in current currency), employment status in t-1, working time in t-1 (in weekly hours), schooling in t-1, dummy variable if individual was householder in t-1, age in t-1, dummy variable if the individual was self-employed or employer in t-1, number of household members in t-1, five economic activity dummies for the pre-disaster job (Agriculture, forestry and fishing; Construction; Manufacturing, mining and electricity; Wholesale and retail trade, hotels and restaurants, transport and storage; and other activities), and age.
2. For the likelihood of having a wage increase after the earthquake: Same as above.
3. For the likelihood of increases working hours in t: Same as above.

2.4 Case studies: Ecuador, Chile and Italy

The Ecuadorian coast was shaken by an earthquake of 7.8 Mw on April 16, 2016 (20 km deep), its hypocenter was located off the coast of the canton Perdernalles (Province of Manabí). The provinces of Manabí and Esmeraldas were the most affected regions, both suffered the greatest infrastructure damages. The disaster left a total of 671 human lives lost, 113 individuals have been rescued alive, and in the three days after the earthquake almost 4,859 people have received aid (IG-EPN, 2018; Comité para Reconstrucción y Reactivación Productiva, 2016). According to the quarterly management report of the “Comité de Reconstrucción Productiva y Reactivación Productiva (mayo – agosto 2016)”, the areas most affected by the disaster correspond to vulnerable areas, both physically and socio-economically. The earthquake damaged the electrical distribution system (635 km of subtransmission lines, 22 substations, 9 destroyed agencies) and road connectivity; the municipal drinking water systems were affected, especially in the province of Manabí; a total of 146 educational establishments had serious affectation; 12 health centers, 6 general clinics and 3 general hospitals were unable to operate; 31.9% (of 44,813 dwellings) required rebuilding. The estimated lost flows of the production of goods and services in manufacturing were 92 million of dollars,

⁷December 2016 for Ecuador, the year 2009 for Italy and for Chile the year 2010.

⁸We refer to the pre-earthquake period as t-1.

in commerce 285.3 million, in tourism 19.5 million, in agriculture, livestock, aquaculture and fishing 102.1 million. In general, the estimated reconstruction costs reached the amount of 3,344 million of dollars: 1,369 million in the social sector, 862 million in the infrastructure sector, 1,032 million in the productive sector, and in others (81 million).

The national government promulgated actions and regulations for the recovery of the affected areas. By executive decree 1001 of April 17, 2016, a state of exception was declared for a period of 60 days in the provinces of Esmeraldas, Manabí, Santa Elena, Santo Domingo, Los Ríos and Guayas; the Ministry of Finance assigned the public funds necessary for the state of exception (Art. 1, Art. 3, Art. 4). On the other hand, by executive decree 1004 of April 26, 2016, the "Comité de Reconstrucción y Reactivación Productiva y del Empleo en las zonas afectadas por el terremoto del 16 de abril de 2016" was created, which had to execute the construction and reconstruction of infrastructure and implement plans, programs, actions and public policies to reactivate production and employment in the affected areas (Art. 1). This Committee will coordinate all the actors (national and international) for the structuring of plans, programs and projects, identifying and prioritizing them (Art. 3). The axes of action and intervention (Art. 5) were: "1. Emergency stage: includes immediate post-disaster assistance in rescue, health, food, shelters, debris removal and demolition of disabled buildings ... ". "2. Reconstruction: construction and reconstruction of public infrastructure, integral rehabilitation of public services, design, planning and construction of housing for victims ... ". "3. Productive reactivation: execution of plans, programs, policies and productive regulations, reactivation of local and national employment; and, financing for the affected areas ... ".

On May 20, 2016, the Ecuadorian government created: "Ley Orgánica de Solidaridad y de Corresponsabilidad Ciudadana para la Reconstrucción y Reactivación de las Zonas Afectadas por el Terremoto de 16 de abril de 2016". This Law stipulates solidarity contributions that are collected on remunerations, wealth, utilities, immovable property and representative rights of capital existing in Ecuador owned by companies resident in tax havens. The value added tax was temporarily increased by 2 percentage points⁹ from 12% to 14% throughout the country, except for the provinces of Manabí and Esmeraldas. Incentives were established for new productive investments in

⁹This increase was a solidarity contribution for seismic areas.

these two provinces; such as easier credit for productive investments, construction, housing, microcredit, education; exoneration of exit currency tax (impuesto a la salida de divisas, ISD) and duties for imports of capital goods (not produced in the country) that are destined to productive processes or to provide services; the payment dates of the obligations with Ecuadorian Social Security Institute (Instituto Ecuatoriano de Seguridad Social, IESS) and with the IESS Bank are postponed for a period of 60 days; etc. By May 30, 2018, 2,876 million dollars have been allocated, which were distributed as follows: 2,100.8 million for reconstruction, 412.6 for productive reactivation and 362.6 for emergency. In addition, the government delivered food kits, food vouchers, hospitality vouchers, and rental vouchers: in total 118,421 vouchers were delivered (Secretaría Técnica del Comité de Reconstrucción y Reactivación Productiva, 2017). As of April 14th, 2017, the Productive Reactivation Committee indicates that more than 44,000 direct and indirect jobs have been generated (80% of the hiring of workers responds to local unskilled labor). Finally, the Technical Secretariat of the Committee of Reconstruction and Productive Reactivation (2019), reported that until October 2018 Public Banking placed 689 million dollars in the provinces of Manabí and Esmeraldas (550 million USD in Manabí).

February 27th 2010: Chile earthquake

In the night of February 27th 2010, an earthquake of 8,8 Mw shook central part of Chile for four minutes long. The epicenter was located 12.5 km far from the closest coastline and 17 km from the town of Cobquecura, the magnitude and the distance induced a tsunami wave that hit the Chilean coast 35 minutes after the seismic shake. The event left 525 official losses, of whom 100 perished because of the tsunami, about 500,000 people were immediately displaced, and more than 200,000 buildings reported damages. The main earthquake was clearly felt in great part of the country and in some parts of Western Argentina, causing physical damages and human losses in six Chilean regions (Biobío, Maule, O'Higgins, Valparaiso, Metropolitana and Araucanía). Immediately after the earthquake, basic services such as water or electricity were shut off and many cases of looting were reported, inducing the authorities to order the first curfew since the end of the dictatorship regime in 1989, following a declaration of "state of catastrophe". The damaged area was vast and there were collapsed buildings and infrastructures in all the affected regions. But, while in the regions away from the epicenter most of the damages were due to a scattered single building vulnerability, the catastrophic outcome emerged

mainly in the two regions close to the epicenter: Biobío and Maule. The economic and demographic structure of Chile is heavily centralized in the region of its capital Santiago (the Region Metropolitana), where in 2009 the 40% of Chileans lived and the 48% of GDP was concentrated. Differently from other centralized countries, not all the peripheral regions in Chile are poorer than the capital. Unfortunately, the two regions most affected by the 2010 earthquake, Maule and Biobío were both poorer in terms of GDP than the national average, an economy mainly based on forestry, fishery, other agricultural activities and energy production. Biobío is a region richer than Maule (10% of national GDP compared to 3.8%, in 2009), thanks to an increasing manufacturing sector and the vibrant urban area of Concepción, the second largest after Santiago, with its one million inhabitants (Banco Central de Chile, 2011). The 2010 earthquake affected mainly highly dense areas and the two cities of Concepción (Biobío) and Constitución (Maule), where the signs of the earthquake are still persistent almost ten years later.

In April 16th 2010, the Presidency released a reconstruction plan where almost 30 billions of USD were estimated as the overall cost of the catastrophe. To boost reconstruction, the government engaged 8.4 billions of USD for the period 2010-2014, mainly spent for public infrastructures (Government of Chile, 2010). A remaining part was covered by 6.2 billions USD from private insurances, but most of these funds never arrived because of insolvency (Brain and Mora, 2014), the latter 50% of remaining costs have been not explicitly covered. No explicit post-disaster policies have been enacted for the jobs creation or local development. Moreover, while an implicit boost to occupation can be enacted by direct reconstruction funds, in Chile the social protection is externalized to the firms, protecting workers that were already less vulnerable (Dresdner and Sehnbruch, 2010). So, in 2010, only 16,634 workers got an unemployment subsidy.

2009 L'Aquila: Italy Earthquake

At 3:32 am on April 6th 2009, the city of L'Aquila (Italy) was hit by a 6.3 magnitude earthquake, the highest of a long seismic swarm in those days. 309 inhabitants died, 1600 were injured and about 100,000 were evacuated from L'Aquila and the surrounding municipalities during the following weeks. Differently from the South American earthquakes, European and especially Italian seismic events are characterized by a lower energy release but a highly devastation concentrated in a small area, because of the shorter fault lines, the complicated geology of these and the older construction techniques (Lam et

al. 1996; Viti 2019). The earthquake of L'Aquila, despite its smaller magnitude produced an enormous devastation in a relatively small area, even higher than the previous cases, tsunami excluded. Despite the high concentration of damages, some collapsed buildings were recorded in the regions of Umbria, Marche and Lazio as well.

The Abruzzo region, where L'Aquila is the capital, has always been one of the poorest and most vulnerable regions of Italy, both in terms of socio-economic and seismic vulnerability. Historically agricultural grounded, in the 20th century it developed a small but intensive IIT and manufacturing sectors in L'Aquila and Pescara, the biggest city of the region. The proximity to Rome made Abruzzo a cheap alternative to locate industrial facilities and, at the same time, the University of L'Aquila was a great boost for local development. Nevertheless, the economic decline and slow depopulation of Abruzzo inner areas was starting already in the 1990s, and the subsequent 2009 earthquake could have been a fatal hit if not properly managed. Besides the horrible death toll, the earthquake capital loss was enormous and remarkable: more than 22,000 private houses were damaged, 2000 firms suspended their business and the compute of the total cost from the earthquake is estimated at 11.2 billions of USD (10.7 bln euros). The 28th of April, the government approved the emergency law Decreto Abruzzo (L 77-2009) where, together with the first reconstruction norms, are described the no tax areas and social securities for the affected population, comprehending an unemployment subsidy for self-employed and employers. Followed in 2012 by a larger law for the overall reconstruction (L 83-2012) that brings the total public reconstruction expenditure at almost 13 billions of USD, more than the estimated cost. This huge amount of public funds would be used mainly for the private housing reconstruction subsidies but a relevant quota (530 mln USD) would go instead for local development projects.

TABLE 2.1: A summary for the three earthquakes

	ECUADOR	CHILE	ITALY
Date of peak shake	April 16 2016	February 26 2010	April 6 2009
Magnitude	7.8 Mmw	8.8 Mmw	6.3 Mmw
Mercalli Scale	VIII-IX	VIII-IX	IX-X
Victims	671 (+ 9 missing)	525 (+ 23 missing)	309
Tsunami	No	Yes	No
Displaced inhabitants	80000	500000	80000
Damage estimated at the moment	\$ 3.3 bln	\$ 30 bln	\$ 11.2 bln
Public expenditure (total)	\$ 2.9 bln	\$ 8.4 bln	\$ 12.7 bln
Public expenditure for local development	\$ 412 mln	–	\$ 530 mln
Unemployment rate change (national)	+ 0.4%	- 1.6%	+ 1.4%
Unemployment rate change (affected regions)	-2.0%	- 0.1%	+ 1.4%

2.5 Results

Labor income distributional differences

To have a first approach of labor income shifts, between pre and post disaster scenario, we perform a quantile comparison of labor income¹⁰ between two years, first for affected areas and then for unaffected areas of each country, using a Harrell and Davis (1982) quantile estimator for robust tests for two independent groups. Scope of these tables is to understand the changes in income inequality the post-earthquake labour market presents in a more descriptive way. According with Mair and Wilcox (2019) we reject the null hypothesis (no quantile difference) if $p\text{-value} < p\text{-critic}$. In the Ecuadorian case, only for the first wage quintile there was a positive and significative difference on labor income for the affected areas in 2016, but for unaffected areas there was a negative difference in 2016 for the first and second quintile.

¹⁰We only took wages > 0 .

TABLE 2.2: Ecuadorian labor income quantile difference: natural logarithm of income

Ecuadorian Wage (logarithm) Quantile Difference: Affected Areas									
Quantile	N 2016	N 2015	Average 2016	Average 2015	Difference	CI low	CI up	p.crit	p.value
0.2	2524	2426	5.05	4.85	0.2	0.05	0.31	0.01	-
0.4	2524	2426	5.6	5.52	0.08	-0.02	0.16	0.01	0.05
0.6	2524	2426	6	5.99	0.01	-0.02	0.05	0.03	0.33
0.8	2524	2426	6.44	6.42	0.02	-0.04	0.08	0.05	0.45
1	2524	2426	9.24	10.82	-1.58	-2.3	0.81	0.02	0.21

Ecuadorian Wage (logarithm) Quantile Difference: Unaffected Areas									
Quantile	N 2016	N 2015	Average 2016	Average 2015	Difference	CI low	CI up	p.crit	p.value
0.2	25405	24797	4.84	5.02	-0.18	-0.22	-0.14	0.01	-
0.4	25405	24797	5.58	5.71	-0.12	-0.16	-0.09	0.01	-
0.6	25405	24797	6.03	6.04	-0.01	-0.03	0.01	0.03	0.29
0.8	25405	24797	6.47	6.48	-0.02	-0.05	0.02	0.02	0.2
1	25405	24797	11.51	10.56	0.95	-0.82	1.39	0.05	0.74

In Chile no wage differences we found for the affected areas, only for unaffected areas there was a negative and significant wage difference in the first, third and fourth quintiles.

TABLE 2.3: Chilean labor income quantile difference: natural logarithm of income

Chilean Wage (logarithm) Quantile Difference: Affected Areas									
Quantile	N 2010	N 2009	Average 2010	Average 2009	Difference	CI low	CI up	p.crit	p.value
0.2	6097	6333	11.51	11.51	-0.001	-0.06	0	0.01	0.04
0.4	6097	6333	11.92	11.92	0	0	0	0.05	0.74
0.6	6097	6333	12.03	12.04	-0.014	-0.04	0.02	0.01	0.29
0.8	6097	6333	12.43	12.43	0	-0.02	0.01	0.03	0.65
1	6097	6333	15.42	14.91	0.511	-0.18	0.52	0.02	0.5

Chilean Wage (logarithm) Quantile Difference: Unaffected Areas									
Quantile	N 2010	N 2009	Average 2010	Average 2009	Difference	CI low	CI up	p.crit	p.value
0.2	14279	14931	11.7	11.71	-0.013	-0.07	0	0.01	-
0.4	14279	14931	12.01	12.01	0	0	0	0.05	0.45
0.6	14279	14931	12.15	12.18	-0.038	-0.07	0	0.02	0.01
0.8	14279	14931	12.45	12.51	-0.065	-0.11	0	0.01	0
1	14279	14931	15.61	15.76	-0.154	-0.34	0.02	0.03	0.22

In Italy there were positive and significant wage differences in 2016 for affected areas in the first to fourth quintiles, both in affected and unaffected zones.

TABLE 2.4: Italian labor income quantile difference: natural logarithm of income

Italian Wage (logarithm) Quantile Difference: Affected Areas									
Quantile	N 2009	N 2008	Average 2009	Average 2008	Difference	CI low	CI up	p.crit	p.value
0.2	855	1022	6.73	6.46	0.27	0.2	0.36	0.03	-
0.4	855	1022	6.98	6.89	0.09	0.04	0.15	0.02	-
0.6	855	1022	7.11	7.05	0.06	0.02	0.12	0.01	-
0.8	855	1022	7.28	7.21	0.06	0.02	0.11	0.01	-
1	855	1022	8.01	8.01	-	-	-	0.05	1

Italian Wage (logarithm) Quantile Difference: Unaffected Areas									
Quantile	N 2009	N 2008	Average 2009	Average 2008	Difference	CI low	CI up	p.crit	p.value
0.2	5634	7206	6.73	6.48	0.25	0.2	0.28	0.03	-
0.4	5634	7206	7	6.91	0.1	0.09	0.11	0.02	-
0.6	5634	7206	7.15	7.07	0.08	0.06	0.1	0.01	-
0.8	5634	7206	7.32	7.24	0.07	0.06	0.1	0.01	-
1	5634	7206	8.01	8.01	-	-	0.04	0.05	0.95

In summary, we found heterogeneous wage differences between years, both in countries and in affected or unaffected areas, and only for some quantiles. In Ecuador only the first income quintile in affected zones showed a statistically significant wage increase, and for the unaffected areas in the first two quantiles there was an income decrease. For Italy, both in seismic and not seismic areas there was a wage increase (quantile 1 to quantile 4), only for the first quintile this increase is greater in affected locations. Finally, in Chile no significant differences were found for affected territories.

