UNIVERSITÀ
DEGLI STUDI
FIRENZE

# DOTTORATO DI RICERCA IN ECONOMIA

CICLO XXIX

COORDINATORE Prof. Donato Romano

# ADAPTIVE RESILIENCE AND NATURAL DISASTERS: THE CASE OF EARTHQUAKES IN JAPAN

Settore Scientifico Disciplinare
SECS-P/08 Economia e gestione delle imprese

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Anni 2013/2016

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## Abstract

One of the intrinsic elements of modern economic systems is change. But over the last few years, this constant element is accelerating as a consequence of the rising of major shocks that periodically have disturbed the growth path of regional and urban economies. These perturbations can be ascribed both to the continuing evolution of the economic context and to sudden disturbances, as social, economic and environmental shocks.

Since the early research of resilience in ecology in the 1970s, definitions emerged and proliferated contributing to define a theory of resilience but increasing criticism and uncertainty about the theoretical value of the concept. When this criticism was raised, a part of scholars in Evolutionary Economic Geography proposed a new theory of regional economic resilience focusing on resilience through an evolutionary approach. According to this vision, resilience relates to "adaptive ability", the capacity of a system to change its structure and functions to cope with external pressures. This notion may contribute to explain the evolution of the system clarifying the attitude of some regions to reorganize and renew in responding to a shock. Several studies focused on adaptive resilience as the capacity of regions to cope with economic crisis but we do not have exhaustive knowledge of the ability of recovering and changing after natural shocks.

In accordance with such reflection, the thesis wants to study the adaptive resilience of economies in response to natural shocks. In the first part, principal definitions of resilience among different disciplines are revised. Special attention is paid to approaches and definitions in evolutionary economic geography. In the research design this framework is applied to the field of natural disasters underling gaps of the literature, questions and hypotheses of the research. The last part of the thesis is an empirical application of the theoretical insight of evolutionary economic geography to investigate adaptive resilience in face of major earthquakes occurred in Japan. Measurement of resistance and recovery indices may provide information of the ability of economic systems to respond

to environmental shocks in the short-term returning to a growth path already conceived. The analysis of the case of Kobe may include important reflections on the long-term implications of natural disasters highlighting the ability of economic systems to change economic structure and promote the innovation activating process of adaptation and adaptability. The aim of the thesis is to demonstrate that sudden interruptions, as natural shocks, can favour processes of adjustment able to promote both the rejuvenation of existing path and the creation of new trajectories of local development.

## Abstract

I moderni sistemi economici sono in continuo cambiamento. In anni recenti, tuttavia, si è assistito ad un'accelerazione di tali dinamiche dovuta alle crescenti perturbazioni cui sono state oggetto economie nazionali, regionali e urbane. Se una parte di tali disturbi può essere ricondotta all'intrinseca evoluzione del contesto economico, un'altra parte deriva da improvvise interruzioni di tale flusso legate a disastri ambientali, perturbazioni economiche e shock sociali. Questo nuovo scenario, caratterizzato da una crescente incertezza, ha portato un rinato interesse per i temi legati allo studio della resilienza dei sistemi.

A partire dai primi lavori degli anni '70 sulla resilienza degli ecosistemi, le definizioni e le applicazioni del concetto sono proliferate contribuendo alla creazione di una teoria della resilienza ma, allo stesso tempo, indebolendo la validità teorica del concetto.

Una parte di studi nell'ambito dell'*Evolutionary Economic Geography* si è focalizzata sul tema al fine di contribuire allo sviluppo di una teoria della resilienza che potesse spiegare l'evoluzione dei sistemi economici in risposta agli shock esogeni. Sulla base di tale visione, la resilienza è legata alla "capacità di adattamento" dei sistemi economici, la capacità di modificare la propria struttura e le proprie funzioni per far fronte alle pressioni esterne. Tale definizione può contribuire a spiegare l'evoluzione dei sistemi chiarendo la propensione di alcune economie a riorganizzarsi e rinnovarsi a seguito di uno shock esterno. Gli studi sulla resilienza adattiva, tuttavia, si sono ampiamente focalizzati sulla capacità di città e regioni di affrontare shock di tipo economico mentre lo studio della resilienza in risposta al verificarsi di shock naturali resta ancora un campo poco discusso.

Alla luce di tali considerazioni, la tesi si propone di studiare la resilienza adattiva in risposta agli shock naturali.

Nella prima parte del lavoro, sarà esposta una rassegna delle principali definizioni di resilienza in diverse discipline. Particolare attenzione è rivolta agli

approcci e alle definizioni discusse in ambito evolutivo. Nel *research design* tale quadro sarà rivisto e applicato al campo dei disastri naturali, evidenziando le principali lacune della letteratura ed esaminando le domande e le ipotesi della ricerca. L'ultima parte della tesi cercherà di testare empiricamente la teoria della resilienza adattiva attraverso un'analisi dei maggiori terremoti avvenuti in Giappone. Il fine sarà quello di studiare la risposta delle economie Giapponesi ai terremoti cercando di comprende sia la capacità di resistere a tali shock, sia eventuali nuove traiettorie create a seguito dei disastri. Per raggiungere tali obiettivi, una prima applicazione empirica verterà sulla costruzione di due indici volti a misurare l'impatto economico dei terremoti sull'occupazione delle prefetture Giapponesi colpite. La seconda analisi si incentrerà sul caso di studio della città Kobe, distrutta da un violento terremoto nel 1995, al fine di comprendere quali siano state implicazioni di lungo periodo del disastro. Attraverso i concetti di *adaptation* e *adaptability*, tale analisi cercherà di comprendere la capacità dei sistemi di riorganizzare la propria struttura economica e promuovere l'innovazione.

Lo scopo della tesi è quello di dimostrare che disturbi improvvisi, come gli shock naturali, possono favorire processi di riorganizzazione in grado di promuovere sia il riadattamento di percorsi di crescita esistenti sia la creazione di nuove traiettorie di sviluppo.

## Acknowledgement

This thesis represents the conclusion of an important period, not just for the opportunity of professional growth but also in relation to an important personal enrichment. It is for this reason that I would like to extend thanks to the many people, in different countries, who generously contributed to the work presented in this thesis.

First, I want to thank my tutor, Prof. Luciana Lazzeretti, for her precious advice and support during the whole PhD period but also for her constant enthusiasm and motivation in the research activity that she has taught me.

I am also thankful to Prof. James Simmie for our long discussions and his precious suggestions during my period at Oxford Brookes University. I am grateful to some Scholars who I was lucky enough to meet during the Oxford period. Special thank goes to Prof. Philip Cooke, Prof. Ron Martin and Prof. Andy Pratt that gave me important suggestions to address my work.

Similar, profound gratitude goes to Prof. Sasaki for the wonderful period spent at the Osaka City University to collect the data necessary to the empirical part of the thesis. I extend thanks also to all the Professors and colleges of URP office who help me with my research and my Japanese life.

I am grateful to the PhD coordinator, Prof. Donato Romano, and to the Professors of the Doctoral Committee for the advice and teachings that provided the basis of the doctoral course.

Also, I want to thank Dr. Francesco Capone and Dr. Niccolò Innocenti for their support during the drafting of the thesis.

A big thank you goes to all my colleagues and friends of the PhD course with whom I shared this important experience.

Finally, I would like to thank my family and friends for their inexhaustible support and patience.