Logistic regressions

We performed a logistic regression¹¹ with analysis of the marginal effects to compute how the three earthquakes (independent dummy variables for people located in seismic areas) are associated with the probability of being employed, having a wage increase, and increasing the amount of working hours. It is important to recall that all covariates are referred only to the pre-earthquake conditions. We identify too if previous conditions could have improved the likelihood for a positive outcome in terms of labor market performance in the immediate post-disaster months. For the three countries, each of the comparable samples (most affected regions and the rest of the territories) were included in the regression analysis (see Table 5). The variables used in order to estimate the pre-disaster determinants for a positive outcome are sex, wage (in current currency), working time (in weekly hours), employment status, the fact of being registered as head of the household, age, the condition

¹¹All the regressions use the official expansion factors as weights.

of self-employment or employee, household size and the economic sector for the pre-disaster job.

The first parameter to observe is the direct effect of being in one of the most affected regions (Manabí and Esmeraldas for Ecuador, Maule and Biobío for Chile and Abruzzo for Italy). Controlling for all the other variables, the only general trend between the three countries is that working hours decrease significantly for the most affected regions. While in Chile and Italy we observe negative parameters for employment and wages, in Ecuador there was a positive effect on wages and employment status, which is coherent with the results in the previous sub-section. The gender gap is clear: men have more likelihood of being employed, receiving wage increases and working more in all scenarios, with the only exception of salaries in Italy. Higher levels of past wages and working hours have an ambiguous effect on the logit models and it is not possible to identify clear trends, since the pre-existent condition of employment had always a positive effect (except for Chilean working hours). Also, educational levels are a clear positive driver in all the countries for wages, but negative in Ecuador for the employment status and hours. Age is the only variable completely nation dependent for all the regressions: always negative for Ecuador and Italy and always positive for Chile.

Concerning the economic sectors, it is interesting to assess that general negative outcome in wages for all the sectors with respect to “other activities”, for all three countries. The construction sector, crucial in disaster scenarios, presents positive outcomes for Chile and Ecuador in increasing working hours and only for the case of Ecuador affects the probability of being employed. In a vertical comparison, wage regressions are the most similar between the three countries. With notable differences only concerning the affected regions and gender.

TABLE 2.5: Logistic regression for employment, wages and working hours

	ECUADOR			CHILE			ITALY		
	(1) emp_2016	(2) i_wage	(3) i_hour	(1) i_empl	(2) i_wage	(3) i_hour	(1) i_empl	(2) i_wage	(3) i_hour
affected regions	0.0391*** (0.00258)	0.348*** (0.00233)	-0.0493*** (0.00263)	-0.147*** (0.00205)	-0.162*** (0.00204)	-0.0243*** (0.00252)	-0.121*** (0.00483)	-0.149*** (0.00369)	-0.113*** (0.00320)
sex (M)	0.242*** (0.00197)	0.373*** (0.00185)	0.423*** (0.00205)	0.525*** (0.00182)	0.562*** (0.00181)	0.509*** (0.00223)	0.195*** (0.00384)	-0.0687*** (0.00296)	0.0729*** (0.00257)
wage	0.000838*** (0.00000493)	-0.000812*** (0.00000250)	0.000120*** (0.00000162)	1.841*** (0.00937)	1.290*** (0.00757)	-1.308*** (0.00898)	0.0000307*** (0.00000527)	0.000124*** (0.00000380)	0.000833*** (0.00000334)
hours	0.0409*** (0.000103)	0.00557*** (0.0000653)	-0.0496*** (0.0000759)	-0.0000561*** (0.00000727)	0.0000246*** (0.00000705)	-0.0284*** (0.000152)	0.00325*** (0.000123)	0.00171*** (0.0000436)	-0.0114*** (0.0000817)
employment_pre	0.882*** (0.00427)	2.306*** (0.00367)	3.132*** (0.00403)	2.900*** (0.00314)	2.980*** (0.00293)	-0.396*** (0.00701)	5.688*** (0.00657)	4.334*** (0.00661)	3.545*** (0.00544)
education	-0.00289*** (0.000228)	0.0589*** (0.000209)	-0.0226*** (0.000225)	0.120*** (0.000207)	0.109*** (0.000206)	0.167*** (0.000257)	0.467*** (0.00218)	0.0447*** (0.00190)	0.00184 (0.00157)
head	0.571*** (0.00248)	0.547*** (0.00207)	0.293*** (0.00226)	0.684*** (0.00230)	0.670*** (0.00226)	0.482*** (0.00305)	0.488*** (0.00433)	0.0534*** (0.00286)	-0.0152*** (0.00254)
age	-0.0124*** (0.0000572)	-0.00669*** (0.0000588)	-0.00932*** (0.0000639)	0.00945*** (0.0000518)	0.00825*** (0.0000521)	0.00770*** (0.0000617)	-0.152*** (0.000634)	-0.0719*** (0.000597)	-0.0855*** (0.000503)
self employment	0.0798*** (0.00276)	-0.126*** (0.00189)	0.140*** (0.00202)	-0.306*** (0.00291)	-0.506*** (0.00272)	0.0921*** (0.00499)	0.425*** (0.00764)	-6.315*** (0.0329)	0.526*** (0.00462)
Sectors									
Agriculture	0.693*** (0.00369)	-0.325*** (0.00270)	0.576*** (0.00295)	-0.360*** (0.00397)	-0.349*** (0.00385)	0.344*** (0.00806)	0.237*** (0.0157)	-0.672*** (0.0120)	-0.929*** (0.00837)
Construction	0.582*** (0.00584)	-0.229*** (0.00355)	0.522*** (0.00391)	-0.125*** (0.00481)	-0.0438*** (0.00464)	0.536*** (0.00710)	-0.791*** (0.00756)	-0.662*** (0.00531)	-0.730*** (0.00446)
Manuf., Min., En.	0.455*** (0.00453)	-0.0782*** (0.00295)	0.523*** (0.00336)	-0.221*** (0.00400)	-0.155*** (0.00383)	0.0772*** (0.00701)	-0.560*** (0.00601)	-0.190*** (0.00339)	-0.329*** (0.00316)
Trade, Tour., Trans.	0.0870*** (0.00314)	-0.181*** (0.00236)	0.804*** (0.00268)	-0.106*** (0.00304)	-0.0982*** (0.00288)	0.212*** (0.00535)	-0.447*** (0.00565)	-0.363*** (0.00324)	-0.294*** (0.00284)
Other services	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)
household size	-0.0261*** (0.000694)	-0.0110*** (0.000633)	0.00399*** (0.000690)	0.0493*** (0.000506)	0.0275*** (0.000503)	0.0610*** (0.000631)	0.176*** (0.00163)	0.166*** (0.00112)	0.104*** (0.000978)
_cons	-0.658*** (0.00430)	-3.222*** (0.00443)	-2.580*** (0.00474)	-3.988*** (0.00419)	-3.859*** (0.00416)	-4.396*** (0.00505)	-3.964*** (0.0128)	-4.580*** (0.0118)	-3.607*** (0.00967)
N	51123	51123	51123	60647	60647	60647	19695	19695	19695
chi2	4807166.2	1935222.3	1796464.8	8218379.1	7918078.4	848850.6	7995741.1	2724385.5	2661045.5
rank	15	15	15	15	15	15	15	15	15
ll	-4322903.0	-5134233.6	-4459129.7	-4725136.1	-4780492.7	-3373479.1	-1468471.3	-2127680.4	-2737272.4

The second regression (see table 6) shows that logit parameters for the wage estimation were the most similar across the three countries, besides the earthquake dummy (affected regions) and the gender binary variable (as well as age and household size, important but less related with this paper focus). This table is focused on the gender wage differences within the affected regions, estimating separated regressions for male and female workers to deconstruct and understand the determinants of these differences. Because of the different

sample size, this second table helps us to understand the determinants of wage increases for affected populations only. First, the similarities with the previous regressions are few: only the education level and the previous employment status keep their (positive) association on wages for all the countries, both for men and women. All the other parameters change, for one or both genders, in the most affected regions. Due to some reporting technicalities, the Italian data for self-employment is missing. Starting from the top, it is possible to determine a lower probability of an increase in wages for higher salaries for the cases of Italy and Ecuador, while the opposite is true for Chile.

The main differences between countries, genders and affected regions are the ones concerning economic sectors. While in the previous table there was a clear negative effect for every economic sector in all three countries, when we focus on gender gaps and the most affected regions the situation changes. The agricultural sector suffers for both sexes in Ecuador, and for female Chilean workers, while in Italy and for Chilean men positive parameters were found. The manufacturing, mining and energy sectors have positive parameters only for Chile and Ecuadorian men, and it is negative for all other categories. Trade, tourism and transportation sectors keep its negative trend with the exception of Chilean and Ecuadorian men. Finally, the construction sector, crucial in earthquake affected areas, becomes positive in Ecuador and for Chilean men, remaining negative for Chilean women and Italian men. Surprisingly, there are no recorded changes for Italian women in the construction sector, maybe due to the very strict sample size of the Abruzzo region for female workers. In the end, summarizing the differences in sign with respect to female and male regressions, in all of these negative signs are associated with females, and positive signs with males. Most of these differences in Ecuador and Chile happen in productive sectors, but is remarkable to find opposite signs in Ecuador for household size and in Italy for being the head of household, a bad signal for the internal family inequalities.

TABLE 2.6: Logistic regression for wage increasing by gender, affected regions only

	ECUADOR		CHILE		ITALY	
	(1)	(2)	(1)	(2)	(1)	(2)
	i_wage	i_wage	i_wage	i_wage	i_wage	i_wage
	WOMEN	MEN	WOMEN	MEN	WOMEN	MEN
wage	-0.00128*** (0.0000171)	-0.00168*** (0.0000117)	4.269*** (0.0427)	1.956*** (0.0275)	-0.00425*** (0.0000413)	-0.00251*** (0.0000236)
hours	0.0154*** (0.000332)	0.000457* (0.000237)	-0.000515*** (0.0000260)	0.0000396 (0.0000242)	-0.000500 (0.00111)	-0.0151*** (0.000738)
employment_pre	2.821*** (0.0158)	2.141*** (0.0142)	2.838*** (0.00958)	2.755*** (0.0108)	6.116*** (0.0415)	5.579*** (0.0460)
education	0.0529*** (0.000932)	0.0548*** (0.000769)	0.120*** (0.000731)	0.0762*** (0.000624)	1.033*** (0.0173)	0.640*** (0.0102)
head	0.280*** (0.00976)	0.831*** (0.00826)	0.791*** (0.00731)	1.019*** (0.00695)	-0.373*** (0.0210)	0.317*** (0.0152)
age	0.00305*** (0.000285)	-0.00586*** (0.000218)	0.00758*** (0.000174)	0.00261*** (0.000167)	0.0178*** (0.00417)	0.135*** (0.00327)
self employment	0.250*** (0.0105)	0.00284 (0.00702)	-0.398*** (0.0106)	-0.470*** (0.00787)	0 (.)	0 (.)
Sectors						
Agriculture	-1.577*** (0.0171)	-0.112*** (0.0102)	-1.015*** (0.0119)	0.0813*** (0.0101)	1.320*** (0.0662)	0.134*** (0.0467)
Construction	1.839*** (0.0614)	0.198*** (0.0119)	-0.467*** (0.0470)	0.212*** (0.0121)	0 (.)	-0.334*** (0.0181)
Manuf., Min., En.	-0.375*** (0.0167)	0.697*** (0.0116)	0.127*** (0.0158)	0.183*** (0.0118)	-0.606*** (0.0203)	-0.113*** (0.0130)
Trade, Tour., Trans.	-0.958*** (0.0111)	0.202*** (0.0102)	-0.0771*** (0.00944)	0.149*** (0.0103)	-0.515*** (0.0182)	-0.877*** (0.0159)
Other services	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)
household size	-0.0547*** (0.00297)	0.0306*** (0.00232)	0.0420*** (0.00178)	0.0498*** (0.00154)	0.0903*** (0.00689)	0.183*** (0.00466)
_cons	-3.342*** (0.0194)	-2.478*** (0.0160)	-4.294*** (0.0145)	-3.328*** (0.0115)	-6.117*** (0.0867)	-6.413*** (0.0628)
N	2465	2374	10290	9617	370	545
chi2	152573.4	109274.2	765064.8	898027.1	48774.9	68691.0
rank	13	13	13	13	11	12
ll	-230575.6	-374774.4	-458248.7	-514393.3	-79060.3	-117855.2

Discussion

Understanding the effects of an earthquake on the work force during the first months after the event is not a linear process. After having identified changes in employment status, working hours and wage parameters, the first distinction to adopt in this discussion is between the most affected regions and the surrounding¹² population, more or less physically affected. Starting from a simple comparison of employed, unemployed or inactive people before and after the earthquake.

In Ecuador there was a great transition of unemployed and inactive citizens to the active labor force in the most affected area. This trend of uprising labor parameters is clear in Ecuador, it could have been caused by a young demographic structure (low inactive and unemployment levels) and a general State intervention to boost the local economy in the short run. In Ecuador, the most affected lower quintiles faced a significant increase in wages, becoming smaller for high earners, and a reverse trend for the less affected areas. Despite the magnitude of the earthquake and the relatively low levels of social protection, Chile faced the earthquake with good resistance, both in the most affected regions, as well as the rest of the country, showing only a slight passage from unemployment to inactivity. We observed very few changes in employment status for the most affected regions with respect to the rest of the country. Chilean wages too did not face significant changes in the different quintiles. The Italian case is very peculiar, an old population in the year of the economic crisis made Abruzzo region more likely to increase unemployment (also passing from inactivity, even if there are no subsidies for the ones passing from inactive to unemployed, but there were for the ones that found jobs). Summarizing, the most affected regions in the three nations are very similar under a profile of peripherality¹³ with respect to the national economic flows. The earthquake worsened a bit some indicators in Italy and Chile but was a small boost for employment and better wages in Ecuador.

The gender gap is multidimensional and strongly persistent in the three cases, where women have lower probability of find a new job, a better salary, or to work more in any sector in all three countries, with small exceptions in

¹²With exception of Ecuador where the unaffected individuals were in provinces different than Manabí or Esmeraldas

¹³In Chile the most populated and economically important area is the Metropolitan region (Santiago, the country capital is here). In Ecuador three cities are the most important in terms of population and economic flows: the capital Quito (Pichincha province), Guayaquil (Guayas province) and Cuenca (Azuay province). In Italy the most important productive cities are the capital (Rome) and those located at the northern regions of the country.

Italy. But when the family exceptions can be quantified (as having a numerous household or a female head of the household) negative outcomes are always put on the women side.

2.6 Conclusions

This brief study of short run effects of an earthquake on the local labor markets shows different scenarios where the state role could be crucial, not only in the long run. The speed of recovery could depend both from intrinsic characteristics of the regions and from the capabilities of policy makers to help these processes. The amount of public money spent for reconstruction and local development could play a good role even on the short term labor market reactions, although these funds are not deployed yet, enacting some rational expectations from the local economic agents. We saw how a smaller and poorer, but younger and more dynamic economy such as the Ecuadorian was able to react in a positive manner to the disaster shock, specifically in terms of employment and wages in the most seismic areas. More mature economies with a more liberalized system, like Chile, seems to suffer the short run negative effects of a massive earthquake. At the same time, a very “old” (even in literal sense) economic system as the Italian one, where the role of State in catastrophic events is almost totalitarian and the social securities are more guaranteed, seems to experiment too short run negative effects in local labor markets of the affected zones.

Although we provide important empirical evidence of short run labor market transitions, testing whether employment and wages shifts may be common for all territories and countries or may differ depending on socio-economic characteristics, or their starting point. There are many challenges for future research in this topic, we show a first distributional approach with the salary comparisons per quintile in our manuscript. According to our results, Ecuador is a special case in which there was an average salary increase from the first to fourth quintiles in seismic areas, but there was an average wage decrease for unaffected areas in the same quintiles between the pre and post-earthquake periods. However, there is not enough evidence to conclude that an existing distributional effect was found. For this reason, a causal distributional approach is one of the future challenges in order to reveal whether the earthquake affects local labor markets homogeneously or not according with the wage range of workers. This could be a crucial part in

designing good mechanisms in public policy to minimize potential damages the earthquake could cause to workers, and the labor markets they comprise. Further research directions in this area can be both plentiful and offer a lot of insight, especially when comparing multiple countries that have suffered similar disasters. Othake et al. (2012), suggests as a future line of research, to study the changes in the industrial structure, which could help policy makers to identify economic sectors in need, and guide the post-disaster economy with better tools. Ewing, et al. (2005) suggest that new research ideas might focus in determining what characteristics make resilient regions, a very broad concept that has been explored in depth in this literature, but rarely using cross-country comparisons with micro-data. Xiao and Feser (2013) also point out that future research could focus on determining the influence of pre-disaster economic conditions (sectoral structure, urban and rural composition, employment and unemployment), on the labor market reaction and adjustment.

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3 Housing.

Post-disaster, housing market and state intervention.

Counterfactual analysis for Italy 2009

ABSTRACT

There are several ways to recover from a disaster such as an earthquake. Housing is one of the most affected market and its recovery is a good signal for the overall regional development. Most of the preexisting literature states the housing issue as a simple private risk aversion problem, focusing on the safety and the possible effects on the demand side. A correct approach that underestimates the general negative externalities a disaster such an earthquake can bring to an affected area. The focus of this paper is on the housing supply side and on the risk of small landowner to leave if not properly helped to reconstruct their building(s). State intervention has a key role for the recovery process, but very rarely there is a massive investment for private housing reconstruction, as in Italy. Using an Italian case as quasi-laboratory, L'Aquila earthquake in 2009, this paper adopts a difference-in-differences methodology with different control groups. The scope is to define the combined impact in the medium run of the earthquake damages and State driven reconstruction process for the affected housing markets. Results show a displacement effect between negative earthquake damages and public reconstruction funds, with some heterogeneity in the geographical distribution. Surprisingly, as far the land gradient goes away from the epicentre, housing prices are relatively decreasing

3.1 Introduction

Housing is one of the most important issues to deal with after an earthquake (Beron et al., 1997). As for other types of disasters, in an earthquake the prevention is essential and the housing demand in a seismic area is strongly driven by safety and risk characteristics (Votsis and Perrels, 2016). A common approach is to assess the determinants of the housing price mainly in term of private insurance, where the occurrence of a harmful natural event can just change the risk perception and push downward the land values (Naoi et al. 2009). But there are circumstances where the effect of such events is not only restricted to the private market, the whole social and economic environment changes, sometimes forever, and these phenomena are defined as disasters (Alexander, 2000). In case of a disaster, a strong State and community commitment is common, sometimes this is bound to the mere emergency stage, sometimes it goes beyond, helping to rebuild the infrastructure and taking care even of the many aspects of the post-disaster issues in the long run. Also in the

case of housing, there are different post-earthquake strategies of intervention around the world. In the USA, for instance, the State grants reconstruction loans or renting bonuses, while in China the government directly rebuilds all the houses, generally State-owned. The majority of policies focuses on the housing demand side, hence they do not prevent prices from decreasing. This paper builds a theoretical framework where the collapse of house prices after a disaster are motivated by this oversupply. Private households cannot afford the reconstruction costs and so they are forced to sell their house to find a cheaper accommodation, or even leave the affected area. A policy directed at the small private supply side can prevent this.

The empirical part of the paper looks at the changes in the characteristics of the housing market in the case of L'Aquila, Italy, which was severely hit by an earthquake in April 2009. At 3:32 am on April 6th 2009, the city of L'Aquila (Italy) was hit by a 6.3 magnitude earthquake, the highest of a long seismic swarm in those days. 309 inhabitants died, 1600 were injured and about 100,000 were evacuated from L'Aquila and the surrounding municipalities during the following weeks. Together the horrible death toll, the capital loss was enormous and remarkable, mainly in terms of housing (Alexander, 2010). After the earthquake, there was a significant flow of public money invested in the reconstruction process. Six billion euros were spent just for financing private buildings (OECD, 2012). The combination of these two external shocks, namely the earthquake and the reconstruction subsidies, are supposed to produce counterbalancing phenomena, where the possible negative impact from the earthquake is absorbed by the reconstruction policy. The methodology to estimate this possible displacement effect is a difference-in-difference model, where the area helped by the public reconstruction funds (157 municipalities) is matched to a group of municipalities with similar characteristics before the earthquake (identified with the Mahalanobis distance matching algorithm) and with the 83 municipalities outside the policy beneficiary area.

The paper is organized as follows. Section 2 presents the relevant literature for housing markets affected by socio-natural disasters and the possibility of a State intervention on the housing supply side. Section 3 presents the theoretical model Section 4 introduces the case study of L'Aquila. It describes the dataset, where the housing market observation at neighbourhood level are compared with housing and municipal characteristics, obtained from the Housing Market Observatory, the National Statistics Bureau and the Special Office for the Reconstruction. Section 5 presents the empirical strategy. It

implements the difference-in-differences methodology, drawing the counterfactual control groups, from a matching and a distance point of view. Section 6 presents a preliminary comparison between groups in analysis and the regression results, discussing the implication of these. Section 7 concludes.

3.2 The Impact of an earthquake on the housing markets

Increasing urbanisation and climate change expose more and more people to harmful natural phenomena (IPCC, 2011). The increasing attention on possible disasters push the scientific community to investigate areas in a wider approach. Because of the unpredictability of human activity effects on natural environment, it can be useful to learn from phenomena whose causation is not related to human activity. An earthquake is one of the few harmful events not imputable to climate change nor to a direct human impact. When an earthquake occurs, there are different costs to a region (Meyer et al., 2013). The most important are direct costs, that is the damages due to direct contact with the natural phenomenon, generally related to buildings and infrastructures. This paper analyses the housing market after a natural disaster considering housing as one of the main direct costs of an earthquake (Meyer et al., 2013). After a natural disaster, considering the initial housing stock destruction, most of local and global markets can be shocked (Chang, 2010).

Different markets can be directly or indirectly affected by natural disasters. The direct mode is the destruction of buildings and infrastructures (MacDonald et al., 1987; Chang, 2000; Meroni et al., 2017). Housing market is a peculiar market (Glaeser, 2009) because the life span of a single commodity (house) is very long and the market dynamics are highly correlated with demographic, labour and income changes. Nevertheless, it is one of the few market where many households are both consumers and suppliers (Ioannides and Rosenthal, 2006). Studying the housing market is essential to understand the recovery process after a disaster. Earthquakes and other disasters can affect with different magnitude different areas in the world. However, while the international or even interregional disparities are often object of analysis (Stephens et al., 2013), for the intranational or intraregional aspects the literature is still scarce (Stromberg 2008; Cavallo and Noy, 2011). Common characteristic for many sub-national regions is the cohabitation of both urban and rural spaces. In

most regions worldwide this dichotomy is still persistent even when a region is not hosting a metropolis but just an urban attractor for the “urbanised rural” population (Christiaensen and Todo, 2013). DuPont and Noy (2015) give an important contribution to literature for economic effects of natural disasters at subnational level. They observed that the occurrence of a seismic event can negatively influence the path of economic growth of the affected area, especially in the long run. A similar comparison has been enacted by Pagliacci and Russo (2018) for the Italian earthquake in Emilia-Romagna 2012. Their analysis, although, is focused on the productive side only. At the same time the municipal size can induce a different level of democratic participation in public expenditure uses, creating community benefits (Barone and Mocetti, 2014). Different evidences came from different areas around the world when a recovery process was enacted (Hassink, 2010) with different performing outcomes.

In a worldwide perspective there is a strong evidence for a general decline of the housing markets after an earthquake, especially when those markets are in a typical free market framework, as in the case of USA, Japan and New Zealand (Beron, 1997; Naoi et al., 2009; Fraser and Mcalvey, 2015). In most of disaster housing market literature, both when the analysis is ex-ante or ex-post, the common approach is to study the housing market in such regions as a pure “private insurance” problem, where the final price is determined by the risk assessment on the demand side (Murdoch et al., 1993; Aldrich, 2011; Votsis and Perrel, 2016). The most used approach is the hedonic model, where the final price is divided in several characteristics, intrinsic or extrinsic in the building itself, and the willingness to pay derives from the buyer risk aversion; it’s the hedonic model (Goodman, 1988; Zabel, 2015; Roebeling et al., 2016) These studies are correct but not exhaustive when the event is so disruptive that singular safety measures are not enough to prevent massive changes in the social and economic structure of a region (Martin, 2011). It is not easy to define what a disaster is. Etymology suggests the term indicate a moment “against the star” (dis-aster, from latin), so against the constituted order. It can be courageously assessed that “a natural disaster is not a natural event” (Hallegatte, 2014, p. 9) because the nature forces can be followed and even the strongest event can cause very few casualties; in many disaster cases, moreover, the hardest time was the medium term after the tragedy, when the institutions were not able to rearrange a new harmonic situation and many conflicts arise (Alexander, 2000). For these reasons, many scholars consider as more appropriate to define such disasters

as “socio-natural” (Arteaga and Ugarte, 2015). The threshold defining when a phenomenon became a disaster is all related to human perspective. Or, by an economic point of view, “a natural disaster can be defined as a natural event that causes a perturbation to the functioning of the economic system, with a significant negative impact on assets, production factors, output, employment, or consumption” (Hallegatte, 2014, p. 9). So, when studying natural disasters, we are dealing with phenomena causing strong exogenous economic shocks. Many theories described economic cycle as a subsequence of endogenous or exogenous shocks, Hallegatte and Ghil (2008) suggest that natural disasters studies could be part of a coherent economic general theory.

Concerning public economics, most of classical theories suggest a direct positive intervention of governments on single market have the general effects to keep price low, both on demand or supply side. Very few studies in literature suggests that housing prices can be boosted upward when targeted by a consistent positive housing policy (Di Pasquale, 1999; Dachis et al., 2012; Ferraresi et al., 2018). Can this effect imply a displacement on housing prices, absorbing the expected negative effect due from an earthquake? In Italy, 73% of households own their home (Eurostat, 2015) and, nevertheless, there is a strong culture of publicly-funded reconstruction in case of disaster (Alexander, 2009). These two simultaneous phenomena make the study of the Italian case very important to assess the relationship between State, local communities and free market movements in the housing sector after a natural disaster. In countries with free market reconstruction propensity there is strong evidence that earthquakes let housing prices go down in the mid-term (Murdoch et al., 1993; Naoi et al., 2009). It is interesting to assess if and why this phenomenon happens even where the State is totally funding the reconstruction process (Cook, 2015).

3.3 Theoretical Framework

The following theoretical model explains how a targeted policy on housing supply can boost prices after a socionatural disaster. A strong literature stream considers the post-disaster housing as a household risk model (Naoi et al, 2009; Votsis and Perrel, 2016). This approach is, although correct, does not take into account the difference between a small housing damage and the wider devastation a disaster can bring. The economic framework assumes the

disaster shock as given and suggests a scenario of housing supply collapse and the possible outcome of a targeted policy.

The model assumes for a given area k a homogeneous and fixed housing stock with an endogenous population growth equal to zero, this implies the absence of new housing stock and the changes in population size are determined only by the attractiveness from other areas. As suggested by Ioannides and Rosenthal (1994), households are both housing consumers and investors; simplifying, housing ownership is considered as the only investment for households. The last assumption involves the exogenous disaster shock, sufficiently large to affect all the housing units in the damaged area but sufficiently small for not influence the national government budget efficiency ¹.

The housing demand function (1) is depicted from Saiz (2010):

$$P_k^d = A_k + w_k + \chi \times r' + t \times d \quad (3.1)$$

where the housing demand price P in the area k is defined by the attractiveness A_k the level of wage w , the housing characteristics vector χ times the rent per housing unit r' and the space-time distance from the Central Business District $t \times$. The housing supply function (2) is the simple proportion of existent housing stock H_k defined by the exogenous poisson-distributed shock λ , suggested in Glaeser et al (2009)²:

$$P_k^s = \lambda H_k \quad (3.2)$$

this extremely simplified supply function is explained by the "no new constructions" assumption and the study of the exogenous parameter λ plays a

¹A more exhaustive review about government expenditure efficiency in case of disaster can be —Pindyck, R. S. and Wang, N. (2013)

²“we assume that each current homeowner receives a Poisson-distributed shock with probability λ in each period that forces the homeowner to sell, leave the area and receive zero utility for the rest of time. Homeowners who do not receive the shock do not put their homes on the market. While convenient, not allowing homeowners to time their sale abstracts from potentially important aspects of housing. Even though each individual homeowner’s decision to sell is stochastic, we assume a continuum of homeowners, so the number of existing homes for sale at time t is deterministic, proportional to the existing stock of homes and equal to $\lambda H(t)$.” (p. 199). In synthesis, the parameter lambda is useful in the model to justify the push to sell after the shock. In the earthquake case, this increase in lambda is defined by the budget constraint change in housing costs those, increasing, instead of just pushing upward maintenance costs and so the final equilibrium price, induce a push to leave the city for the higher costs of living.

crucial role. We introduce now the Households Budget Constraint defined as:

$$Y_i = (P_k - c)H_{ik} + w_i \quad (3.3)$$

where the household i income Y is given by its wage w plus the net value of its housing stock (the price P minus the maintenance cost c). Substituting the supply curve in the constraint we obtain a quadratic relation housing stock - households income:

$$Y_i = \lambda H_{ik}^2 - cH_{ik} + w_i \quad (3.4)$$

Assuming an income maximization behaviour for any household i ; for $Y_i \geq w_i$, there are first order solutions in: $H_{ik} = 0$ and $H_{ik} = \frac{c}{\lambda}$. The fixed housing stock assumption implies the non destruction of housing stock in case of exogenous disaster, with the consequence that the disaster shock would bring an increase only of the parameter c and consequent decrease of Y_i , these are the housing reconstruction costs. In order to maintain constant the household income, the immediate balancing behaviour would be an opposite increase of λ . The exogenous shock on the supply curve will shift it negatively, bringing a general decrease of housing prices on the market.

An effective policy to prevent housing market to collapse would consider the new housing maintenance costs as: $c_k = c_0 + RC$, where c_0 is the constant fixed cost not affected by the disaster and RC is the pure reconstruction cost related to it. With an arbitrary exogenous Reconstruction Fund (RF) given to the households such that:

$$c_{ik} = c_0 + RC_i - RF_i \quad (3.5)$$

a policy of price containment reaches its maximum effectiveness in $RF_i^* = RC_i$.

3.4 Dataset: the earthquake of L'Aquila 2009

The 2009 earthquake damaged more than 22,000 private buildings, generating a requested reconstruction fund of 8.3 billion euros in the city alone (80% of all the funds for the affected region). Public finance for reconstruction in L'Aquila included not only schools and public offices but also housing units owned and managed by public institutions; the funds necessary have been estimated at one billion euros. Furthermore, the medieval old town, very difficult to rebuild (Alexander, 2009), with its enormous (and unique) historic and artistic heritage, was damaged for about 70% (Alexander, 2010). The subsequent

reconstruction process passed through different phases and policies, with a huge media attention. Reconstruction policies did not always follow a clear scheme. For example, the University of L'Aquila chose not to charge fees to its students for three years, in order to stimulate people to stay. At the same time, the municipality adopted a policy of repurchasing the homes of families who wanted to leave the city; about 500 households took advantage of this opportunity.

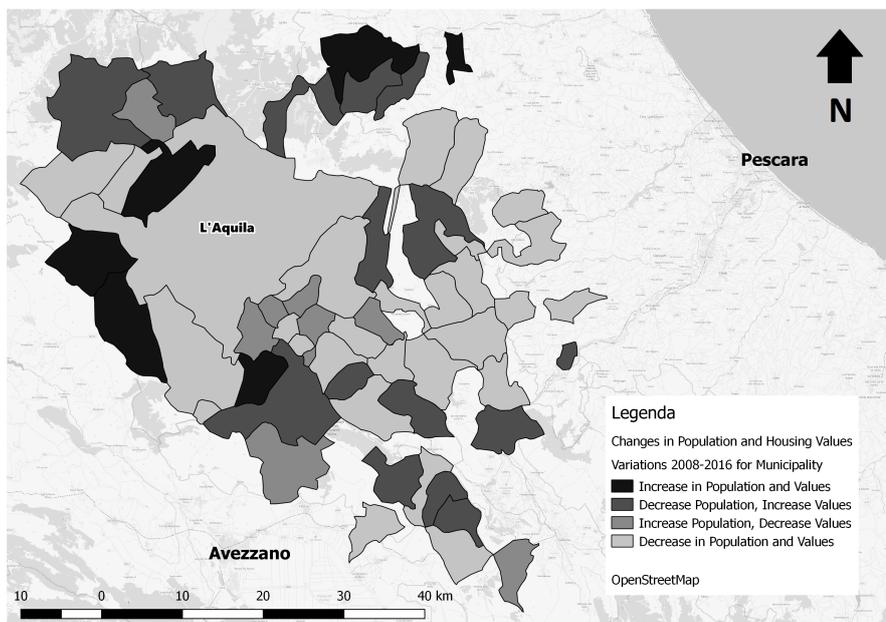
In 2016, over 20,000 private homes were renovated with the use of more than 3.5 billion euros of government funding. The access for the reconstruction funds was on voluntary base. A huge majority of requests was accepted with a little spatial heterogeneity. For this reason in the paper the mismatch between observed economic damage and reconstruction funds is only indirectly estimated.