## Abbreviations

| | |
|---|---|
| ADRC | Asian Disaster Reduction Centre |
| CRED | Centre for Research on the Epidemiology of Disasters |
| EEG | Evolutionary Economic Geography |
| EM-DAT | Emergency Disasters Data Base |
| GDP | Gross Domestic Product |
| GRP | Gross Regional Product |
| ISDR | International Strategy for Disaster Reduction |
| NCEI | National Centre for Environmental Information |
| NOAA | National Oceanic and Atmospheric Administration |
| NPOs | Non-Profit Organizations |
| OECD | Organization for economic cooperation and development |
| SESs | Socio-Ecological Systems |
| UN | United Nations |
| UNCRD | United Nations Centre for Regional Development |
| UNDESA | United Nation Department of Economic and Social Affairs |
| UNPD | United Nations Development Programme |
| WCED | World Commission on Environment and Development |

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## Glossary of Japanese Terms

| | |
|---|---|
| *Bijutsu* | Art |
| *Gijutsu* | Technology |
| *Kagaku* | Science |
| *Kiki* | Crisis |
| *Machizukuri kyogikai* | Local association for urban planning |
| *Monozukuri* | Manufacturing |
| *Namazu* | Giant catfish belonging to Japanese popular tradition and considered as responsible for earthquakes |
| *Setsuzoku* | Ties, connections |
| *Shimbashira* | Pillar of Japanese cypress constructed to maintain the stability of tall buildings |
| *Shūshin koyō* | Lifetime employment |
| *Tō* | Pagoda, tower with multiple eaves |
| *Toshikeikaku* | Urban planning |

The Japanese word *kiki* means crisis.
It is composed of two characters:
"danger" and "opportunity".
This reveals the wise Oriental insight that
a crisis is an opportunity for prosperity.

# Introduction

The thesis wants to investigate the relationship between resilience, natural disasters and economic change analysing how economies respond to environmental pressures, actors and resources involved in this process.

Over the last two decades, a global goal has been the achieving of a harmonic development between economic, social and environmental systems. It has been called "sustainable development" (WCED, 1987) and it has been aimed to maintain a balance between economic, social and environmental components of the global system to reach higher levels of wellbeing.

In recent years, however, financial crisis, natural shocks and social instability have increased the uncertainty of the contemporary economic scenario paying attention to the impossibility to perpetuate the equilibrium required from the notion of sustainability. Finding a new approach in understanding and supporting development become a priority.

When this new scenario has emerged, the notion of resilience has found its fortune and has become a guidance in navigating this increasingly uncertain world. Resilience reflects the idea of a development able to overcome crisis, interconnecting the past trajectories with the new possibilities created by the shocks (Martin, 2012; Martin *et al.*, 2015; Hu and Hassink, 2015). It is a powerful concept because it links together different scales of the human system - economic, social and environmental - acknowledging their fragility. It evidences the impossibility to guarantee a balance between the different components of systems and the need of managing resources in uncertain circumstances. Moreover, it emphasizes the continuing evolution of systems (Simmie and Martin, 2010).

In the last ten years, the issue of resilience has become one if the major topics in different disciplines and a watchword for several policies and governments (Adger *et al.* 2002; Luthans, 2002; Rose, 2004; Resilience Alliance, 2007; OECD, 2016).

The World Economic Forum of 2013 focused on "Resilient Dynamism" and the recent global, regional and industrial transformations in response to uncertainty and risk. In the same year, the inaugural address of US President Barack Obama recalled the resilience of American people in coping with crisis. The United Nation Development Programme (UNDP) has highlighted the importance to look at vulnerability and resilience through a human development lens in order to understand why some societies recover quicker than others in the face of adverse events.

> "*There is much debate about the meaning of resilience, but our emphasis is on human resilience—ensuring that people's choices are robust, now and in the future, and enabling people to cope and adjust to adverse events*" (UNDP, 2014, p.1).

On the European side, the Cohesion Policy for 2014-2020 expects to strengthen the resilience of cities by promoting integrated strategies to enhance a sustainable urban development.

If resilience has been the goal of policies in last decade, also Academia has discussed the topic analysing resilience in several disciplines. From ecology to architecture and engineering, from studies of organizations and emergency management to psychology, many areas of study used the concept to explain phenomena related to different fields, enriching the topic with several definitions. The emergence of a number of scientific publications and books related to issue of resilience confirms this renovated enthusiasm.

This Special Issue on "Exploring Resilience in Social-Ecological Systems" (2006) of *Ecology and Society* proposed an enlargement of the study of resilience defining and applying theories in interlinked systems of people and ecosystems, with expansions in social science. The edition of *Cambridge Journal of Regions, Economy and Society* titled "The resilient region" (2010) was devoted to examining regional resilience in order to identify the theoretical foundations and the empirical evidence of the concept in building a theory for regional science.

Cooke, Parrilli and Curbelo (2012), in the book *Innovation, Global Change and Territorial Resilience* tried to address the debate concerning the ability of local and national territories to increase their resilience improving their competitiveness and their capability to innovate in the context of global change. The Special Issue of *City culture and Society* edited by Lazzeretti and Cooke (2015), focused on the understating of urban and regional economic resilience reflecting on the role of resilient and creative city.

However, alongside this increasing enthusiasm and confidence in the possibility of an alternative resilient development, a general criticism started to take hold. Several doubts relate to the lack of a clear definition of resilience and the inability of classical definitions to explain the continuing evolution of the economic system. Another part of criticism refers to the "neoliberal" attitude of resilience (MacKinnon and Derickson, 2013) which involves the reaching of a resilient development as a top-down strategy and increases competition between territories. The concept of resilience has quickly infiltrated many areas of policy decision. According to a sceptical vision, the success of the concept reflects its proximity to the neoliberalism and emphasizes the need to promote economic growth as the solution to the problems of the contemporary economic scenario. Furthermore, resilience seems the latest of a series of naturalistic metaphors applied to the study of regional economies, which had the effect of disconnecting cities and regions from important determinants of human systems. It is a static concept and if it should be applied to social sciences, it could encourage the adoption of unequal social structures. Finally, despite positive reactions to shocks have been widely discussed in literature, poor attention is paid on those cases that can be defined as "unresilient spaces", underling that a process of "arrested dialectic" contribute to a stasis in the academic debate of resilience (Cooke, 2017).

Resilience of New Orleans in coping with the hurricane Katrina has largely been discussed (Campanella, 2006) but there has been lower interest in analysing cases of abandoned cities after the occurrence of a disaster. Ghost cities are less

attractive than modern and stylish reconstructed urban centres. However, to understand the reasons which made these places "unresilient" is as important as understanding the remarkable resilience of successful cases.

Evidence suggests that socio-economic resilience is not absent of failures.

> "*Thus academia is, not for the first time, trapped by 'resilience' in its own addiction to optimism rather than a more balanced realism" (*Cooke, 2017, p. 4).

Although such criticism, the notion of resilience can be a useful concept in order to study evolution and changes in the face of major shocks. It can provide a valid support in identifying the features that make a place able to overcome negative consequences of a shock and can help in comparing different responses to similar scenarios. These goals can be achieved as long as a punctual framework of resilience is proposed in order to attenuate the ambiguity of the concept.

In the field of regional studies, scholars of Evolutionary Economic Geography (EEG) tried to build the basis for a new theory of resilience overcoming the criticism of ecological and engineering visions and proposing an evolutive approach to resilience (Pike *et al.*, 2010; Simmie and Martin, 2010; Martin, 2012; Porter *et al.*, 2013; Pratt, 2015). Despite these efforts, a number of gaps can be underlined in this new framework.

First, while studying economic shocks is common, there is less interest in studying relationships between resilience, natural disasters and economic change. This is an important lack in order to build a strong theory of resilience. A conclusive theory should analyse the economic system in a holistic vision. Moreover, in relation to the increase of natural shocks in the contemporary scenario and the consequent effects on the economic sphere, environment cannot play a secondary role.

Second, the incidence of historical conditions in the creation of new trajectories are still under-researched (Martin *et al.*, 2015). In specific

circumstances, historical conditions may be an opportunity to induce a re-orientation of technologies, capabilities and institutions (Boschma, 2015).

Finally, it is still missing a theory of factors that affect resilience. Generally speaking, the problem concerns if specific behaviour, resources or actors can affect resilience. On the one hand, some scholars suggest that innovation, creative and cultural resources can have a positive impact on resilience. Balland *et al.* (2015) suggest that resilience can be defined as the ability to generate new technological knowledge in the long-term. Some empirical researches evidence that creative workers can be more prone to respond to crisis (De Propris, 2013) while a large part of successful cities host a high number of people employed in creative activities (Comunian and Faggian, 2011). Furthermore, Boix *et al.* (2017) suggest that urban redevelopment through creativity can improve the responsiveness to shock if it is correctly integrated with the rest of the city. Sasaki (2010) argues that creativity can involve social inclusion making territories more resilient and less vulnerable. Vecco and Srakar (2017) underline how the economy of event can improve the resilience of touristic places in small towns. On the other hand, decisions of policy makers and institutions can influence the ability of a system to respond to a shock (Martin and Sunley, 2015). Moreover, although agents react in similar ways to similar shocks, the meaning and the effect of such actions may be influenced by unique and "path dependent" features of system (Bristow and Healy, 2015).