The city of L'Aquila suffered the highest damage by the earthquake but it was not the only one municipality affected. More than 200 municipalities, all in the Abruzzo region, were considered for at least one reconstruction act from the central government. Of these 201, 56 were entitled to be in the "seismic crater" (cratere sismico in Dlgs 11/2009 law), a perimeter of municipalities more affected where the reconstruction efforts will be greater. A town or village listed in the crater is part of a special policy condition involving development program and massive public funded reconstruction process.. These group of municipalities are all in one NUTS-2 region (Abruzzo) and they are clustered on the mountain areas for 2090,5 square kilometres, with an overall density of 60,72 people per square kilometre. Half of the crater population (69,605 inhabitants in 2016) lives in the municipality of L'Aquila only, with a very sprawled distribution, just 147 inhabitants per square kilometre makes L'Aquila the less dense Italian city with more than 60,000 people. In addition to the single households aggregate reconstruction refunds from the State, these municipalities received many other funds for public facilities and economic development programs (Contreras et al., 2014).

Considering demographic and households income flows as the two main indicators influencing housing demand (Gleaser and Quigley, 2009), a preliminary study on the demography of L'Aquila and suburbs shows little mid-term effect. Despite an initial decrease in the population after the earthquake, the impressive minimum occurred in 2011, due to a statistical gap between registry office data and the 2011 National Census. In that case, the Italian National Statistics Office (ISTAT) noted that there were 1.9 million people fewer

respect to the sum of each municipal registry office (ISTAT, 2011). L'Aquila itself "lost" 6,000 inhabitants. Ignoring this measuring gap, the population the whole seismic crater registered a loss of about four thousand inhabitants, if comparing 2008 (144,302 inhabitants) with 2016 (139,138). But it is still important to remark that, after the 2011 census, the municipality adjusted its population data according to national statistics. Therefore, it is hard to declare if the earthquake brought a run of residents abandoning L'Aquila only looking at its own data. Figure 3.1 shows the changes in population and housing prices for the Seismic Crater (56 municipalities) in the period 2008-2016. Most of the municipalities had decreases in population and values, with some exceptions mainly related to the inner belt surrounding L'Aquila. This can be a symptom of a small run of L'Aquila inhabitants to the closer municipalities, where the reconstruction may have been better performed.

FIGURE 3.1: Changes in population and housing prices for the Seismic Crater, 2008-2016



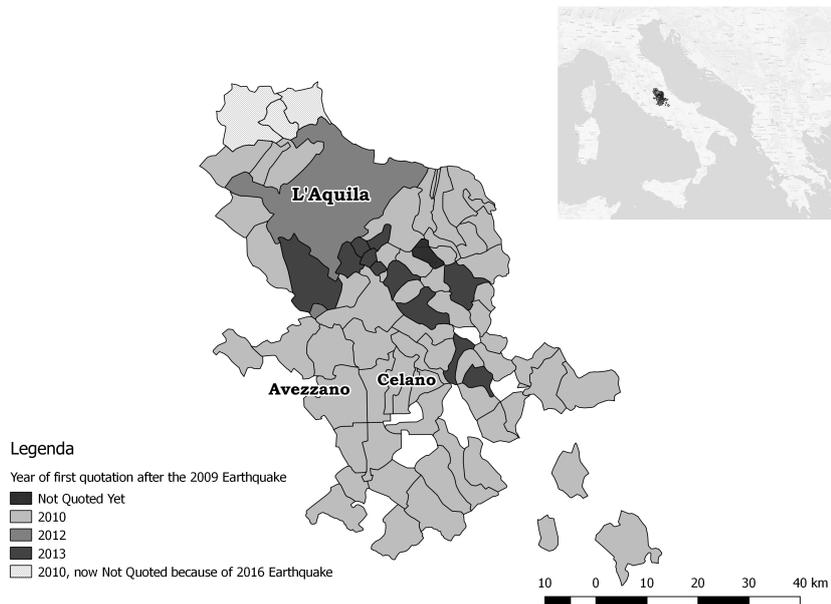
Considering the economic performance, the declared income in the area does not show any significant negative effect because of the earthquake. Per capita income was increasing before 2009 earthquake and continued to grow in 2016, according to income tax database. Average income per capita in L'Aquila province (where most of seismic crater is) grows from 15,961 € in 2008 to 18,444 € in 2016, with richer households in the city and poorer in the suburbs (MEF, 2018). Again, mainstream literature about decreasing in population and income for earthquake affected areas is not persistent in this case. There is

space to suppose the usual trends in housing market will not be applied. A preliminary studies from the OMI database and Scenari Immobiliari (Omi is still not evaluating L'Aquila city centre) shows a relevant downward trend for L'Aquila housing prices, still at 7 years from the earthquake (-28% for OMI, -32% for Scenari Immobiliari for the period 2008-2016). While the situation in the rest of the seismic crater is more heterogeneous, where many municipalities gained both in terms of housing prices and in term of population.

Observation units for this paper are the OMI housing values quotations (Real estate observatory, for the Italian National Tax Agency), representing a neighbourhood-level housing sales average distinguished for housing related characteristics. Each observation is a single neighbourhood (Zona OMI) divided according to year (two different observation per year), housing status (villas, social or normal housing) and housing quality (bad, normal, good). In this dataset, all the variables have been computed as a neighbourhood average, presenting so between 2 and 18 observations per neighbourhood per year, according to territorial variety. Secondary level of study is the municipality, where the covariates and cluster analysis are applied. Each municipality presents from 2 to many dozens of neighbourhood, so from 6 to about 200 of observation per year, according to its own dimension.

The time horizon for this research makes a comparison between the pre-earthquake housing market, from 2002 to 2016, with many jumps. During the period 2009-2012 the housing market in the affected area was too biased by the earthquake effects and there are no data for many municipalities in some periods (e.g.: zero in 2009). Time path for the coming back for these municipalities in a proper housing market is shown in Figure 3.2. It is important to remark how, once the municipality is quoted back in the OMI dataset, there is not a relevant collapse in housing transactions.

FIGURE 3.2: Municipalities not quoted in OMI housing market because of the earthquake, time path



There is a sufficient interval of time between pre- and post- earthquake, when the emergency stage is over; earthquake effects are still vivid while a sufficient part of reconstruction has been done. The Municipal covariates are determined by an ISTAT dataset (Istituto Nazionale di Statistica – National Statistics Bureau) where it has been added the public expenditure for households reconstruction, per capita at municipal level, taken from the USRA and USRC (Special Offices for the Reconstruction) dataset on opendataricostruzione.gssi.it. With this last exception, municipal covariates are purely geographical or demographical, to let the housing value absorbing the economical peculiarities. All the variables in use are presented as follows in Table 1.

TABLE 3.1: Summary statistics

Name	Description	Obs	Mean	Std. Dev.	Min	Max	Source
PR_AVG	Average selling price(Euro/m2)	171,413	842.02.00	407.02.00	67.05.00	4350	I
PR_LOG	Average selling price, natural logarithm	171,413	646.11.00	.4260835	262.40.00	845.32.00	I
PR_MUN	Average municipal price(Euro / m2)	171,413	873.21.00	365.03.00	384.15.00	1557.05.00	I
	Treatment						
TREAT	Dummy for treated municipalities	171,413	.2358398	.4245238	0	1	III
SHOCK	Dummy for period after shock	171,413	.5171836	.4997061	0	1	I
TIME	Semesters in use (from 2002 to 2016)	171,413	528.35.00	429.03.00	84	113	I
	Housing covariates						
DIST	Distance from city centre (Fascia OMI, from 1 to 5)	171,413	158.19.00	691.40.00	1	5	I
STAT	Housing status (from 0 to 4)	171,413	439.35.00	261.51.00	0	4	I
QUAL	Housing quality (from 0 to 2)	171,413	1065.35.00	.328004	0	2	I
	Municipal covariates						
POP	Municipal Population (2016)	171,413	18209.41.00	46811.26.00	83	324198	II
FOR_POP	Foreign Population (2016, in %)	171,413	.0602619	.0346419	.0021231	2975318	II
DEN_POP	Population density (inh. Per sqkm)	171,413	293.34.00	556.07.00	2	3521	II
ALT	Altitude (in metres)	171,413	454.46.00	294345	2	1433	II
EQ_RK	Seismic risk (from 1 to 4)	171,413	267.11.00	.652778	2	4	II
CLIM	Climatic zone	171,413	810.14.00	.8863063	2	11	II
IN_AR	Inner Areas	171,413	789.06.00	514.23.00	0	5	II
MOUN	Mountain category	171,413	574.11.00	.9293268	4	8	II
PUB_EXP	Public expenditure (. € per capita)	46,526	13507.01.00	37484.05.00	0	1898.02.00	III

I stands for OMI, II for Istat and III for opendata

3.5 Empirical Strategy

The empirical strategy to assess the possible displacement effect of the reconstruction funds is a Difference-in-Difference methodology, applied to several counterfactual groups, according to the different typologies of data in use. The housing demand function is defining the covariates system and the housing supply function creates the theoretical basement for the difference-in-difference, the empirical estimation proves whether there is a crisis of housing prices after the earthquake if compared with similar cases, in line with the literature or whether the public policies can displace this effect and keep the price in trend with the rest of the population. The econometric counterfactual specification is inspired by Diao et al. (2017) and it is presented as

$$\text{Log}(\text{Pr}) = \beta_0 + \beta_1 \text{Post} + \beta_2 \text{Treat} + \beta_3 \text{Post} \times \text{Treat} + \beta_4 \text{Affection} + H' \gamma + M' \theta + \phi + \tau + \epsilon \quad (3.6)$$

where $\text{Log}(\text{Pr})$ is the natural logarithm of housing price in the long term, β_1 is the coefficient for the post-disaster period; β_2 is the coefficient for the treatment group; β_3 is the Difference-in-Differences estimator and β_4 is the coefficient for the most affected area. $H' \gamma$ is a vector of housing characteristics, such as distance from city centre or building quality, etc.; M' is a vector of municipal characteristic; ϕ and τ are geographical and timing covariates

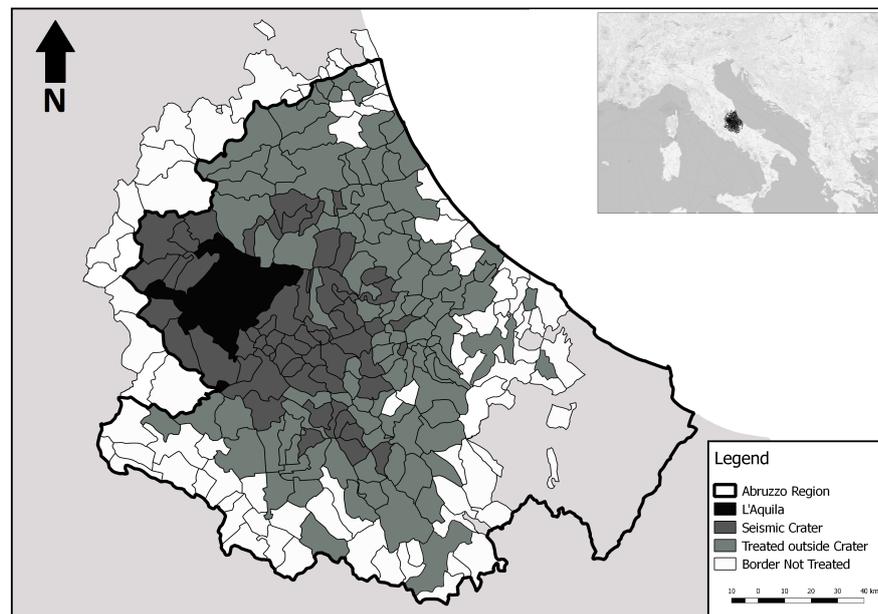
Moreover, the direct impact of the reconstruction funds (7) on the final housing prices is defined by an OLS regression, where the reconstruction funds (RF)

are evaluated in linear and quadratic functions and the rest of the equation is defined as in (6).

$$\text{Log}(Pr) = \beta_0 + \beta_1 RF + \beta_2 RF^2 + \beta_3 Affection + H'\gamma + M'\theta + \phi + \tau + \epsilon \quad (3.7)$$

This paper adopts a Difference-in-Differences methodology, with parallel control groups. The first step is to assess the direct impact on the housing prices simply differentiating between affected area and its own control groups. The treated group in use are all the 157 municipalities in Abruzzo that are beneficiary at least of one euro for the private reconstruction, further subdivision within the group will be adopted in order to identify internal heterogeneity. In order to identify the most suitable control group, all the 8000 Italian municipalities have been grouped according to geographical and demographical characteristics. A matching for average housing prices identified the most similar municipalities according to these fixed criteria as: seismic risk, density, altitude, foreign population and mountainous index. The Mahalanobis Distance Matching with Radius Caliper is an accurate method to identify the most suitable control in policy analysis (Iacus et al., 2019) and this is the one in use for this research, because other algorithms (e.g. nearest neighbour[s], caliper, kernel density), were either less time efficient or did not provide significant results. Using a caliper of 0.08 (the smallest giving enough municipalities), the algorithm identifies 496 small municipalities and 5 NUTS-3 capital cities to adopt in the counterfactual analysis for the treated group. The Mahalanobis Distance in Propensity Score Matching identifies the first control group (Rubin 1974; Iacus et al. 2019) The second step is to compare the affected area with its own frontier belts of municipalities, according to Dachis et al. (2012) and Votsis and Perrell (2016) the distance to a policy targeted area can be a good counter indicator for housing market forces. A geographical map of L'Aquila, the Seismic Crater, the other towns affected outside the crater and the border control in use is in Figure 3.3.

FIGURE 3.3: Geographical distribution of L'Aquila and affected municipalities



Furthermore, in an inhomogeneous territory as the one in study, housing market trends could be seriously differentiated. This peculiarity permits to introduce a separation between rural and urban settlements, assessing whether the earthquake and the subsequent reconstruction policies influenced the housing markets with different outcomes. In addition to this, a specific control groups is identified for L'Aquila city with a Synthetic parametric control with nested optimization comprehending a weighted average of all the 110 NUTS-3 capital cities. (Abadie et al., 2010). Table 2 shows a brief description for these three groups in analysis.

TABLE 3.2: Groups description

Group	Municipalities	Population 2016	Obs per year
Seismic Crater	57	140,486	696
Affected Outside Crater	101	626,444	2192
TREATMENT (SC + AOC)	157	766,930	2888
MDM Control	501	3,023,621	7543
Border Control	83	505,699	1813
TOTAL	741	4,926,180	12244

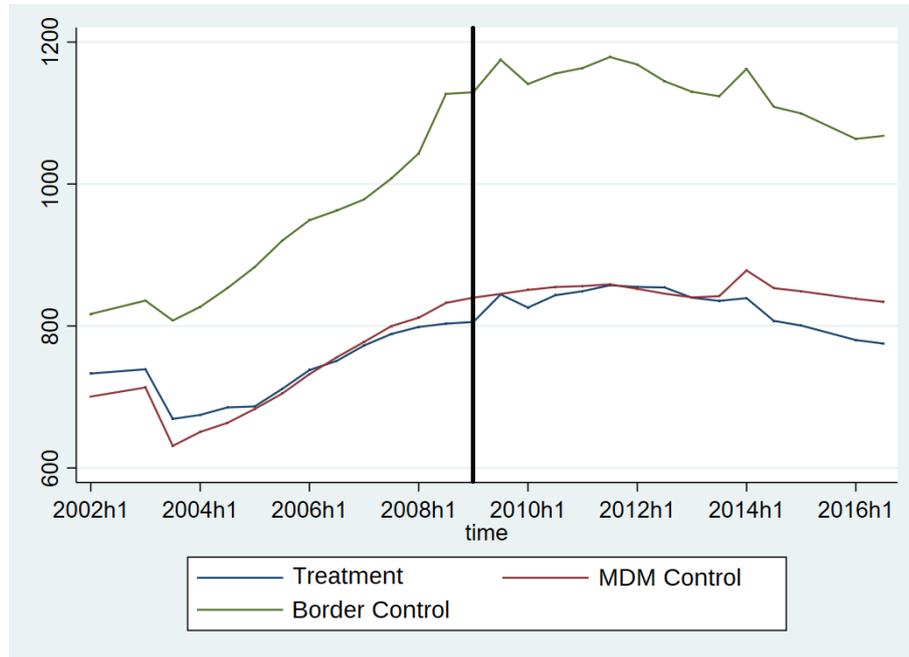
3.6 Results

The first result are the preliminary comparison of the average housing prices between the analysed groups, as in Figure 4 and Figure 5. Figure 4 shows the time series for the three groups in analysis (Treatment area, the Mahalanobis Distance Matching control and the Border control). The left side of the graph illustrates the common trends of the housing prices before the 2009 earthquake and, *de facto*, it proves the consistency of the control groups in use. The right side, beyond the black vertical line, there are the post-earthquake outcomes. Surprisingly, the general trends for the groups are similar, in line with the national trends of declining prices after 2003, a general increase until 2009 and a smooth downward level of prices after the financial crisis. While the Border control (green line) always present a higher level of price compared to the treatment affected area (blue line), mainly due to the presencd of the richer city of Pescara, the MDM control (red line) had a substantial overlapping with the treatment until 2014, when the curves started to diverge but still with a common downward trend.

In first analysis, it appears that the hypothesis of displacement between earthquake crisis and public expenditure took place. It is important to remark, indeed, the fact that a mere comparison of aggregate housing prices can be simplistic and misleading, mainly because the Italian law does not allow to sell damaged houses after an earthquake and this implication blocked the market in several municipalities. The blue line represents, especially until 2013, a very small portion of the overall housing stock, the few building that could have been sold or the municipalities where the market started again. These lack of supply could have triggered internal movement into the affected area, pushing upward the prices just because there were no other options in the area. The following paragraphs will explain in deep these phenomena but the first result is still remarkable: with a strong state support on the supply side, the housing prices do not collapse after an earthquake ³.

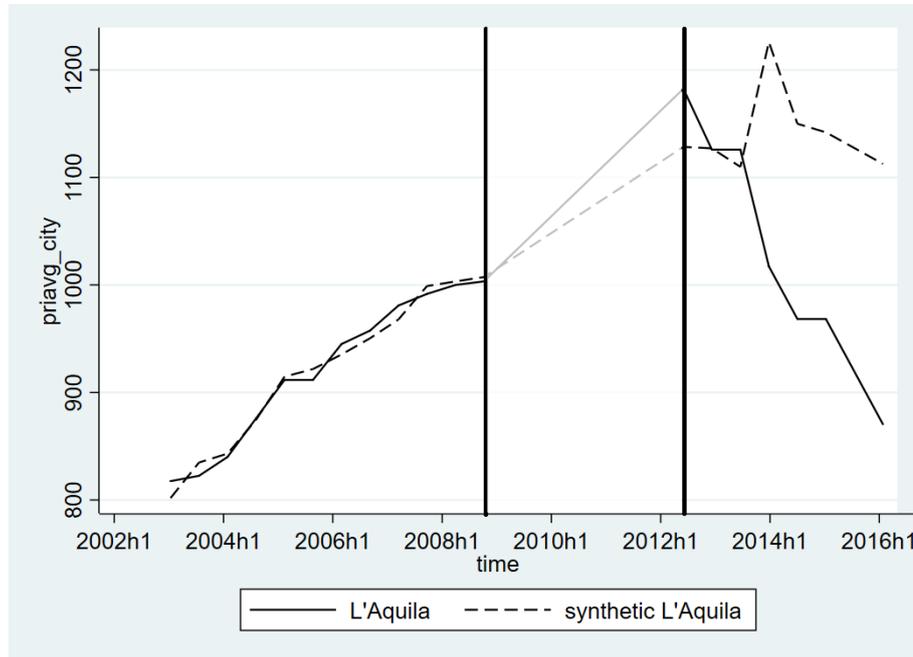
³According to Mora and Reggio (2012), these common trends are tested for linear parallel paths, showing consistent significant results

FIGURE 3.4: Housing price time series per group groups in analysis, vertical line shock at time 2009h1



In Figure 5 there is a focus between the housing prices in the city of L'Aquila and its Synthetic control ones, generated from a weighted average of neighbourhood level prices from all the 110 NUTS-3 level cities in Italy. As expected, the algorithm generated a perfect matching for the pre-earthquake period. When the prices monitoring came back in 2013, the ongoing situation became completely different: after a first moment of better performing, maybe due to a scarce supply and high demand, the two pattern critically diverge. The aggregate L'Aquila housing prices completely collapse. The preliminary results from the urban - and extremely most affected - case show a different pattern from the rest of the affected zone. The following regression table will explain in a more exhaustive way the forthcoming processes.

FIGURE 3.5: Housing price time series for L'Aquila and its Parametric Synthetic Control, vertical lines delimit the shock period



The results of the first counterfactual estimation apparently contradict the graphic specification above. As is depicted in Table 3, the Difference-in-Difference parameter is negative and significant at 99% in both the control groups, with or without the control variables specification. The regression parameter for the shock is misleading, because it absorbs the general higher level of housing prices respect to the pre-crisis period, not adjusted by an inflation in any case very low in the long run. All the explanatory variables respect the hypothesis: the distance from the city centre, the altitude, the classification as *inner area* (municipality distance from a secondary service provider) and the earthquake risk have a negative impact on housing prices while the housing quality and status, the city size and administrative role and population density have a positive impact on prices in both the models. Interesting is the case of the foreign population, that has a positive impact in the larger MDM model and a negative for the Border control model. This can be related to the geographical specificity of the population in study, an higher quota of migrants can be both sign of place attractiveness (migrants want better jobs and better salaries) or unattractiveness (migrants go where the cost of living is lower).

The most interesting result of Table 3 is the Seismic Crater estimator. Contrary to usual common sense, but in line with this paper intuition, housing prices in the most affected and damaged municipalities are relatively higher respect

to the rest of the area. But only after the earthquake, while before the values are consistently lower. This is another insight for the strong impact of the reconstruction funds, even in rational expectations to receive them in a future. It is important to remind these prices are neighbourhood level aggregate, so they do not only reflect the performance of a single housing unit but instead mirror the general behaviour for very small collective geographic units. An increase in neighbourhood level prices can imply a general trust in the reconstruction and regeneration process.

As mentioned before, a general assessment for the whole affected area is important but it can be not sufficient for an exhaustive overview. The large majority of funds financed the Seismic Crater but most of them were for the city of L'Aquila alone. Considering the rural settlements only, all the non NUTS-3 city capitals in the groups, the situation slightly changes.

Table 4 shows a scenario similar with the previous one for all the explanatory variables and for the timing variables. The Diff-in-Diff estimator is still negative and consistent in all the models but the MDM control differs. The overall Treatment estimator is never significant, and it proves the efficiency of the control identification but the Crater parameter is negative, differently from Table 3. The Seismic crater small municipalities received, on average, more than twenty times more funds per capita respect to the municipalities outside the crater but with an extreme internal inequality. With an average public expense of 10,368 € for the whole treated area, the internal distribution is extremely heterogeneous, even inside the Seismic Crater. The prices trend per municipalities too are strongly unbalanced, with the best performance belonging to the close periphery of L'Aquila and to the touristic areas closer to the upper mountains (as Torninparte, Pizzoli, Montorio al Vomano or Rocca di Cambio). The Southern East part of the crater, instead, suffered of a slow but constant depression, both in terms of price declining and population decreasing. These slow trend is common to many Italian rural municipalities that have been unable to catch the economic changes and this depression scenario is reflected in the positive and significant parameter for the Seismic Crater in the Border Control. Most of the border control belongs to the Southern side of the Abruzzo region, a slowly depressed and depopulating area, the better performing of the Seismic crater may exist mainly because of the poor performance of them. In any case, the earthquake funds can have played a deterrent role from not let completely collapse the crater municipalities too.

TABLE 3.3: DiD for average housing price (in log) per OMI neighbourhood - All the municipalities

PR_LOG	MDM Control		Border Control	
	(1)	(2)	(1)	(2)
TREAT	0.0413*** (0.00339)	-0.0139* (0.00788)	-0.220*** (0.00455)	-0.0645*** (0.00904)
SHOCK	0.138*** (0.00277)	0.332*** (0.00710)	0.170*** (0.00519)	0.346*** (0.0115)
Diff-in-DiFF(T#S)	-0.0393*** (0.00494)	-0.0631*** (0.0114)	-0.0717*** (0.00661)	-0.0836*** (0.0143)
CRATER#PRE		-0.0613*** (0.00403)		-0.0168*** (0.00376)
CRATER#POST		0.0507*** (0.00587)		0.0322*** (0.00443)
NUTS-3 city		0.155*** (0.00366)		0.0171*** (0.00427)
DIST		-0.0660*** (0.000522)		-0.0847*** (0.000639)
STAT		0.114*** (0.000607)		0.101*** (0.000727)
QUAL		0.246*** (0.00236)		0.263*** (0.00324)
POP		0.0630*** (0.000952)		0.134*** (0.00143)
FOR_POP		1.764*** (0.0259)		-0.242*** (0.0279)
DENS_POP		0.0436*** (0.00132)		0.00649*** (0.00188)
ALT		-0.0386*** (0.000916)		-0.0171*** (0.00105)
EQ_RK		-0.111*** (0.00140)		-0.0294*** (0.00176)
MOUN		0.00597*** (0.00126)		-0.0423*** (0.00164)
IN_AR		-0.0294*** (0.000883)		-0.0180*** (0.00151)
Constant	6.548*** (0.00197)	5.056*** (0.0169)	6.809*** (0.00362)	5.181*** (0.0226)
Observations	146025	146025	65814	65814
R-squared	0.023	0.615	0.116	0.725

Robust standard errors in bracket. * significant at 90%. ** significant at 95%. *** significant at 99%. Weights per municipal population. Timing and climate parameters significant and not reported

TABLE 3.4: DiD for average housing price (in log) per OMI neighbourhood – Rural Municipalities

PR_LOG	MDM Control		Border Control	
	(1)	(2)	(1)	(2)
TREAT	0.00284 (0.00318)	-0.00984 (0.00781)	-0.275*** (0.00444)	-0.0706*** (0.00901)
SHOCK	0.129*** (0.00260)	0.317*** (0.00706)	0.155*** (0.00527)	0.352*** (0.0117)
Diff-in-DiFF(T#S)	-0.0446*** (0.00460)	-0.0475*** (0.0117)	-0.0709*** (0.00650)	-0.0878*** (0.0147)
CRATER#PRE		-0.0851*** (0.00376)		-0.0115*** (0.00346)
CRATER#POST		-0.0173*** (0.00472)		0.0488*** (0.00439)
DIST		-0.0585*** (0.000532)		-0.0717*** (0.000643)
STAT		0.113*** (0.000625)		0.101*** (0.000762)
QUAL		0.245*** (0.00245)		0.267*** (0.00349)
POP		0.0645*** (0.000954)		0.140*** (0.00139)
FOR_POP		1.742*** (0.0255)		-0.179*** (0.0279)
DENS_POP		0.0462*** (0.00133)		-0.00208 (0.00189)
ALT		-0.0504*** (0.00108)		-0.0225*** (0.00122)
EQ_RK		-0.115*** (0.00141)		-0.0257*** (0.00173)
MOUN		0.0165*** (0.00130)		-0.0393*** (0.00151)
IN_AR		-0.0259*** (0.000899)		-0.0207*** (0.00151)
Constant	6.505*** (0.00183)	5.032*** (0.0169)	6.783*** (0.00359)	5.191*** (0.0226)
Observations	134434	134434	58324	58324
R-squared	0.024	0.556	0.170	0.700

Robust standard errors in bracket. * significant at 90%. ** significant at 95%. *** significant at 99%
Weights per municipal population. Timing and climate parameters significant and not reported

The scenario changes completely when the analysis is focused on the L'Aquila case only, as in Table 5. In these regressions, the historical city centres of all the cities are not taken in analysis, because the L'Aquila ones is still not completely back on the market. Nevertheless, the results for all the other neighbourhoods are completely in line with the theoretical framework in use: the Diff-in-Diff estimator is still negative but inconsistent in the more defined specifications. When the regression is on the Synthetic Control, the simple model (1) reflects indirectly Figure 5, with a clear divergent path of L'Aquila from the control. When the model becomes more specified, these clear downward path are nuanced and the treatment effect is in line with the expectations. Similarly in the case where L'Aquila is compared with its closest 5 Nuts-3 level cities. A possible explanation is in the morphology of L'Aquila municipality: a scarcely populated extremely vast administrative area (474 sq. km), three times the municipality of Milan with the 5% only of its population. In L'Aquila the earthquake mainly affected the medieval city centre, the only one with a proper urban density, and the population sprawled everywhere, waiting for their coming back in town. For this reason it's not easy to compare its housing market, especially without any internal differentiation. In fact, when L'Aquila neighbourhoods are compared with similar neighbourhoods in terms of distance from CBD, the displacement effect of public expenditure on earthquake damages arises again. Concluding, the city of L'Aquila is a peculiar case and it should be studied with a better granularity.

TABLE 3.5: DiD for average housing price (in log) per OMI neighbourhood – L'Aquila case

PR_LOG	Synthetic Control		NUTS - 3 Closest Cities	
	(1)	(2)	(1)	(2)
TREAT	-0.0103 (0.0206)	0.517*** (0.0521)	-0.194*** (0.0201)	0.0480 (0.0528)
SHOCK	0.187*** (0.0107)	0.243*** (0.0255)	0.134*** (0.00938)	0.302*** (0.0211)
Diff-in-DiFF(T#S)	-0.108*** (0.0313)	-0.0215 (0.0571)	-0.0555* (0.0309)	-0.0916 (0.0643)
DIST		-0.238*** (0.00317)		-0.146*** (0.00230)
STAT		0.101*** (0.00295)		0.123*** (0.00195)
QUAL		0.156*** (0.0161)		0.258*** (0.00963)
POP		-0.150*** (0.00804)		0.101*** (0.00748)
FOR_POP		-2.092*** (0.132)		-8.209*** (0.237)
DENS_POP		0.0281*** (0.00938)		
ALT		-0.128*** (0.00397)		
EQ_RK		-0.311*** (0.0127)		
Constant	6.743*** (0.00768)	8.428*** (0.139)	6.927*** (0.00612)	5.936*** (0.0909)
Observations	8501	8501	4791	4791
R-squared	0.069	0.583	0.082	0.756

Robust standard errors in bracket. * significant at 90%. ** significant at 95%.

*** significant at 99%. Historical city centre not in analysis. Timing and climate parameters in appendix A

The last regression table of this Result section investigate the possible displacement effect in analysis from another perspective. While the counterfactual methodologies assess whether the final effects of the public policies on housing price mitigates the effect of the earthquake, in a comparison with similar cases not affected by the disaster; Here the focus is on the direct effect of

public reconstruction funds for private housing on the final selling price. The observations are the same from the previous cases but restricted in time, after the earthquake, and space, only in the treatment area. The neighbourhood housing prices are regressed related to the municipal per capita public expenditure for all the 157 municipalities. The matching is not on the direct neighbourhood expense for data restriction and for absorbing possible spillover effects from municipal policies, as in the case of the Seismic Crater, where municipalities received additional funds for public amenities, for example. The population studied presents a strong heterogeneity in public expenditure. While for the overall expense the city of L'Aquila takes the 80% of funds, the primacy for the per capita expenditure is belonging to the small village of Villa Santa Lucia degli Abruzzi (108 inhabitants), where they received 329,578 € per capita for the private reconstruction only, against the 87,508 € for the city of L'Aquila, 51,559 € for the Seismic Crater on average and just 1,538 € for the municipalities affected outside the crater. But Villa Santa Lucia is not the only case, 11 other municipalities received more than 100,000 € per capita, one of these even being outside the crater.

One of the hardest point is the difficulty to identify a clear difference between private reconstruction costs and reconstruction funds, the data available for the 2009 seismic damages are widely too categorical (in a scale from 1 to 6) and the neighbourhood averages where everywhere very similar, so these are ignored in this analysis. On the other hand, to use the mismatch between requested funds and financed funds can be misleading to, because of possible free-riding implication. The adopted method to overcome this empirical gap is the hypothesis of a quadratic relationship between reconstruction funds and final price, identifying a possible extremum in the function. The results in Table 6 confirm the hypothesis. In the pure linear model (1) and (2), the reconstruction funds estimator changes of sign in the two specification, when in the seismic crater the result is always negative. This should not be easily interpreted as a simple "more funds, less values" but instead as a more difficult ability to intercept the real reconstruction cost in places where the damage has been underestimated. Reading the linear quadratic model, as in specification (4), with a negative inconsistent in the linear term and positive and consistent quadratic term shows an internal local minimum. This U-shape curve describes the initial mismatch between real costs and coverage for the small and less affected municipalities, then becoming more relevant and positive where the earthquake losses were seen as catastrophic and the State intervened more effectively, pushing up the final prices. Not surprisingly,

in specification (4) the significance of the negative parameter for the Seismic Crater decreased.