Despite such efforts, the analysis of systems components able to improve resilience is still un-researched.

Based on these research gaps, the thesis aims to advance the understanding of the resilience of economies in response to natural disasters and identify resources and actors involved in the process. The purpose of the thesis is to enlarge the knowledge in understanding the relationship between resilience, natural disasters and economic change. The thesis is framed in the field of EEG and would be an advancement in studying the evolutionary dynamics originated in economic systems in response to external pressure.

Thus, the research wants achieve the following objectives:

1) To identify a framework to study economic resilience in relation to change and transformation of systems as a consequence of shocks.

2) To test on case studies the efficacy of the framework for the purpose of identifying conditions for resilience.

3) To identify the transformations, innovations and new trajectories originated in cities after the occurrence of a shock.

4) To understand actors involved in the generation of new trajectories and how they can positively affect resilience.

5) To propose a measure of resilience in relation to natural shocks.

To achieve these objectives, the thesis wants to respond to the following general research questions:

- *"What is the relation between resilience, natural disasters and the creation of new trajectories?"*

There is a wide debate concerning the economic effects of natural disasters and how these effects can influence the performance of systems. Two main contrasting positions discuss effects of natural disasters on economy. On the one hand, a negative effect of environmental shocks on performance is highlighted and, on the other hand, it is asserted a general low incidence of natural disasters on economic growth. Although the interest of this debate, scholars of resilience have not widely considered repercussion of natural shocks on resilience and evolution of regional economies.

To contribute to answer this general question, the thesis wants to address three specific questions related to the research gaps identified in the literature review:

- *"How can resilience in response to natural shocks be evaluated?"*
- *"Can new trajectories be created after a natural shock?"*

- *"Which is the role of social, institutional and economic actors and resources of the system in fostering resilience?"*

To address these questions, the thesis proposes to study the relationship between resilience, natural disasters and economic change through the case of earthquakes in Japan.

According to data provided by the Asian disaster reduction centre (ADRC) natural shocks have risen in the last twenty years. Especially earthquakes have increased from 1960s until today. In some cases, the economic damage caused by earthquakes has suffered from a slow recovery in relation to the global economic crisis started in 2008. In the last few years, with the perpetual of the negative trend due to the crisis, effects of natural disasters intercept and overlap those of economy making more dangerous the precarious economic scenarios.

Japan is one of the countries that have the highest number of seismic events because of its dangerous position in one of the areas with the greatest risk of earthquakes in the world. At the same time, it is one of the more advanced economies in the study of earthquake prevention and disaster management. A preliminary investigation has counted about 51 institutions, including universities and research centres, engaged on several fronts in the study of earthquakes, while about 66% of the registered patent in the field of earthquake-resistant buildings belongs to Japanese inventors.

Thus, the case of earthquakes in Japan appears as an interesting context to evaluate resilience in order to understand if phenomena of recovery, structural adjustment or development of new trajectories emerged as a consequence of natural shocks.

The thesis is structured in five chapters. The first chapter wants to introduce the notion of resilience starting from the classical definitions adopted in literature among different disciplines. Definitions and measurements will be critically discussed through an analysis of the principal criticisms highlighted in literature.

This first chapter will lead towards the definition of resilience as theorized in EEG in the second chapter. Main approaches in studying resilience in the evolutionary framework will be discussed and, finally, notions of adaptation and adaptability will be introduced as lens to evaluate resilience in systems. The final part of the chapter will discuss of measurements adopted to evaluate resilience in the field of EEG.

Following the discussion of the main literature of resilience, the third chapter will introduce the research design. It will be highlighted gaps of the literature, discussed research questions and hypotheses of the research. It will be introduced the methodology applied to study resilience. After a brief discussion about main methodologies applied to study natural disasters and particularly earthquakes, will be defined the methodology to build recovery and resistance indices to evaluate resilience of Japanese prefectures to earthquakes. Finally, it will be discussed the methodology used to build the case of study of the recovery of Kobe after the Great Hanshin Earthquake of 1995.

The fourth chapter will focus on the measurement of resilience through an analysis of the major earthquakes in Japan. A discussion of natural disasters in Japan will introduce the topic. It will be discussed the methodology in the context of earthquakes evaluating changes in employment in relation to the occurrence of the shock. In the final part, a discussion around each single earthquake will try to intercept relationships between earthquakes and economic performance.

The final chapter will analyse the case of Kobe and its recovery after the Great Hanshin earthquake of 1995. The case study will be debated through a context analysis of the main features of the city of Kobe before the earthquake and a specific analysis of the effects of the disaster. Finally, main trajectories of change will be analysed through the processes of adaptation and adaptability in order to understand if the city had resiliently responded to the shock.

The conclusion of the thesis will debate of the key findings of the research and the theoretical contribution to the literature. To a complete dissertation of

the research, main limitations will be exposed and ideas for future researches will be proposed.

The redaction of the thesis had two main and fundamental steps. The draft of the theoretical chapter benefits from a visiting period at the Department of Planning of the Oxford Brookes University from April 2015 to September 2015. During the research period, literature of resilience has been analysed. Moreover, through the participation in several conferences, it has been possible to enrich the theoretical framework with a critical analysis. Finally, during that period, the possibility to discuss the topic with some scholars in Evolutionary Economic Geography improved and enlarged the theoretical framework.

The empirical application benefits from a visiting period at the Urban Research Plaza[1], at the Osaka City University, from October 2015 to January 2016. During this period, data and information has been collected and provided the basis for developing the application of the theoretical framework to the Japanese case. The period in Osaka was an opportunity to visit several times the city of Kobe to get interviews, collect documents and have a real perception of the changes which occurred in the city following the earthquake. Moreover, during the period in Japan a visit to the district of Tohoku was the chance to get information on the earthquake which occurred in 2011 and to reflect about comparison between different effects and reactions to seismic events.

[1] The URP is research institution specialized in different field of the urban studies.

# 1 Resilience: origins, definitions and critiques

## 1.1 Introduction

In recent decades, external shocks have become more common both in developed and developing countries leading to an increase of analyses devoted to understand the capacity of individuals, communities and regions to respond to negative events. The basic idea of these analyses was to try to understand why some subject, systems and economies can positively respond and recover to external shocks. The understanding of such process could contribute to identify the characteristics of those subjects and systems which better cope with disturbances. Moreover, it can be helpful to address policies and interventions in order to minimize the vulnerability of systems.

In this scenario, the concept of resilience has rapidly started to spread among disciplines that through different schemes and definitions have tried to study the topic to understand the ability of specific individuals, communities and systems to cope with external shocks.

Over the last years, resilience has been used in several disciplines gaining of interdisciplinary. From ecology to architecture and engineering, from studies of organizations and emergency management to psychology, many areas of study used the concept to explain phenomena related to different fields of study.

Despite it seems a controversial topic, its popularity can be ascribed to its malleability to the fact that it can assume different meanings to different people and be interpreted in a broader meaning across disciplines (Brand and Jax, 2007; Christopherson *et al.*, 2010). It can be considered as a "boundary object" able to adapt to several viewpoints maintaining identity across them (Star and Griesemer, 1989).

However, these alternative meanings have two salient characteristics: resilience is linked to the ability to overcome the change and the capacity to regain functionality (Zolli and Healy, 2012).

## 1.2 **The roots of resilience: engineering and ecological definitions**

The term resilience derives from the Latin verb *resilire*[2]. It literally means *bounce back* and refers to the ability of an organism or a system to recover elastically shape and position after a disturbance or an interruption.

The most important works of resilient system are ascribable to the Canadian ecologist Stanley Crawford Holling (1973). Holling's studies are often cited as the origin of the modern theory of resilience (Folk *et al.,* 2002; Klein *et al.*, 2003; Walker *et al.*, 2004; Folke, 2006).