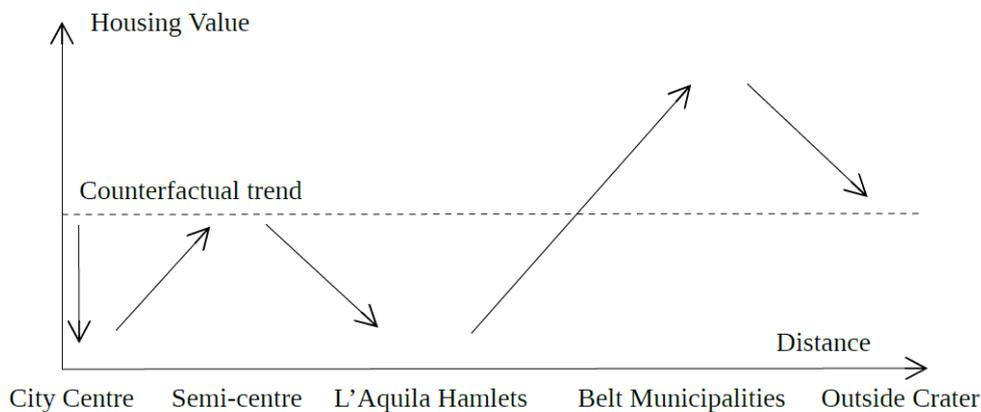
TABLE 3.6: Parametric estimation for public expenditure on treated area (Crater and Affected Outside Crater) housing market after the shock

PR_LOG	Linear		Quadratic	
	(1)	(2)	(3)	(4)
REC_EXP	-0.000776*** (0.000100)	0.000300*** (0.0000801)	-0.00205*** (0.000183)	-0.000211 (0.000150)
REC_EXP^2			0.00000644*** (0.000000878)	0.00000309*** (0.000000631)
CRATER	-0.217*** (0.00726)	-0.0197*** (0.00498)	-0.159*** (0.00791)	-0.00989* (0.00534)
NUTS-3 city		0.117*** (0.00675)		0.124*** (0.00707)
DIST		-0.0759*** (0.00104)		-0.0679*** (0.00107)
STAT		0.109*** (0.00121)		0.108*** (0.00129)
QUAL		0.352*** (0.00788)		0.368*** (0.00745)
POP		0.142*** (0.00258)		0.149*** (0.00260)
FOR_POP		0.354*** (0.0537)		0.630*** (0.0567)
DENS_POP		0.0219*** (0.00351)		0.0111*** (0.00364)
ALT		-0.0109*** (0.00203)		-0.0114*** (0.00211)
EQ_RK		-0.0129*** (0.00313)		0.00872*** (0.00323)
MOUN		-0.0632*** (0.00259)		-0.0643*** (0.00250)
IN_AR		0.0491*** (0.00294)		0.0516*** (0.00297)
Constant	6.751*** (0.00303)	4.846*** (0.0431)	6.680*** (0.00365)	4.787*** (0.0435)
Observations	22997	22997	22997	22997
R-squared	0.054	0.686	0.054	0.655

Robust standard errors in bracket. * significant at 90%. ** significant at 95%. *** significant at 99%
Weights per municipal population. Timing and climate parameters significant and not reported

Concluding, figure 6 presents a graphic representation of the comparison of each sub-group with its own MDM control in the Diff-in-Diff term, starting from the most affected area (the city centre of L'Aquila) and going outside in distance. It is interesting to observe the different "waves" of values going up and down respect to their own counterfactual group. While the city centre of L'Aquila, not surprisingly, still suffer of attractiveness respect to other similar city centres in Italy, its surrounding semi-central areas are in lines with similar neighbourhood, symptom that the more modern and sprawled areas were more resilient and ready to host a sort of run from the city centre. Completely different case for the already mentioned "rural hamlets" inside the administrative border of L'Aquila, there the reconstruction is still far from being over and maybe many of these villages will never come again to life. Opposite to them, the small municipalities surrounding L'Aquila, maybe because of a larger independence in allocation choices, were able both to increase in population and prices, representing the only case were their Diff-in-Diff parameter is consintently positive over all the specification. Going away from the Seismic crater, the negative spillover effects arise again and the many municipalities inside the crater but away from L'Aquila and affected outside the crater deeply suffered the earthquake effect.

FIGURE 3.6: Land Gradient from L'Aquila city centre



3.7 Conclusions

The destruction of a natural phenomenon such an earthquake implies economic effects on the housing market that go far beyond the simple problem of building safety. When a regional socioeconomic system is affected by a disaster, the measures in the medium and long run usually take account of

many economic indicators to understand whether the crisis is over. Post-disaster studies look at the housing market mainly from a private insurance perspective and the risk aversion relied on the demand side. In this paper the scope is to investigate on how the general decline in housing prices after a disaster such an earthquake can be related also to the housing supply. Consequently, to understand if a proper policy on private reconstruction can absorb or displace the negative effect due to the disaster, this paper examined the case of the city of L'Aquila, Italy, In 2009, a massive earthquake in 2009 generated a significant public effort of 6 billions of euro for the private reconstruction only. Results show a clear non collapsing of prices for the affected area but just a small distance to the MDM control and the 83 municipalities outside the area beneficiary of the public policy. The housing prices are constantly decreasing respect to their counterfactuals when going away from the central zones of L'Aquila. Despite the internal trends of "winners" and "losers" of the post-disaster process, it is possible to identify a clear path of depression for those rural areas not able to intercept any touristic flows or not situated in the belt outside from larger municipalities. The massive investment for keeping landowners wealth results effective in the medium run but it can just absorb the effect of an exogenous destruction. There is a general decline for marginal areas (both rural and urban) where there is mainly a simple money transfer is effective but not sufficient.

3.8 References

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4 Land.

Earthquake and Housing demand. A Hedonic Model for Risk Perception, Land Vulnerability and State Intervention in a Post Disaster City

ABSTRACT

Risks related to land vulnerability are common to many human settlements. Earthquakes are one of the most harmful causes related to these risks. The last decades show an increase in new techniques of Seismic Hazard Assessment models, with risk maps on regional and local scale. Some of these techniques, as the NDSHA, can be applied to buildings themselves, giving households a better perception of the risk they are exposed to. Some of these risk assessments maps are precautionary, made to protect cities from possible upcoming disasters. Others are made after a catastrophic event occurred, in order to prepare in case of another disaster. In economics, the best method to assess risk perception over households behaviours is the study of housing prices. The final housing price can be disentangled according to several housing characteristics, it is called the hedonic price model. In this paper, the aim is to define the value given to past and possible future hazards in housing transactions, where the hedonic price model is the best way to understand demand side movements for the housing market of a post-disaster city. L'Aquila, a city in central Italy, was severely hit by an earthquake in 2009. This paper takes as a case study the city of L'Aquila due to its uniqueness, as it is the first case where all the reconstruction process has been state funded and completely recorded. Due to the latter, it is possible to define the land vulnerability, the effective damage after the earthquake and the amount of money spent for the reconstruction for the same housing unit sold. Through these and other earthquake related parameters, as well as normal hedonic factors, it is possible to define the impact of earthquake and reconstruction process on the single households risk perception. Results show a consistent higher value for not reconstructed houses and for low land vulnerability. At the same time, building damage and all the neighbourhood related variable are not consistent when adjusted for the money spent for private reconstruction, the latter provides us insights for a general positive trust of the house owners on the public driven reconstruction.

4.1 Introduction: The land is shaking

Catastrophic events caused by a natural phenomenon (natural disasters) are an increasing problem that societies are dealing with. The increasing urbanisation, the population growth, the soil consumption and the climate change are exposing larger share of population to dangerous events year by year, across

the world (IPCC 2011; 2015; 2019). Natural disasters are not catastrophic by themselves, they are catastrophic when the human settlements facing them are not prepared or excessively vulnerable, they can be considered as “social in nature” (Quarantelli, 1989), so, and a new stream of literature prefers the term “socio-natural disasters” (Arteaga and Ugarte, 2016). Earthquakes are a particular and very interesting case of natural phenomena causing disasters: when they do not induce tsunamis or landslides, the greatest problem are the damage derived from the land shaking, not directly hurting human lives but easily destroying buildings and other human infrastructure (Cassidy, 2013). Our abilities to predict precisely the earthquake incidence are increasing but still not sufficient to evacuate and protect the population. The optimal way to be protected from this, the most harmful natural phenomenon, is the prevention through seismic codes, safe buildings and a proper information to the exposed populations (Pelling, 2003; Cassidy, 2013). Because of this peculiarity, this paper focuses on earthquakes.

Disasters are increasing but in parallel is increasing our awareness and our techniques to be protected from them, Clarke and Dercon (2016) suggest that human society can and should reduce the impact of such catastrophes at almost zero. The issue is not trivial, many scholars (Crespo et al., 2008; Becker and Reusser, 2016) point how disasters can be a great opportunity for renewing regions, especially in developing countries. Cevik and Huang (2018) designed for the IMF a framework for governments suggesting to be financially prepared for catastrophic events, where prevention costs are systematically more effective than the combination of disaster shock and recovery boost, but this latter option should be taken into account when the total prevention is impossible (Schumacher and Stobl, 2011). To confirm the non triviality of this issue, Xu and Lu (2018) suggest to face the dichotomy prevention – recovery also from a theoretical point of view. It is important to remind how most of the advancements in the seismic prevention codes occurred after massive destructive events (Cassidy, 2013) and the study of disaster cases in favour of good prevention practices is not enough. One of the pillars of the prevention from earthquake disasters is the Seismic Hazard Assessment, the exhaustive study of the global and local determinants of a seismic event, both in terms of probability and magnitude of a possible earthquake in a particular area and in terms of direct effects on the inhabited lands affected by the seismic waves (Panza et al., 2011).

There are not univocal methodologies to assess the seismic risk for an area,

the most used one today is the Probabilistic Seismic Hazard Assessment, based on the probability a determinate seismic event occur with a 10% of probability in a time span of 50 years, following the assumption of 475 years seismic cycles (Nekrasova et al., 2013). This static assumption failed many times to predict an earthquake and it revealed itself as dangerous also in earthquake prone areas (Zuccolo et al., 2010). The Neo Deterministic Seismic Hazard Assessment (Panza, 2001) starts from the assumption of the PSHA but implements a more prudential approach, based on the Maximum Credible Earthquake and suggesting to update the hazard maps in a more risk-adverse methodology (Magrin et al., 2017), where the occurrence of an earthquake is taken as given. The NDSHA approach is useful to update microzoning techniques (Parvez and Rosset, 2014), where these techniques are used to map meter by meter particular areas, understanding the local and micro effect a seismic motion can have on the soil, given by the intrinsic characteristics of the land. Neo Deterministic microzoning techniques have been implemented in Sofia and in other cases with good outcomes (Paskaleva et al., 2007). A derivative aspects of the Hazard Assessment is their effect on building safety (Clemente et al., 2015), where a too generous PSHA approach would induce builders to reduce their prevention expenses because an upcoming massive earthquake can be distant in time, while there are no empirical evidences of this cycles (Zuccolo et al., 2008). At the same time, Indirli (2013) remarks how the most suitable earthquake prevention on building can be made on new constructions only and a margin of unsafety will be always left to renewed buildings, as is the case of L'Aquila in Italy. This uncertainty regarding risk models and their effects on buildings in earthquake prone areas can lead to an ambiguous effect on the risk perception of the citizens living those areas, especially in already affected territories (Deng et al., 2015).

The most used method to understand these changes in behaviours is to use the housing price as a proper "thermometer" (Kaklauskas et al., 2015) for populations fears. Households may prefer to abandon areas they consider as too risky, reducing their housing prices as well for limited neighbourhoods as for entire cities (Önder et al., 2005; Timar et al., 2018). These housing price changes for changes in risk perception are not exclusive for earthquakes, housing prices can change for other natural phenomena as floods (Votsis et al. 2015) or for human driven events, as the shale gas drilling (Muhelenbachs et al., 2015). These changes in risk perception can affect also something considering as an amenity, like to live close to a vulnerable hill (Kim et al., 2017) and they can increase urban income inequalities (Maldonado et al.,

2016). It is possible to study other markets, indirectly related to housing, like the labour market (Chang, 2000; Brown et al., 2006; Mehregan et al., 2011). Otherwise, it would be useful to examine more in-depth the housing market, assessing all the characteristics that could determine a final price. A commonly accepted methodology is the hedonic approach (Rosen, 1974; Zabel, 2015) with its price model that considers the final price as a linear vector of several variables, which may be correlated with characteristics related to earthquake risks (Brookshire et al., 1985; Beron, 1997; Naoi et al., 2009). The paper is structured as follows: Section 2 introduces the hedonic price model and it implements the original specification about the risk perception. Section 3 presents the empirical strategy, through a Pooled Ordinary Least Squares regression. Section 4 introduces the case of L'Aquila and it presents the data processing. Section 5 illustrates and discusses the results. Section 6 concludes.

4.2 Hedonic price model: a review

The hedonic approach is based on the assumption that commodity prices can be depicted as a vector of several related characteristics (Goodman, 1998). These characteristics can be either intrinsic or extrinsic and the aim of this approach is to define the impact of some peculiar characteristics on the final price (Lancaster, 1966). Hedonic models first started studying the supply side but this methodology passed early to demand-side studies as well (Rosen, 1974; Epple, 1987). Theory “suggests that the price of a good (house) represent the sum of expenditures on a number of bundled (housing) characteristics, each of which has its own implicit price.” (Brasington and Hite, 2003, p. 59) Theoretically speaking, the hedonic approach is applied in utility maximisation problems that regard housing demand when the Marshallian utility function is determined by a hedonic price function (Rosen, 1974; Goodman, 1988). In an econometric estimation, hedonic models concentrate on parameters determining price elasticity. The most commonly used regressions are linear, log linear or semi-log linear (Mayo, 1980). The housing market has been often studied using hedonic approach because of the relevance of amenities as well as the commodity’s long life span (Nelson, 1978; Can, 1992). For many other markets, the hedonic model approach is considered as unstable and “outdated” (Bartik, 1987; Hirakata, 2005) because of rapid changes, sizes and volatility of most markets, despite some remarkable attempts to improve the methods (Diewert, 2000; Bajari and Benkard, 2005). Indeed, in the housing

market scarce long-distance tradability, the presence of very small supply-side agents (i.e.: owners who are selling) and the long-life span of goods make housing different and still suitable for hedonic analysis (Goodman, 1988; Brasington and Hite, 2003; Zabel, 2015). This ability of the hedonic approach to disentangle characteristics can be very interesting when a product characteristic is affected by uncertainty and complexity (Berlyne, 1970). When the first risk-related behavioural economic studies appeared, hedonic housing price models started adopting them (Ehrlich and Becker, 1972; Kask and Maani, 1992). Housing markets in areas affected by natural disasters have been studied with this hedonic approach for uncertainty (MacDonald, 1987). Parameters related to risk perception and information have often been assessed as relevant when the price elasticity is considered (Brookshire et al., 1985). The risk perception can decrease land values in earthquake exposed areas (Nakagawa et al., 2007). In earthquake affected areas, several pre- and post-event hedonic model research studies show that hazard indices have a significantly negative impact on housing prices in both time periods. In the 1989 earthquake in Loma Prieta (USA) this hazard impact was higher in the pre-earthquake period (Beron et al., 1997) with a drop in housing prices (Murdoch, 1993). Naoi et al (2009) make a relevant contribution to the literature. These researchers applied the hedonic model to the entire Japanese housing market, differentiating for earthquake (at least 6.1 magnitude) affected areas. Their results suggest that the post-quake discounts for property values more than doubled, compared with pre-quake values. They argue that homeowners initially underestimate earthquake risk. Most of the markets studied (USA and Japan) are private reconstruction based even if a state-aid was involved. Current research provides us with results based on wholly public-covered reconstruction in post-earthquake housing markets. Next sections provide a hedonic price model where housing prices are affected (or not) by the perception of earthquake vulnerability in this reconstruction scenario.

4.3 Theoretical model under uncertainty

In continuity with Ehrlich and Becker (1972), Kask and Maani (1992) and Naoi et al. (2009), the Individual utility function can be depicted as:

$$U = U(h, x) \tag{4.1}$$

where h is the vector of household and housing characteristics h_1, \dots, h_n and x is the composite good (with unitary price) numeraire incorporating all the others. Considering the case of an earthquake affected market, there are two possible states, 1 and 0, corresponding to "earthquake" and "no earthquake", in which π is the probability assessed to state 1 occurs. If this probability is objective or subjective is now irrelevant. In the uncertainty condition described, the expected utility function is given by:

$$E(U) = \pi U^1(h_1, x_1) + (1 - \pi)U^0(h_0, x_0) \quad (4.2)$$

where

$$\frac{\delta U}{\delta x} > 0, \frac{\delta^2 U}{\delta x^2} < 0 \text{ and } \frac{\delta U}{\delta h} \neq 0, \frac{\delta^2 U}{\delta h^2} < 0 \quad (4.3)$$

The apex 0 or 1 is always considered as the "no earthquake" or "earthquake" status.