In his analysis of ecosystems, he inquired how diverse behaviours of natural ecosystems could lead to a different resources management. In its preliminary analysis, he identified two different properties to define the behaviour of ecosystems: stability and resilience. While stability is the ability of a system to return to a state of equilibrium after a temporary disturbance, resilience is the ability to absorb such change. Thus, while resilience measures the ability to cope with disturbances and still maintain the same relationships between system entities, stability emphasizes the maintaining of the equilibrium within a predictable world with minimum fluctuations of the system (Bhamraa *et al.*, 2011). Based on this statement, on the one hand, a resilient system can in any case be unstable and, on the other hand, a balance between stability and resilience will result from the response that ecological systems have been historically able to give in face of the change. As the same Holling (1973) suggests:

[2] According to Alexander (2013), the word resilience first appeared in scientific language thanks to Francis Bacon and his *Sylva Sylvarum* of 1625, a compendium of writings on natural history. The term had its first English dictionary definition around mid-1600 and it was added to the *Glossographia* of Thomas Blount with the double meaning of rebounding or going back.

"*the balance between resilience and stability is clearly a product of the evolutionary history of these systems in the face of the range of random fluctuations they have experienced*" (p. 18).

Later works have expanded and elaborated Holling's studies of resilience (Holling, 1996; Holling, 2001; Gunderson and Holling, 2002; Walker *et al.*, 2004) defining multiple forms of resilience. Viewpoints of resilience and stability have been further extended to develop the ideas of "ecological resilience" and "engineering resilience".

Engineering resilience is based on the ability of a system to endure shocks and is measured by the speed with which the system returns to its pre-existing equilibrium (Pimm, 1984; Pimm, 1991). This definition emphasizes aspects such as efficiency, consistency and predictability, typical attributes of "fail-proof" engineering design (Martin and Sunley, 2015). Thus, a system able to quickly restore the prior equilibrium after the occurrence of a shock is considered more resilient than one which takes longer (Martin, 2012).

Ecological resilience, instead, emphasizes the ability of a system to adapt to shocks and move on new schemes differing from the previous equilibrium. This kind of resilience can be measured from the amount of noise absorbed by the system before the change of its structure. Based on this definition, resilient systems will not remain trapped in sub-optimal equilibrium situations (Dawley *et al.*, 2010) but they will be able to generate new multiple equilibria. Hence, resilience is conceived as the magnitude of disturbance that can be tolerated before a system moves into a different state and set of controls (Holling 1973; Holling, 1996). It has three main properties: (a) the amount of change that systems can sustain remaining in the same function and structure; (b) the degree to which the system is capable of self-organization; (c) the degree which measures the ability of the system to learn and adapt (Carpenter *et al.*, 2001).

A breakthrough in studying resilience comes from the theory of socio-ecological systems (SESs), systems including both human and biophysical

subsystems (Gallopín, 1991). Theorizing resilience in SESs constituted the starting point for the creation of the "resilient thinking" approach (Folke, 2006; Walker and Salt, 2006), which moved the concept of resilience from being considered as a simple feature of the system to a more complex and systemic vision[3]. Resilient thinking aims at understanding the world and its constant change.

According to SESs theory, shocks can be analysed through four variables: robustness, resilience, vulnerability and adaptive capacity (Gallopín, 2006; Young *et al.*, 2006). Such variables are strongly connected but their relationship is highly controversial. While robustness is the ability of a system to resist disturbances without changing structure or dynamics, resilience is the ability of competing with external disturbances. Vulnerability, instead, occurs when robustness and resilience are not able to allow the survival of the system without a structural change. Thus, resilience is related to vulnerability by adaptive capacity that is the ability of SESs both to cope with external shocks and to improve functions and structure of the system.

In the field of SESs resilience is defined as:

> "*the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks*" (Walker *et al.*, 2004, p. 1) [4].

[3] Part of scholars in resilience of ecological and socio-ecological systems founded in 1999 the Resilience Alliance, an international and multidisciplinary network of resilience scholars guided by Holling to advance studies and applications of the concepts of resilience, adaptive capacity and transformation of societies and ecosystems in order to cope with change and support human well-being.

[4] According to Walker *et al.* (2004), three feature of SESs can influence their future pathways: resilience, adaptability and transformability. The first is the capacity of the system to overcome disturbance returning on the existing functions. Adaptability is the ability of the actor of system to influence resilience and transformability is the capacity to create new systems if the existing are unsustainable.

According to such a view, resilience is the ability to reorganize the system's components in response to a perturbance in order to maintain the same functions. It does not involve a change but it is a property of the system that implies the ability to manage the disturbance coming back to a pre-existing structure waiting for a possible change.

The table 1.1 shows how the notion of resilience evolved in the field of ecology studies.

*Table 1.1 Evolution of the notion of resilience in the study of ecological and socio-ecological systems*

| Author | Context | Definition |
|---|---|---|
| Holling (1973) | Ecological systems | The measure of the persistence of systems and of the ability to absorb change and disturbance and still maintain the same relationships between population or state variables. |
| Holling (2001) | Ecological systems | The resilience of the system, a measure of its vulnerability to unexpected or unpredictable shocks. |
| Gunderson and Holling (2002) | Ecological systems | The magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behaviour. |
| Walker *et al.* (2002) | Socio–ecological systems | The ability to maintain the functionality of a system when it is perturbed or the ability to maintain the elements required to renew or reorganise if a disturbance alters the structure of function of a system. |

*Source: Author's elaboration*

## 1.3 **Resilience across disciplines**

Origins of the modern notion of resilience are ascribed to the studies of Holling (1973) in ecology but the concept has been successfully applied to several research fields. Among the multiplicity of disciplines, it is possible to evidence important contributions in engineering, psychology, studies of disasters, urban studies, organizations studies, social and economic fields.

In engineering, resilience is the ability of a structure to resist a sudden shock and to not crack. The term has been used in the field of materials science[5] and it has been defined as a property of a material (Martin-Breen and Anderies, 2011). This definition refers to:

> "*the quality of being able to store strain energy and deflect elastically under a load without breaking or being deformed*" (Gordon, 1978.)

Resilience in engineering expresses the extent to which a material subjected to external stress can return to its initial shape when the external pressure is no longer applied.

In psychology, the notion of resilience generally refers to the individual ability to overcome a traumatic event. Within this field, analyses concerning the ability of individuals to cope with adverse situations were common but resilience became a specific field of study only in recent years[6]. Resilience can be conceived as a psychic function and it can modify over time in relation to experiences and changes in the mental processes. The American Psychology Association (2016) defines it as:

> "*the process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress — such as family and relationship problems, serious health problems or workplace and financial stressors. It means "bouncing back" from difficult experiences*" (Paragraph 2).

In order to study disasters, the notion of resilience has been used among several areas of research involving emergency management, climate changes or

[5] The material science is a field that applies fundamental sciences, such as chemistry and physics to the study of the behaviours and properties of specific materials.

[6] Several studies in psychology has tried to understand how people overcome traumatic events. Early studies refer to individuals survived to concentration camps (Antonovsky et al., 1971) or surveys related to understand effects of family separation and reunion due to the second world war (Hill, 1958).

natural hazards. These fields can be attribute to the general approach of disasters management, an area that pertains to the study of mitigation, response and preparedness to disasters (O'Brien and O'Keefe, 2013). The United Nation Office for Disaster Risk and Reduction, UNISDR, an agency dedicated to the implementation of the International Strategy for Disaster Reduction (ISDR) defines resilience as:

> "*the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions*" (UNISDR, 2009, p. 24).

Defining resilience in the field of hazards mitigation, Mileti (1999) associates resilience to disasters to the ability of a place to overcome an extreme natural event with a tolerable level of losses.

In urban studies analyses of resilience have exploded in relation to the increasing urbanization of recent decades[7]. Definition of resilience comes from the fields of urban ecology and urban theorists (Meerow *et al.*, 2016). It pertains to the ability of urban systems to cope with several possible shocks, only a part linked to climate change and natural threats[8]. In the urban ecology, definition of urban resilience refers to definition of ecological resilience (Leichenko, 2011). Alberti *et al.* (2003) defined urban resilience as:

> "*the degree to which cities are able to tolerate alteration before reorganising around a new set of structures and processes*" (p. 1170).