Considering Y as the total household income and L the loss of income in case of earthquake, where $L = Y^0 - Y^1 > 0$. Also, in the hedonic approach, it is suitable to consider the housing demand function as:

$$p = p(h, \pi) \quad (4.4)$$

The budget constraint function is, then, derivable in a linear form:

$$Y = x + p(h, \pi) \quad (4.5)$$

Where x is the numeraire good of price 1, by definition, and the housing demand function is considering earthquake risk.

Substituting, we can derive the Expected Value Function, submitted to maximisation:

$$E(V) = \pi U^1(h_1, Y^1 - p(h, \pi)) + (1 - \pi)U^0(h_0, Y^0 - p(h, \pi)) \quad (4.6)$$

Applying the first-order conditions it is possible to obtain the equilibrium conditions required for optimal levels of the j -th housing specific characteristics and earthquake risk.

$$p_h = \frac{\delta V}{\delta h} = \frac{\pi U_h^1 + (1 - \pi)U_h^0}{\pi U_x^1 + (1 - \pi)U_x^0} \neq 0, \quad (4.7)$$

$$p_\pi = \frac{\delta V}{\delta \pi} = \frac{U^1 - U^0}{\pi U_x^1 + (1 - \pi)U_x^0} < 0 \quad (4.8)$$

Function [4.7] shows that the expected amenity value attributed to housing characteristics and location is reflected in the implicit price. More interesting, the First Order Condition applied considering earthquake risk [4.8] demonstrated the negative relationship of this phenomenon (perception) with the aggregate individual utility. Taking into account the fact that both partial derivatives are divided by the expected marginal utility of numeraire goods consumption, these implicit price estimates provide a convenient way to compute the marginal willingness to pay (MWP) in this simplified situation.

Adjusting for perceived vulnerability

In the previous paragraph, the earthquake risk has been seen as something completely external to model, where the damages affecting properties considered as given, ineluctable. When probability is considered as a degree of belief (De Finetti, 2016), people is worried about possible disruption caused by earthquakes than to the seismic movements themselves (Mulilis, 1990). Considering the safety theory equation: $RISK = HAZARD * VULNERABILITY * EXPOSURE$ (Panza et al., 2011), it can be possible, asymptotically, to depict a zero-vulnerability earthquake model. In this case, individual perceptions are very important. In a society in which disaster policies are almost completely delegated to government, people rely on market goods that are certified and safe. Considering exposure and hazard as external and constant for an housing model, vulnerability is the main issue. That is why it is important to introduce the variable ϕ , the safety perception, in order to update the previous model. Where $0 \leq \phi \leq 1$, 0 is the total destruction case and 1 is the zero-damage scenario. So, the safety is the reciprocal of vulnerability and it is negatively correlated with risk.

Earthquake risk probability function, before as a constant, became

$$\pi = \pi(\phi) \text{ with } \frac{\delta \pi}{\delta \phi} < 0, \frac{\delta^2 \pi}{\delta \phi^2} < 0 \quad (4.9)$$

the hedonic housing demand function [4.4] is as well changing as

$$p = p(h, \phi) \quad (4.10)$$

where ϕ became the vector of all household, housing and location characteristics related to systemic earthquake vulnerability¹.

Adjusting [4.6], in the acknowledgement of Ehrlich and Becker (1972) and Kask and Maani (1992), the new Expected Value Function is represented as

$$E(V) = \pi(\phi)U^1(h_1, Y^1 - p(h, \phi)) + (1 - \pi(\phi))U^0(h_0, Y^0 - p(h, \phi)) \quad (4.11)$$

considered as exogenous for h the adjustment, it is possible to consider unchanged Eq. [6] and applicable the First Order Condition respect to ϕ only.

$$p_\phi = \frac{\delta V}{\delta \phi} = \frac{\frac{\delta \pi}{\delta \phi} U^1 - U^0}{\pi(\phi)U_x^1 + (1 - \pi(\phi))U_x^0} > 0 \quad (4.12)$$

first derivative of π respect to safety perception and the total expected utility loss in case of earthquake are both negative, the incidence of ϕ to demand function and expected utility is positive. The paragraph demonstrated how household, housing and environmental earthquake vulnerability could directly affect the housing market either positively or negatively.

4.4 Empirical Strategy

The primary purpose of the model is to specify the parameter determining the impact of earthquake related variables before and after such event. The estimation model can be written as a semi-log linear regression, common for many hedonic models (Rosen, 1974; Epple, 1987; Diewert, 2003):

$$\text{Log}(Pr_{it}) = \beta_0 + \beta_1 SP_{it} + \beta_2 \bar{P}_{it-1} + \beta_3 RF_{it} + \beta_4 X_{it} + \epsilon_{it}, \epsilon \sim N(0, \sigma^2) \quad (4.13)$$

¹It is important to remark how ϕ is not necessary a "good" variable, in a moral sense. It just represents how the perception of safety could positively affect the housing market. Ignorance about earthquake risk could also be an excellent way to improve ϕ (Sornette, 1997)

Differentiating regression for rental transactions and sales: measured housing prices for households i in time t . SP_{it} is the vector that includes all the vulnerability related variables of buildings and soil (the so-called safety perception), as well as pre-seismic safety classification, reconstruction costs and the damage affection. \bar{P}_{it-1} is the neighbourhood average housing price autoregressive term. RF_{it} is the vector with all the public expenditure for private reconstruction. X_{it} is the vector for all housing and household characteristic not directly earthquake related, the hedonic variables. ϵ is the error term. The standard interpretation for variable parameters concerns their impact on final price. A marginal willingness to pay respect to each variable would be evaluated analysing their sign and statistical significance. Time is evaluated as a categorical variable, making the specifications as Pooled OLS.

4.5 Case Study and Dataset

L'Aquila: the 2009 earthquake

At 3:32 am on April 6th 2009, the city of L'Aquila (Italy) was hit by a 6.3 magnitude earthquake, the highest of a long seismic swarm in those days. 309 inhabitants died, 1600 were injured and about 100,000 were evacuated from L'Aquila and the surrounding municipalities during the following weeks. Together the horrible death toll, the capital loss was enormous and remarkable, mainly in terms of housing (Oecd, 2012). More than 22,000 private houses were damaged, generating a requested reconstruction fund of 8.3 billion euros in the city alone (80% of all the funds for the affected region). Public finance for reconstruction in L'Aquila included not only schools and public offices but also housing units owned and managed by public institutions; the funds necessary have been estimated at one billion euros. Furthermore, the medieval old town, very difficult to rebuild (Alexander, 2009), with its enormous (and unique) historic and artistic heritage, was damaged for about 70% (Alexander, 2010). The subsequent reconstruction process passed through different phases and policies, with a huge media attention. Reconstruction policies didn't always follow a clear scheme. For example, the University of L'Aquila chose not to charge fees to its students for three years, in order to stimulate people to stay (Cerqua and Di Pietro, 2017). At the same time, the municipality adopted a policy of repurchasing the homes of families who wanted to leave the city; about 500 households took advantage of this opportunity (Contreras et al., 2016). In 2010, the Regional Civil Protection Department released a report

for L'Aquila where the municipality's land was mapped according to ground vulnerability criteria (microzoning). Independently from the building situation, the vulnerability is assessed according to geomorphological, kinetic and geophysical values, using a mixed method of probabilistic and deterministic models. For example, if distance to fault and seismic velocity are constant, the areas which are nearer to rivers and which are mostly sandy would be more vulnerable if compared to those near granite lands. In 2012, the USRA (Special Office for L'Aquila Reconstruction) assessed a vulnerability statement for each pre-earthquake building, with a classification from A to F where the first one were the completely safe buildings and the latter were the ones to demolish and rebuild. The majority of L'Aquila buildings were classified as A or B, with an extreme cluster of C and E in the city centre and surrounding areas, the most dense part of the city. Legislation concerning earthquake hazard disclosure and mandatory anti-seismic reconstruction for risky areas is very recent (laws n.136/2004 and n.115/2005). These laws give us the assumption that all housing units sold are considered as legally safe. In 2016, over 20,000 private homes were renovated with the use of more than 3.5 billion euros of government funding.

Dataset processing

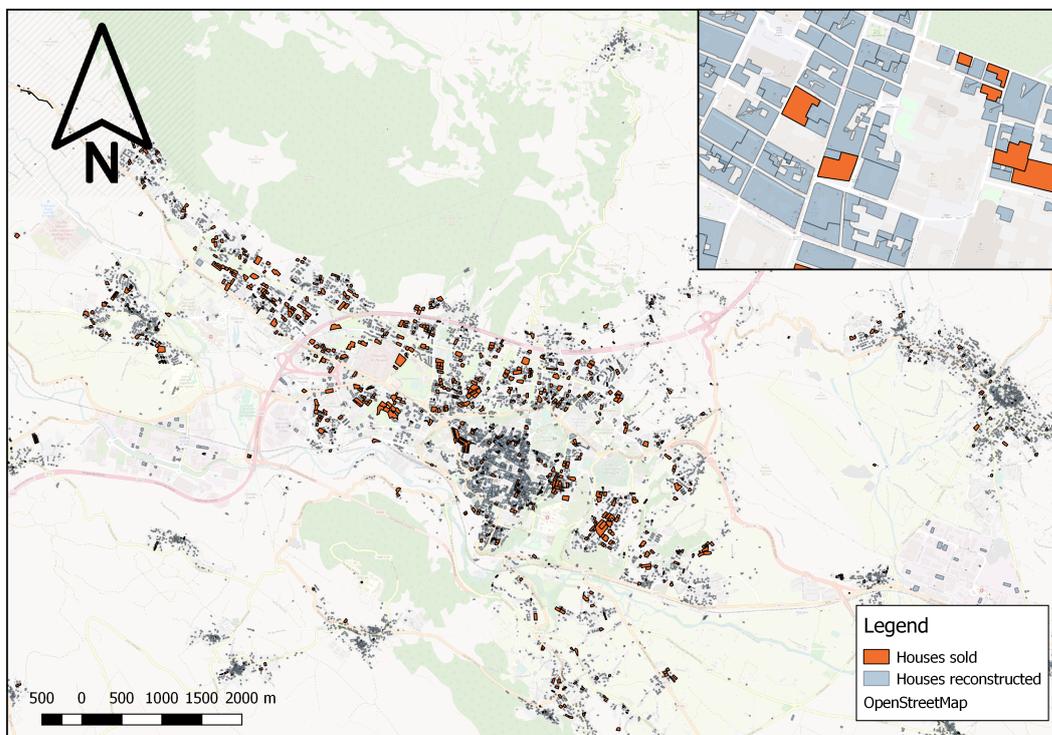
One of the good outcomes of having a complete State funded reconstruction process is the full tracking of every public expenditure. The public database given by the USRA (Special Office for L'Aquila Reconstruction) and its complementary website opendataricostruzione.gssi.it supply all the information concerning the reconstruction process for each of the 20,000 private buildings, as well for the other hundreds of public buildings. This first data source not only provides all the monetary information, but also the buildings damage classification and the land amplification factor, obtained with a microzoning technique. The second main data source is the OMI dataset (Real estate monitor for the National Tax Agency), a special one made for this paper, where every single housing sale in L'Aquila since 2011 is recorded and geolocated with a precision of 20 metres, according the Italian privacy Law, a distance sufficient to match with the building polygons of the Reconstruction dataset. All the other hedonic variables, as the distances from bus stations or industrial areas are taken from the specific pages or subpages from L'Aquila municipality website. The following paragraphs illustrate the specific construction of each variable group, according to our econometric specification [4.13]

The dependant variable of the model is the final (log) housing price, obtained

from the OMI dataset where, for single housing sales contract, the price was cleaned from the values out of range and separated with a dummy from non housing sales (as garages or basements) merged on the same reported price. Prices are then normalised per squared meter. Data are from 2011 to 2017.

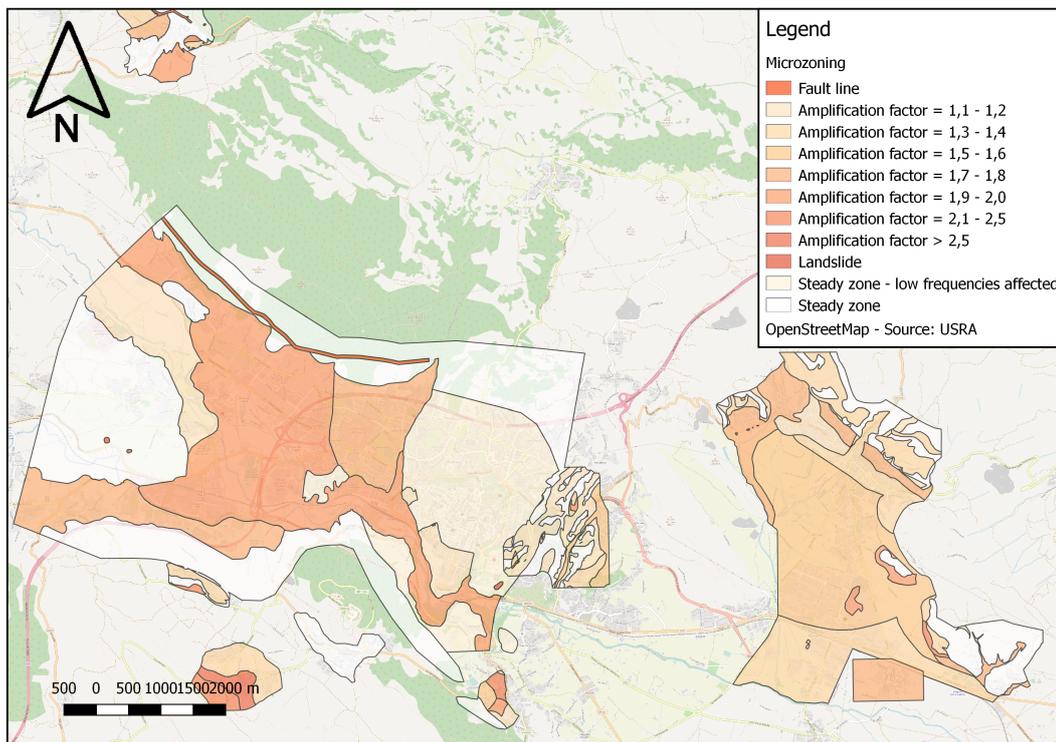
The group of independent earthquake related variables are all depicted from the USRA database. The first one is the damage classification, from A to F, an increasing parameter for each building destruction after the 2009 earthquake. The second vulnerability variable is the land amplification factor, obtained with microzoning techniques, where 100 is set as the safest ground zone and the amplification factor is increasing. Not recorded land zone are considered as a factor of 100. The third variable is the one directly created by USRA, the effective amount of public subsidies financed for private housing reconstruction. The overall amount, for the multi-apartments building, is divided by the number of apartments. The geolocated overlapping of the two main databases (in Figure 4.1) generated the fourth variable of interest: the dichotomous variable for the housing sales not reported in the reconstruction dataset, so the large share of housing units that survived the earthquake or did not need public financing.

FIGURE 4.1: Geolocated representation of the datasets in use



In order to assess the spatial dependant path, in the dataset were introduced

FIGURE 4.2: Microzoning classification for L'Aquila



three neighbourhood related variables: the neighbourhood autoregressive term, the neighbourhood reconstruction path and the neighbourhood reconstruction funds. The objective is to understand how, independently from each housing characteristics, the surrounding processes could affect the housing prices. The neighbourhood is defined as the *foglio catastale* a one squared kilometer cadastral unit. The autoregressive term is simply the average housing prices for the semester preceding the housing sale (time $t-1$), the reconstruction path is the number of ongoing reconstruction sites still not finished at the time t and the neighbourhood reconstruction funds is the gross amount of public funds financed for the all *foglio catastale*.

In the end, as controls are introduced the variables related to the housing unit derived from the OMI database: the already mentioned garage dummy, the number of bedrooms and the housing surfaces. The other controls, the hedonic variables, are taken from their own sources. These variables are: the urban density, the distance from the city centre, the distance from the working poles and four dummies for the presence of a bus station, of a train station, of an industrial area or of a public reconstruction site (as schools, churches, etc). The urban density, is defined by the L'Aquila Master plan in four categories (rural, peripheral, centres, historical centre), interesting is the

fact L'Aquila is a policentric city with more than one city centre, only one third of the municipality inhabitants live in the inner city, while all the rest are in the hamlets each one with its own medieval centre. The second two variables are related to this policentrism, one is the euclidean distance from the historical central crossroad of L'Aquila (*Quattro Cantoni*) and the euclidean distance from the closest of one of the 46 largest (public) firms in L'Aquila. After the earthquake and the destruction of the city centre, many firms were relocated in the peripheries, the land gradient from these working places can be a good hedonic to control from these new temporary city centres.