[7] According to the United Nation Department of Economic and Social Affairs, UNDESA, (2014), about the 54 per cent of the world's population residing in urban areas in 2014, while continuing population growth and urbanization are projected to add 2.5 billion people to the world's urban population

[8] Other types of shock can relate to terrorism, public safety, health, energy supply, economy and so on.

A shared definition in urban theorists identifies resilience as:

> "*a community or region's capability to prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to public safety and health, the economy, and national security*" (Wilbanks, 2007).

This definition refers to the ability of responding and recovering from a shock but also to anticipate such a shock in order to reduce its damage (Colten *et al.*, 2008). More generally, Campanella (2006) describes urban resilience as the ability of urban systems to rebound from destructions. Coaffee (2013) suggests a definition based on the capacity to resist and rebound from disruptive challenges. These definitions pertain to the specific field of *urban hazard and disaster reduction*.

In organizational science, the adaption of the notion of resilience started in late 1990s (Horne, 1997; Horne and Orr, 1998). This part of the literature looks at resilience as the ability to simply rebound from adverse situations and it is opposed to a second perspective that defines resilience as the ability to create new capabilities and opportunities (Lengnick-Hall, 2011). Within the first group, resilience is the ability of a system to withstand the stresses of environmental loading based on the combination/composition of the subsystems, their structural inter-linkages, and the way environmental change is transmitted and spread throughout the entire system (Horne, 1997).

On the other side, McDonald (2006) defines resilience as a property of being able to adapt to the requirements of the environment and being able to manage the environments' variability. This definition emphasizes the ability of organizations to adapt to the changing circumstances in order to be identified as resilient.

Another interesting definition concerns the field of organizational psychology and links together the resilient approach to those of human capital in firms. This definition looks at resilience as:

"*the developable capacity to rebound or bounce back from adversity, conflict, and failure or even positive events, progress, and increased responsibility*" (Luthans, 2002, p.702).

Definition of social resilience is ascribed to Adger *et al.*, (2002) that highlights the idea of social resilience as the ability of a community to resist to an external shock. More precisely, resilience is defined as:

"*the ability of a community to withstand external shocks and stresses without significant upheaval*" (p. 358).

Adger (2000) tried to link the approach of ecological resilience to that of social resilience arguing that the concepts are related by the dependence on ecosystems of communities and economic activities.

Finally, over the last fifteen years, the notion of resilience has been applied to the economic context. Within this context, studies of resilience have generally referred to the ecological notion in order to study sustainable economic development in the field of environmental economics (Brock *et al.* 2002; Perrings, 2006). A part of studies in environmental economic pertains to economic resilience in order to study post-disasters conditions and responses. Rose (2004) defines economic resilience as:

"*the inherent and adaptive responses to disasters that enable individuals and communities to avoid some potential losses. It can take place at the level of the firm, household, market, or macroeconomy*" (p. 307)[9].

Another part this literature focus on resilience to exogenous shocks emphasizing economic vulnerability in relation to economic growth (Briguglio, 2004; Briguglio *et al.* 2009). In these studies, resilience is associated with:

"*actions undertaken by policymakers and private economic agents which enable a country to withstand or recover from the negative effects of shocks. Actions which enable a country to better benefit from positive shocks are also considered to be conducive to economic resilience*" (Briguglio *et al.*, 2009, p. 230).

Interest in economic measurements of resilience is also growing in the emerging literature of urban and regional economies, particularly, in the field of economic geography. A large part of this analysis starts from ecological resilience theory to study the evolution of urban and regional economic and industrial systems. The analysis of resilience in this discipline will be the focus of the next chapter.

Despite definitions of resilience are multiple and applied to several disciplines, they present interesting correlations. They recall some common features among different fields that can be summarized in the following main points:

[9] Rose and Krausmann (2013) enlarge the debate of economic resilience distinguishing between two different types of resilience: static economic resilience that concern with he ability of a system to maintain function when shocked and the dynamic economic resilience that is the efficient utilization of resources for repair and reconstruction. According to Rose and Krausmann (2013), static resilience pertains to making the best of the existing capital stock (productive capacity), while dynamic resilience focuses on enhancing capacity.

- *Vulnerability* that seems to be opposed to those of resilience. Vulnerability gives the idea of a resilience based on a specific context. To be resilient a system need to be first vulnerable to an external pressure. This statement means that resilience cannot be an a-contextual concept and impose to clarify "*resilience to what"* (Martin-Breen and Anderies, 2011).

- Static and dynamicity status characterize resilience and can influence the response of the system. Concerning this point resilience is assumed to be in some cases the ability of the system to overcome the shock restoring previous functions and structures and in other cases the ability to change in response to shock. This last point can be linked to the *transformability* of the system, the ability to introduce new components to create a new stability (Walker *et al.*, 2004).

- A *positive* connotation characterizes the notion of resilience. A large part of definitions refers to resilience as a positive attribute of the systems. However, this point is still debated. Criticism can be related to the different visions of resilience (static and dynamic) arguing that the return to a previous state cannot be desirable in those cases in which previous features of the systems are the causes of the shock (Meerow *et al.*, 2016). Furthermore, the application of resilience to several disciplines related to social science raises important question about the role of policies in influencing paths of development (Leichenko, 2011).

- Origin of studies of resilience can be ascribed to ecology and particularly to the work of Holling. Thus, an exhaustive survey of the concept of resilience needs to analyse the classical definitions of engineering and ecological resilience. Moreover, a discussion concerning the engineering and ecological definition of resilience can help to overcome fuzziness of the concept through the emergence of a common theoretical framework among plurality of definitions.

The main definitions of resilience discussed can be summarized in the Table 1.2 which includes authors and context in which definitions have been applied.

*Table 1.2 A survey of definitions of resilience in several fields*

| Author | Context | Definition |
|---|---|---|
| Gordon (1978) | Engineering | The ability to store strain energy and deflect elastically under a load without breaking or being deformed. |
| Horn (1997) | Organizational | The ability of a system to withstand the stresses of environmental loading based on the combination/composition of the subsystems, their structural inter-linkages, and the way environmental change is transmitted and spread throughout the entire system |
| Mileti (1999) | Hazards Mitigation | Resiliency to disasters means a locale can withstand an extreme natural event with a tolerable level of losses. It takes mitigation actions consistent with achieving that level of protection |
| Adger *et al.* (2002) | Social studies | The ability of a community to withstand external shocks and stresses without significant upheaval |
| Luthans (2002) | Organizations Psychology | The developable capacity to rebound or bounce back from adversity, conflict, and failure or even positive events, progress, and increased responsibility. |
| Alberti *et al.* (2003) | Urban Ecology | The degree to which cities are able to tolerate alteration before reorganising around a new set of structures and processes. |
| Rose (2004) | Environmental Economics | Economic resilience refers to the inherent and adaptive responses to disasters that enable individuals and communities to avoid some potential losses. It can take place at the level of the firm, household, market, or macroeconomy. |
| Campanella (2006) | Urban Hazard and Disaster Reduction | The capacity of a city to rebound from destruction. |

| Author | Context | Definition |
|---|---|---|
| McDonald (2006) | Organisational | Resilience conveys the properties of being able to adapt to the requirements of the environment and being able to manage the environments variability. |
| Wilbanks (2007) | Urban studies | The capability to prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to public safety and health, the economy, and security. |
| UNISDR, (2009) | Disaster management | The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions. |
| Briguglio *et al.*, (2009) | Economic Development | Economic resilience is associated with actions undertaken by policymakers and private economic agents which enable a country to withstand or recover from the negative effects of shocks. Actions which enable a country to better benefit from positive shocks are also considered to be conducive to economic resilience |
| American Psychology Association (2016) | Psychology | The process of adapting well in the face of adversity, trauma, tragedy, threats or significant sources of stress — such as family and relationship problems, serious health problems or workplace and financial stressors. It means "bouncing back" from difficult experiences. |

*Source: Author's elaboration*

## 1.4 **Critiques of the definitions of resilience**

Even though, in many fields the ecological definition has been preferred to the engineering one, the lack of a unique meaning of resilience and its application to several disciplines exposes the notion to a series of criticisms due

to the absence of a clear conceptual determination and a drop in the theoretical validity of the concept (Martin and Sunley, 2015).

Such criticisms can be attributed both to the general definitions of resilience and to the specific notions of ecological and engineering resilience. Moreover, they can be related to the application of resilience to a multiplicity of disciplines, with a particular focus on economic and social studies.

In the last few years, the notion underwent a sudden sprawl of definitions confusing more than clarifying the conceptual framework of resilience leading to define it as "fuzzy" concept (Markusen, 1999). Despite the amount of definitions of resilience makes it a "boundary object" (Star and Griesemer, 1989), often the cross-disciplinary transfers contribute to have unrelated and conflicting meanings.

A point of criticism is based on the relationship between resilience and change. Considering this vision, resilience, driving to a pre-existing equilibrium, could lead to the preservation and the continuity of a sub-optimal equilibrium. However, resilience is not a dichotomous concept that involves the restoration of states of existing equilibria or the generation of a new. It is a complex process that can lead to a mix of multiple states of change and continuity.

A following criticism comes from the ecological nature of resilience: the concept is closely linked to the responses of ecological systems to shocks, this specificity makes it difficult to apply to economic and social systems. In fact, profound differences in structure and configurations characterizes socio-economic organizations: while ecological systems lack of human action and intelligence, this is crucial to respond to shocks in social systems. The different ways in which policy makers respond to crises influence decisively the resilience of economic systems (Martin, 2012).

Furthermore, the ecological nature of resilience ignores the role of institutions, policies and cultural and social factors in explaining the dynamics of the resilient process (Swanstrom, 2008; Gong and Hassink, 2016).

Moreover, resilience does not consider key elements of the recovery such as the connectivity that fosters endogenous interactions in the system and the potential of the system that may sustain innovation (Cooke, 2017).

Another critical opinion sees the study of resilience excessively focused on the ontological systems, reducing them to determinable form and not recognizing their character of heterogeneity[10].

A general criticism argues that resilient approach does not contribute in a decisive way to the expansion of studies of economic development.

Finally, resilience has largely been considered a "neoliberal" concept because it draws solutions for regional problems based on the search for continued growth and competitive advantages. Governments define top-down strategies of resilience applying the same recipe to treat the problems of a globalised word, without any interest for unique localisms (MacKinnon and Derickson, 2013). This leads to a disconnection between the scales of resilience. It appears as a capitalist concept applied to solve regional and local problems.

The main criticisms of the notion of resilience can be summarized in Table 1.3.

Despite these critiques, resilience can help researchers in understanding perturbations in the modern world. In the economic context, it has applied to the fluctuations of markets and to analyse the consequences of shocks on paths of economic development.

These studies involve several forms of shocks - environmental disasters, economic fluctuation, social crisis and technological changes - well suited in the socio-economic context with an impact on the ecological systems. This feature cannot be recognized to other tools of analysis in studying regional and local economies, such as sustainability or competitiveness studies.

[10] This criticism has not a real foundation because the recent studies of resilience not only recognize the complexity of the systems but contemporary consider their dynamism and heterogeneity, judging them connected and multi-scalar (Zolli and Healy, 2012).

However, a step forward is required to formalize the issue and make the concept of resilience applicable. Borrowing and transfers across disciplines not only make difficult to build a solid theory of resilience but increase difficulties in methodology to measure it. Moving from theory to practice arises problems when scholars try to establish pertinent analysis criteria to make resilience operational (Reghezza-Zitt *et al.*, 2012).

*Table 1.3 Summary of main critiques to definition of resilience*

| Context | Key Concepts | Critiques |
|---|---|---|
| General | Multidisciplinary | Fuzziness related to multiple meanings of resilience. Such several definitions are explained, in part, by multiple cross-disciplinary transfers. |
| Engineering-Ecological | Evolution of systems | Lack of a reflection of the continuing and dynamic change that involve the evolution of the systems. |
| Ecological | Human systems | Difficulties in transferring the notion from ecological studies to social and economic areas. Ecological systems lack of human actions that are fundamental in responding to a shock. |
| General | Connectivity of systems | Poor attention of connectivity between component of the system and interaction that can favour resilience. |
| Ecological | Institutions and social factors | Ignoring the role of institutions, culture and communities in shaping resilience. An excess of determinism in the notion of resilience can lead toward a poor attention of the heterogeneity of the systems. |
| General | Neoliberal | Resilience is similar to a top-down strategy based on neoliberal visions and this can lead toward a disconnection of scale of applications. |
| General | Theoretical | Resilience does not lead a fundamental contribution to the study of economic development |

*Source: Author's elaboration*

## 1.5 **Conclusions**

The discussion so far conducted wanted to highlight the main features of the issue of resilience. Far from being considered exhaustive, the analysis focused on the main theoretical contributions of the literature on the topic and the principal domains which adopted the notion of resilience. The analysis did not want to give a mere theoretical exposure of the notions but it tried to intercept the connections between the different approaches to resilience and identify criticisms.

In the first part of the chapter we defined engineering and ecological definitions identifying the origins of the concept of resilience. In the second part, the various definitions of resilience given by disciplines has been discussed. Finally, in the third part we discussed the main criticisms and weaknesses of resilience's definitions debated in the literature.

The aim of the discussion was to highlight the multidisciplinary aspect of resilience suggesting that this may affect both strength and weakness of resilience. On the one hand, multidisciplinary can favour a dialogue between different disciplines, enlarge the domain of application of a concept and beneficing of multiple and diverse perspectives. On the other hand, it can increase fuzziness and influence theoretical value because of the lack of an organic structure. This latter aspect is largely found in the criticisms emerged around the notion of resilience.

Another part of criticisms recognizes in the ecological origins of resilience a problem when the concept is applied to study of economic and social systems. This can lead to consider resilience as static, human disconnected and top-down strategy.

If the aim of the thesis is to investigate resilience in relation to natural disasters in order to discuss economic change, the analysis of the literature need a specific focus on a notion of resilience able to explain the evolution of systems. To achieve such aim in the next chapter, theory of resilience in Evolutionary Economic Geography (EEG) will be discussed.

# 2 Resilience in Regional Sciences

## 2.1 Introduction

The interest of economic and social sciences in resilience can be generally attributed to economic and financial crisis and environmental disasters that have stricken nations, regions and localities in recent years.

Some scholars in EEG focused on the study of evolution of regional economies to understand their continuing adaptation and their capacity to react to shocks (Martin and Sunley, 2006; Martin and Sunley, 2007; Fingleton *et al.*, 2012; Martin, 2012; Martin *et al.*, 2013). In this context, they have recognized and consequently studied resilience as an important factor of growth or decline of local economies and as a fundamental approach to understand the relationships between regional development and innovative capacity.

In studying the evolution of economic systems, EEG combines an historical perspective with a geographical approach in order to understand dynamics of change in regional and urban systems (Boschma and Frenken, 2006; Boschma and Martin, 2010)[11].

However, when an evolutionary perspective is enquired, definitions of engineering and ecological resilience can appear insufficient. The resilient theory should be reformulated in order to investigate socio-economic systems as complex systems[12].

[11] On the one hand, the EEG combines studies of urban and regional economic development with the concepts of Evolutionary Economics trying to introduce an historical perspective to the study of the dynamics of evolution of economic systems. On the other hand, it adds a spatial dimension to the processes of economic recognizing underling the importance of geography in determining the nature and the evolution of the economic paths.

[12] A complex system is characterized by a network of interconnected agents that interact in a non-linear way. Agents operate in parallel, have numerous levels of organization and are characterized by a continuous cycle of learning. These systems are connected to the external environment through internal agents and are always in changing. This implies that continuous innovation characterizes complex systems are by (Holland, 1992).

## 2.2 **Resilience in Evolutionary Economic Geography**

In the previous chapter, we have argued that one of the major critiques to the definitions of engineering and ecological resilience is the lack of references to the dynamism of regional and local systems (Dawley *et al.*, 2010).

On the one hand, the engineering approach that emphasizes the return to a pre-existing equilibrium, does not recognize a potential evolution of economic systems. It is comparable to the neoclassical economics viewpoint characterized by an optimal equilibrium, rationality of economic agents and perfect function of market mechanisms.

On the other hand, despite ecological resilience identifies the possibility of multiple equilibria, it compares the evolution of regional economies to the succession of several states of equilibria.