All the variables in use are summarised in Table 4.1

TABLE 4.1: Summary statistics for data in use

Variable	Description	Mean	Std. Dev.	Min	Max	Source
Dependent Variable						
Price/sqm	Selling price per sqm	1,501,218	1,753,237	1.35	49,796.75	I
Independent Variables						
Damage	Building damage after earthquake, increasing classification	0.04	0.04	0.00	3.00	II
Neigh.Dam	Number of ongoing reconstruction sites at the sale time	8.30	9.78	0.00	1303.00	II
Ground vulnerability	Intrinsic soil amplification factor for seismic shakes (% of best soil)	5.22	1.58	100.00	300.00	II
Not reconstructed	Dummy for houses not in need for reconstruction funds	0.04	0.03	0.00	1.00	II
Autoregressive factor						
Neigh price t ₋₁	Neighborhood average price at time t-1	1,451.21	35.98	1.35	977.35	I
Public expenditure factors						
Building Exp	Public money for single housing unit	541.22	1,350,039	0.00	16,900,000	II
Neigh Exp	Public money for neighborhood	673,751.5	461.39	408.76	3,620,157	II
Hedonic factors						
Rooms	Number of rooms	0.19	0.13	0.00	1.13	I
Surface	Housing surface in sqm	4.84	2.40	2.00	676.00	I
box	dummy for private garage or other non housing surfaces	0.05	0.03	0.00	1.00	I
Urban Density	Neighborhood classification according to the masterplan (from city center to rural)	0.13	0.04	1.00	4.00	III
Distance centre	Euclidean distance from the central crossroad	4,782.55	3,934,248	2.78	20,946.58	III
Min Pole Distance	Euclidean distance from the closest big public working area	1,695.03	1,946,073	0.93	12,399.58	III
Bus	Dummy for bus station at <500 m	0.07	0.01	0.00	1.00	III
Train	Dummy for train station at <1000 m	0.01	0.02	0.00	1.00	III
Industrial	Dummy for industrial district at <1000 m	0.01	0.02	0.00	1.00	III
Public Recon	Dummy for public reconstruction sites (e.g.: schools) at <500 m	0.05	0.03	0.00	1.00	II
Year	time range			2011	2017	I
Sources: I (OMI database) II (USRA database) III (other sources)						

4.6 Results

All the results are reported in a single table [4.2], with the pooled OLS as hedonic regression divided by increasing of variables in the model and the size of the urban area under regression process. The municipality of L'Aquila is not a typical urban area, its surface is about 470 km², three times larger than Milan, with a population of only 70,000 inhabitants. Starting from the 1970s, the population sprawled, lowering the density and increasing the weights in the 59 hamlets of L'Aquila. Nowadays, most of the municipality population is living in the hamlets in a sort of pure rurality or small village lifestyle. For these reasons, the robustness check for the hedonic regression is not only considered for the number of variable in the model but also separated by the whole municipality or the "inner city", the part of L'Aquila can be really considered as the urban centre. Looking at Table 4.2, the first result to observe

is the consistent and significant negative sign for the land vulnerability classification, respect to the state of steady land or not recorded area. Almost in all the specification models, the fact of living in an area more vulnerable has a negative impact on housing prices, despite the magnitude of this vulnerability. The second result, slightly expected, is the combined reading of the housing damage parameters and the public expenditure parameters. In the two specifications without controls and public expenditure covariates, the fact of having a damaged house (categories B,C,D,E,F) has a positive impact on housing prices. When the other variables are implemented, the geographic controls and the public expenditure, this positive effect is annulled, coming to a more expected negative sign, even not significant. The effect of the public euros spent on the single housing units is always positive and significant, while the aggregate reconstruction funds per neighbourhood is mostly negative and not significant. The other neighbourhood parameter (the number of destroyed building at the moment of the housing sale) is ambiguous and almost never significant. The last and interesting parameter to observe is the one for the "survived" and not reconstructed housing units, always positive and significant. For the hedonic variables, not reported in the table, is interesting to remark the strong significance for the housing characteristics and the non significance for the neighbourhood factors, as the presence of a bus stop or an industrial area.

Discussion

The results illustrated above represent some elements of novelty. First of all, with a different size than in Chapter 3, it is proved the displacement effect of the earthquake damage and the reconstruction funds. Before implementing the public expenditure factors, it appears that high level of damage has a positive impact on the final price. This first outcome takes in account the legal binding of a further rebuilding process but it can be misleading to interpret as a pure fact. The majority of most damaged buildings are the historical or high value ones, mainly sited in the city centre or in the historical hamlets. After the geographical controlling, indeed, the damage parameters lose of significance and turn to negative values, as it can be more expectable. More interesting is the impact of public expenditure per house: a positive impact was expected for sure in the case of the datum alone, without implementing the damage classification (as it is in Chapter 3), because more damaged and historical buildings require higher reconstruction effort. The fact that this parameter is still significant and positive even when controlled for the building damage

TABLE 4.2: Risk-related and hedonic determinants on final housing prices in L'Aquila

log Price/sqm	Municipality	Inner City	Municipality	Inner City	Municipality	Inner City
	(1)	(2)	(3)	(4)	(5)	(6)
Land amplification factor						
Low	-0.0455 (0.0388)	-0.0872** (0.0389)	-0.109*** (0.0348)	-0.120*** (0.0363)	-0.101*** (0.0343)	-0.174*** (0.0368)
Medium	-0.124* (0.0727)	0.148** (0.0708)	-0.0721 (0.0488)	-0.0551 (0.0653)	-0.141*** (0.0485)	-0.129** (0.0651)
High	0.00688 (0.0378)	-0.0673* (0.0377)	-0.0774** (0.0365)	-0.0855** (0.0400)	-0.0806** (0.0368)	-0.0286 (0.0446)
Damage						
Low	0.120*** (0.0465)	0.131** (0.0538)	-0.0206 (0.0591)	0.00775 (0.0649)	-0.0334 (0.0558)	0.0174 (0.0606)
Medium	0.0144 (0.0685)	0.0653 (0.0701)	-0.0659 (0.0744)	-0.0725 (0.0794)	-0.0744 (0.0743)	-0.0452 (0.0793)
High	0.136** (0.0543)	0.149** (0.0623)	-0.0705 (0.0767)	-0.0562 (0.0835)	-0.0738 (0.0725)	-0.0178 (0.0784)
Not reconstructed house	0.170*** (0.0459)	0.218*** (0.0550)	0.604*** (0.178)	0.742*** (0.205)	0.323* (0.173)	0.360* (0.201)
Neigh.Dam	0.000246*** (0.0000517)	0.0000847 (0.0000518)	0.0000583 (0.0000472)	0.0000814 (0.0000510)	-0.0000504 (0.0000475)	-0.0000276 (0.0000524)
Public Exp per house	No	No	0.0448*** (0.0164)	0.0516*** (0.0181)	0.0272* (0.0155)	0.0292* (0.0169)
Public Exp per neigh.	No	No	0.0151 (0.0157)	-0.0276 (0.0262)	-0.00349 (0.0175)	-0.0561** (0.0281)
Autoregressive factor	No	No	Yes***	Yes***	Yes***	Yes***
Hedonic factors	No	No	No	No	Yes***	Yes***
Pooled Years	Yes**	Yes***	Yes***	Yes***	Yes***	Yes***
Constant	6.939*** (0.0578)	7.080*** (0.0714)	1.519*** (0.335)	2.966*** (0.555)	2.453*** (0.363)	4.533*** (0.585)
N	2293	1693	2293	1693	2255	1674
R-squared	0.042	0.056	0.358	0.220	0.414	0.295

Robust Standard errors in parentheses. * p0.1 ** p0.05 *** p0.01 (all monetary variables are in natural logarithm)

it can be interpreted as a higher value given to the building safety itself, where, in parity of damage classification, a higher reconstruction cost implies a better reconstruction process, well valued on the market. A different analysis and discussion is applied to the land vulnerability factors (the microzoning): despite the fact the topic is relatively new, not so well communicated and not immediately understandable from the audience, it is clear the households of L'Aquila take in account this factor when they do buy a house. There is a clear understanding of the vulnerability of particular neighbourhoods, even if these land vulnerability maps are difficult to find and landowners are not obliged to disclose such informations when they have to rent or sale an apartment. This understanding can be a key to open a wider public debate about microzoning techniques and to make the topic as more present on press or other issues not only narrowed on a scientific debate between geophysicists. The hazard

coming from living on a not steady soil should not be underestimated and the households in a post-disaster city are aware and they consistently give value to live on a safer land zone.

The results of this paper describe a consistent understanding for private households about their own housing safety. The approach slightly changes when the housing price is analysed in a wider spatial perspective. Of the three neighbourhood-related variable, as it is easy to suppose, the autoregressive parameter is the strongest and more significant. Indeed, great part of the R-squared statistics is given by the impact of the previous semester average neighbourhood housing price. It is a phenomenon completely expected in a normal housing market, it becomes more interesting when related to a post-disaster city. Here, even in the worst situation of physical destruction, the price is still mainly determined by the previous surrounding housing prices, symptom of how adaptive expectations may overcome rational expectations. Rational expectations that the model identify in the other two neighbourhood related variables (hedonic part excluded): the neighbourhood damage (the number of reconstruction sites in the area at the sales time) and the gross amount of public money financed for private reconstruction in the neighbourhood. Differently with the single house case, these two variables have a lower mutual displacement. They are not significant in most of the specifications, the damage is positive and significant in only one model, the less specified and this positive outcome is biased by many factors, while it is non significant in all the others. The public expenditure spatial parameter has an opposite trend, starting as positive and non significant and becoming negative and significant only for the inner city of L'Aquila, where the reconstruction process is still far from ending. This small independence of these neighbourhood parameters towards the final housing prices may signify a general, cautious, trust in the overall reconstruction process. If the neighbourhood is still destroyed but the single house bought is safe, the households pay more attention on this latter, showing a small but consistent hope the overall city reconstruction process will go better in the future.

As final remark of this discussion paragraph there is the most significant result: the clear and unexpected always positive and significant sign for the not reconstructed houses. All the previous words in the housing and urban reconstruction process lose a bit of their value when the attention is posed on the fact the inhabitants of a post-disaster city always prefer to live in a house not affected by the earthquake, no matters the model specification. This is

the greatest alarm for policy makers, the population is aware about the fact a renewed house is always less safe than a new one or a house already safe and tested for an earthquake. If this house survived once, it can survive again, a house already collapsed, may collapse again. The money spent in prevention always repay the investment, at micro as at macro level.

4.7 Conclusions

This article analyses with a hedonic price model the quantitative relationship between housing prices and risk perception in a post-disaster city, such as L'Aquila in Italy. The city has been severely hit by an earthquake in 2009 and, as in many other similar cases, the monitoring of seismic activities and the risk related increased in the following years. In a country where the majority of people, especially away from big cities, live in their own property house, the study of the housing prices is a good method to evaluate the recovery of a territory and the perception of possible future risks. Especially in situations, like the case presented, where the reconstruction process is completely State driven and State funded, so there can be a complete monitoring of the private reconstruction. The focus of the quantitative analysis is posed on few criteria, as the possible displacement on prices of the direct building damage caused by the earthquake and the amount of public money spent for its reconstruction or the new microzonated maps where most of the municipality land has been monitored for possible land vulnerability micro factors of amplification (i.e.: sandy zoned where the land is less resistant than on steady rock) or the simple fact of buying a house who was not affected by any earthquake damage. All of these are corrected for possible spatial dependant trends, as the public funds spent in the entire neighbourhood or the state of its reconstruction or other hedonic variables as the presence of a bus stop or the distance from the city centre. The results indicate a clear and persistent positive impact on prices for the houses that have not been affected by the earthquake at all. The land vulnerability factors, despite their being not so advertised, play also a great role on the housing prices. Neighbourhood spatial effects and the double effect of the earthquake devastation and the subsequent public spending have a good impact on housing prices, even if not majoritarian on the final determinants, nor in a positive nor in a negative sense. The inhabitants of a post-disaster city are caring about their own safety but, at the same time, they put their trust on the final public driven reconstruction process.

Further steps of this research can be a proper policy evaluation framework for the massive state intervention in case of private reconstruction, as well as the role of media related to the risk perception of the future landowners before and after a disaster. The implementation of new hazard assessment techniques, as the NDSHA can be a good starting point for the economic analysis, understanding how a more or a less precautionary risk model can affect the markets. As a final consideration, this paper illustrates clearly how a culture of prevention and a well communicated risk information disclosure can have positive effects on the territorial safety and on households wealth.

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5 Conclusions, what we can do for the future

The purpose of this thesis was to define the work, housing and vulnerability of the land as the three pillars on which to intervene in a post-disaster area, as well as for other territories that are still safe but risky and in decline, implicitly suggesting these as new parameters for local development. The first chapter is a comparison between Ecuador, Chile and Italy regarding the regional post-earthquake labour market. The three short-term workforce surveys are compared, finding the different pre-shock determinants of having a job, an increase in wages or in working hours after the earthquake. Salary distributions are also compared in quantile estimations, including which segments of the population are losing or gaining purchasing power after the disaster. The results show that women and uneducated people suffer most from the state of emergency and, surprisingly, construction workers are not the ones who are gaining from the disaster. The second chapter explores the impact on housing prices of the double shock caused by the 2009 L'Aquila earthquake in Italy and the subsequent reconstruction process financed with public funds. The research adopts a difference in difference approach, using as controls for rural municipalities a Mahalanobis Distance Matching and a border control and a synthetic parametric control for the city of L'Aquila. The results show that the relationship between subsidies for reconstruction and housing prices is positive and quadratic. For rural municipalities that do not depopulate the public spending more than absorb the shock of the catastrophe, with several territorial disparities. The third chapter focuses on the local implication of risk perception on housing prices. Using only the municipality of L'Aquila as a case study, every single post-disaster housing transaction is analysed in a hedonic model. Each housing price is then broken down according to its vulnerability to the land, seismic damage and reconstruction funds. The results show an increasingly higher value for the non-reconstructed houses and for the low soil vulnerability. Building damage and all neighbourhood-related variables are inconsistent if adequate to the money spent on private

reconstruction, the latter providing us ideas for a general positive confidence of homeowners in public-led reconstruction. Summarizing the results of each document, the state intervention can absorb much of the seismic shock but it is extremely expensive and the benefits are always strongly polarized within the local communities, increasing inequalities and causing expulsions from the original territories, in the short and the long term. Earthquakes like any other disaster can be an opportunity to regenerate a lagging territory only if the processes are well managed and well monitored. The best option, both in terms of public expenditure and household wealth, is always to prevent any possible risk and create solid endogenous growth.

Summarising these heterogeneous assessment we can find a double insight for future researches: there is space for a better preventive modelling and for a deeper post-disaster policy evaluation. At the same time, this thesis can indicate a new path for regional development theory, where the focus on households can help to avoid measures that do not bring a good impact on the territories. As mentioned in the theoretical model in Chapter 3, the simplified budget constraint for households is the sum of the wage received and the housing value. These two indicators, joint in a composite one or separated, can be a good outcome to understand the economic health of a territory. In a moment of currency stability, and considering the recent empirical rejection of the Philips Curve, the level of wages in a particular territory can be a good indicator for the state of the local work system. The housing price, positively affected by the wage level but not completely, is an indicator that internalise many of the other good parameter of a local economy, such the quality of life or the attractiveness of a place from many point of view. Both of them are physical and easily measurable indicators and they are rooted in the territory, they cannot be displaced as the firms profits or taking account of immaterial assets as the local GDP (almost always just the sum of the declared income of the inhabitants of a place). In addition to these, a good measurement for the risk prevention, can be the public expenditure for the local risk reduction, adjusted for other indicators. Beyond this suggestion about how to change the method we look at local development, this thesis indicates how scholars and policy makers should improve their modelling for disaster prone areas, an ongoing topic in these years that should be more harmonious between the different needs the involved agents of a vulnerable areas can have. Disciplines should be more interactive and the new methodologies (like the OASIS) for disaster risk reduction can be more aware to the social risk a bad disaster management can bring, when it is settled towards the needs of minoritarian

elites. The post-disaster policy evaluation frameworks should be updated to the complexity the new globalised world, trying to be independent from short-run electoral advantages and trying to have a longer perspective for the needs of the excluded people. The problem of uprising inequalities found its paradigm in the study of disasters, in order to relieve them it is not just sufficient to measure them as best as possible, it is important to design new indicators giving merit to the factors are erasing them. A new society free from inequalities and disasters is still possible.

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