But a strong theory of resilience should clarify both how resilience evolves in the long-term and how this evolution affects the development of future paths (Martin and Sunley, 2007; Simmie and Martin, 2010). In accordance with an evolutionary perspective, regional economic resilience should be considered as a continuous process different from the succession of events leading to the recovery of a new or an existing equilibrium.

Such reflections lead scholars in EEG to theorize a new definition of regional economic resilience trying to address the theoretical problems of engineering and ecological definitions. This alternative approach identifies resilience as:

> "*the capacity of a regional or local economy to withstand or recover from market, competitive and environmental shocks, possibly by undergoing adjustments among its firms, workers, institutions and infrastructures, and where those adjustments may be influenced by policy intervention, so that the region or locality is able to maintain or restore the full and productive use of its physical, human and environmental resources and the standard of living/quality of life of its population*" (Martin *et al.*, 2013, p.6).

Regional economic resilience involves a plurality of perturbances in regional system and identifies different elements of the system on which the effect of the resilient process is spread.

Different approaches have been used to study regional economic resilience (Simmie and Martin, 2010; Dawley *et al.*, 2010; Martin and Sunley, 2006):

- Generalized Darwinism: inspired by biological analogies, it focuses on the role of diversity in shaping the regional economic resilience.
- Complex Adaptive Systems Theory: it emphasizes self-organization, bifurcations and adaptation.
- Panarchy: it links resilience to adaptive cycles arguing that because of the interaction of different scales, the resilience of a system at a particular scale will depend on the influence of the dynamics of the state above and below (Gunderson and Holling, 2002);
- Theory of path dependence: it is focused on the historical continuity, the phenomena of "lock-in" and the processes of path creation.

An inclusive framework of regional economic resilience toward an evolutionary vision should consider this different approaches to fully understand roots and key elements that affect resilience and the generation of new paths after a shock.

### 2.2.1 Generalized Darwinism

Generalized Darwinism, as the name suggests, is based on Darwinian principles applied to economic circumstances. The theory sees the possibility of using the principles of biological evolution as a theoretical framework to analyse the change in socio-economic systems. Hence, the capitalist economy is an evolutionary process in which the competing agents are characterized by a degree of heterogeneity which favours the individual economic growth through a selection mechanism. Economic scenario changes more or less slowly over

time, influenced by and influencing the external environment (Essletzbichler and Rigby, 2010).

Based on this assumption, variety is an essential feature of economic systems: diversity in firms' typologies and behaviours contribute to the survival or death of firms and affect the shape of economic regions in the long period. Selection mechanism allows the adaptation of the system entities in response to the criteria defined by environmental factors.

In this scenario, the incentive to innovate, coming from competition between firms, fosters variety and allows selection, evolution and change. Therefore, innovation is related to the creation of new variations while selection is about how such heterogeneities are tested in the real world (Hodgson and Knudsen, 2006).

Variety becomes a fundamental concept to explain resilience because it influences the latter and consequently the ability of regions to overcome external shocks. Regions with a more or less diversified economy differ in their degree of recovery after a shock and at the same time can have a different innovative capacity (Simmie and Martin, 2010).

Theory of Generalized Darwinism can lead towards important reflections in studying economic systems from an evolutionary viewpoint: identifying variety as a factor that influence response of systems to shocks, it may constitute an important progress in the searching of those elements that can favour resilience. However, an analysis of the economic evolution through a biological viewpoint could have a series of limitations because it lacks any reference to the institutional and social context in affecting resilience.

Darwinian principles constitute a helpful tool to investigate economic dynamics but such principles should be combined with other theories to an organic explanation of evolution of economics.

### 2.2.2 The theory of Complex Adaptive Systems

A second approach to study resilience in regional science is the *complexity thinking*[13]. Studies in this field have involved a number of research based on the dynamical properties and structural transformations of non-linear, "far- from-equilibrium" systems in the natural and physical sciences (Martin and Sunley, 2007).

Several studies of EEG have analysed regional economies as complex adaptive systems. Such systems have functions and relationships distributed on a plurality of scales. Components of the system have a certain degree of connectivity and boundaries between the system and the external environment are not clearly defined. This involve a constant exchange with the outside.

They are characterized by non-linear dynamics arising from complex feedback and self-reinforcing interactions between the components.

Complex adaptive systems have two principal features: emergence and self-organization. This means that macro structures arise from micro behaviour and components interact with each other.

Mechanisms of self-organization involve possibilities for the adaptation of the systems. These processes give an adaptive quality to the systems, which allows transformations in order to response both to changes in external environment and in internal order, allowing evolution.

Evolution drives to a "critical state" able to create chain reactions between system components and generate a major change in the system's structure and dynamics.

This suggests that response of systems to change can be influenced by connectivity and adaptation of the systems. Complex adaptive systems, nevertheless, are characterised by two conflicting trends: while the connection

[13] The study of complexity has been the major topic in the Santa Fe Institute programme of research on the "science of complexity". Santa Fe studies aimed to formulate a formal theory of complexity – or more precisely, a theory of "self- organisation" – that applies equally to both natural and social systems.

between the components of the system increases, the adaptability of system to change is reduced. Hence, it is possible to identify a conflict between connectivity and resilience: more internally connected and more rigid and less adaptive will be a system.

### 2.2.3 Panarchy

Panarchy (Holling, 2001; Gunderson and Holling, 2002) is a theoretical framework conceived to explain the evolution of complex systems overcoming the contradiction of the complex adaptive systems theory.

The aim of this approach is that to investigate the role of complex adaptive systems in understanding ecological, economic and social systems both as unique parts and in their relations to each other.

According to Holling (2001):

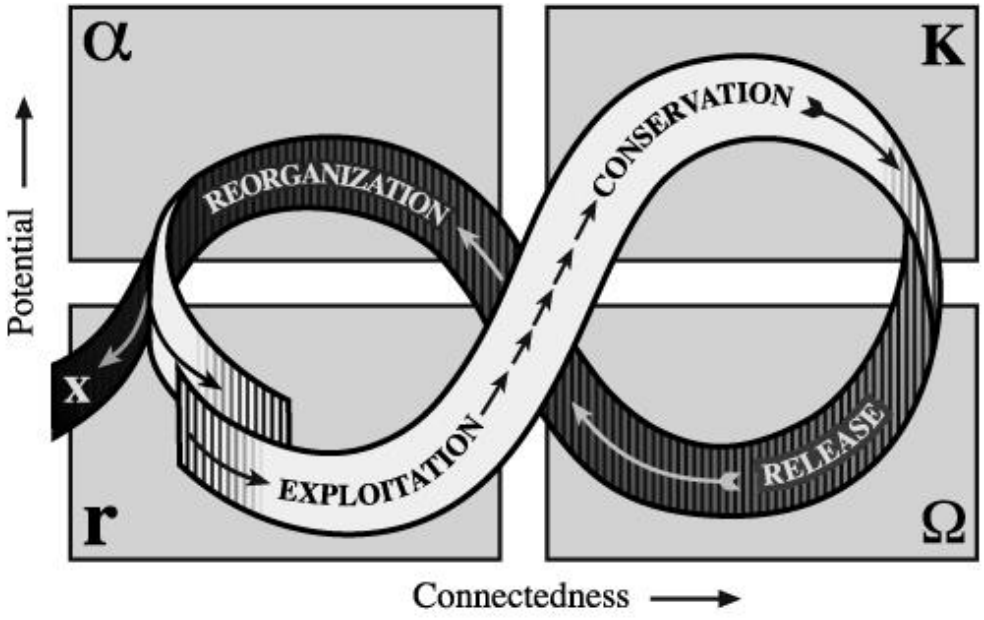
> "*the panarchy describes how a healthy system can invent and experiment, benefiting from inventions that create opportunity and kept safe from those that destabilize because of their nature or excessive exuberance*" (Holling, p.390).

This model wants to look at the unpredictable change in systems and shows which structures support adaptive evolution defining conditions that limit or foster future possibilities.

The dynamics of social-ecological systems (SES) can be described and analysed in terms of cycles, more specifically adaptive cycle. This cycle involves four phases (Figure 2.1):

- Growth and Exploitation Phase (r)
- Conservative Phase (k)
- Chaotic collapse and Release Phase (Ω)
- Reorganization Phase (α)

*Figure 2.1 Representations of different phases in an adaptive cycle*




*Source: Holling, 2001, p. 394*

The cycle is characterized by two loops, one moves from Exploitation to Conservation in which a specific economic path emerges and the other moves from Release to Reorganization in which the path becomes rigid and declines.

The first loop is called "loops back" and is characterized by uncertainty, novelty and experimentation. Exploitation and Conservation phases are slow, cumulative and are characterized by stability and predictability of the dynamics of the system. A phase of continuing Conservation involves the lock of resources and a decrease in flexibility and in the capacity of the system to respond to shocks. This leads to the Release phase and to the stage of Reorganization.

This second loop has features of instability, creativity and flexibility. The process of Reorganization leads to a phase of growth that can be similar to or completely different from the previous.

The metaphor of adaptive cycles provides no fixed phases and there is no hierarchy in phases. Consequently, a system can move from one phase to

another without linearity. The cycles also occur at different scales and can generate cross-scale effects. Thus, socio-economic systems act as "panarchies" because adaptive cycles interact across different scales (Walker *et al.*, 2004).

Holling and Gunderson (2002) indicate three proprieties that influence the change in the system and characterize each phase:

- The potential usable for change that impact on the different change of trajectories.
- The connection between the internal processes of the system that gives a measure of flexibility or rigidity of the system itself.
- The resilience, a way to evaluate the vulnerability of the system in face of a shock.

The model of adaptive cycles is useful to explain the change and the different degree of resilience in the context of regional economies. In the (r) phase, the regional economy grows and accumulates knowledge, productive and human capital. New firms exploit comparative advantages of localization and external economies. More growth involves more connectedness between the actors. Consequently, the structure becomes rigid and resilience decreases. If a shock occurs, the consequences will be a structural decline and decrease: business activities will close or move out of the region, the degree of connectivity will drop and agglomeration benefits will lose their impact. The old models of production and the institutional forms will collapse and resources will be released. This contributes to the possibility of a second cycle of release and reorganization characterized by innovation, experimentation and restructuring. During these phases, new activities will emerge, the connectedness will be low, the creation of new path of development will occur. Such phases will be characterized by high resilience. While specific forms will be exploited for new activities and new technologies, new comparative advantages will grow. Growth and accumulation in the region will start (Pendall *et al.*, 2007).

Adaptive cycle has successfully been applied to the studies of evolution of regional economies (Martin and Sunley, 2011).

The system proprieties can also be interpreted in a regional view (Simmie and Martin, 2010):

- The potential of accumulated resources that the system can use determines the possible options for the change.
- Connectedness occurs between internal actors or system components.
- The resilience of regional system is the degree of vulnerability in face of regional change.

Regional resources include workers' skills, companies' abilities, institutional forms and hard and soft infrastructures. Such resources depend on the previous forms and structures of regional economic development.

Connectivity refers to the internal models of interdependencies between local businesses, including the inputs, the labour division between the companies, local networks of trust, knowledge spillovers, and formal and informal work associations patterns of labour mobility. Even these features derive from previous paths of economic development. The response of the system to changing circumstances depends on the innovative capacity of the system itself. The latter influences creativity and flexibility of the system and determines the destiny of local enterprises. It is related to business skills and new business formation, institutional innovation, access to investment and venture capital, workers' initiative to modernize.

Another interesting feature of this model is its connection to the scale of the system. This connection occurs through two main mechanisms. On the one hand, larger scales affect smaller ones: processes and functions at the regional level - local government, the education system, physical infrastructure in the region - show their results on smaller scales. On the other hand, actions in smaller scales affect circumstances in the large ones particularly within the release phase. Thus, regional economic resilience depends on both large scale and long-term processes and micro scale and short-term processes but also on the interaction between the two.

The model of adaptive cycles can an explain different aspects of resilience. Within the vision of adaptive cycle, resilience evolves and changes.

However, although it has the advantage of linking some regional processes, innovation, capital accumulation and processes of connectivity between firms and institutions, with resilience and a multi-scale approach, it presents a number of limitation.

First, the model was designed to study the ecological systems, which have precise characteristics not always found in regional economies. While ecological systems are characterized by long periods of continuing stability, regional economies are unsettled and often affected by the occurrence of external shocks which changed local circumstances.

Second, the four phases of adaptive cycle assume that regional resilience changes in parallel with the different phases of the cycle. This conceptualization has been considered as the cause of rigidity of the model that cannot be combined with the necessity to study evolution, a concept naturally unpredictable (Hu e Hassink, 2015).

A third limit summarizes the previous two. Regional economies have a social component able to learn and change (Simmie and Martin, 2010). This component can affect the trajectories of development of the region. This aspect makes adaptation in regions unpredictable and not necessarily subject to the of the stages theorized by the model of adaptive cycles. Knowledge is a key component of economic development. Thus, a valid theory in the explanation of evolution of the system should consider both human actions and continuing learning capacity.

Panarchy remains an important model for studying development and change in economic areas, however, this model should be understood only as a conceptual framework because of its lack of dynamism required to study the evolutionary component of the regional dynamics.

### 2.2.4 The theory of path dependence

Path dependence indicates the attitude of history to significantly influence the possibilities for future development. Based on this vision, therefore, the choices available today depend on the choices made previously. The theory of path dependence, originally developed by economists to explain the processes underlying the adoption of certain technologies and the evolution of the sectors, has subsequently become popular in the context of social sciences (Gartland, 2005).

This concept has been adopted by a variety of different disciplines, in the wake of the growing attention to the dynamic and evolutionary aspects that guided social sciences in recent years[14].

From a theoretical point of view, the theory of path dependence is an ideal framework to study the evolutionary processes of local and regional systems, so as to be elected by some economists the first principle of Evolutionary Economy (Martin and Sunley, 2006).

Boschma and Frenken (2006) believe that the evolutionary theory should consider the processes of path dependence as an explanation of the current state of events, recognizing the impact of past actions on the present scenarios.

Walker (2001) defines path dependence as a road map that can facilitate the pursuit of a certain direction rather than another. According to Martin and Sunley (2006), however, a great caution in the use of this concept is required. Despite the theoretical importance played by the concept, it not possible to identify an organic theory of path dependence. Consequently, it is difficult to make comparisons between the characteristics of path dependence among regions: different definitions of path dependence are shaped according to the objectives of regional economic studies.

[14] The theory of path dependence is linked to a series of studies that recognize the importance of history, which includes among others the notions of "adaptive cycles", "panarchy" and "resilience".

Path dependence means "influence of history". Based on this approach, therefore, history matters and what happened in the past will influence significantly the possibilities of change: the possible choices depend on choices made previously.

The origins of the theory of path dependence are mainly due to the work of Paul David (1985; 2001) and Brian Arthur (1994), aimed to investigate the evolution of technologies and technology standards[15]. The former is a scholar of complexity and the latter is an economic historian. Through their studies, Arthur and David wanted to refute the theoretical assumptions of neoclassical macroeconomics challenging the ideas of efficient market forces - able to lead the system to an optimal equilibrium - and the reversibility of technological decisions - related to the possibility of the occurrence of a technological change when more efficient alternatives are available. The basic assumption of the theory of path dependence states that history matters and once a route has been selected by a series of random economic events, the choice will remain unchangeable regardless of the advantages of alternatives. Only an external shock could lead to new paths of development.

Arthur explained and demonstrated in mathematical terms the incidence of history by observing the dynamics of increasing returns and positive feedback: while classical economists identified diminishing returns and a single equilibrium as the best possible result under certain circumstances, Arthur recognized increasing returns and positive feedbacks as leading to a plurality of balance. The development of certain phenomena is driven by these increasing returns, which reinforce the existing development paths (Arthur, 1994)[16].

[15] It is possible remember the work of Douglas, North and Setterfield which nevertheless focuses on the path dependence in relation to the institutional hysteresis: the tendency of institutions, social and cultural arrangements to self-reproduce over time through social and economic systems that they themselves generate, support and stabilize.

[16] Increasing returns effects can be summarized in initial fixed set-up costs and dynamic learning, co-ordination effects between actors who take similar actions, self-reinforcing expectations and routines (Martin and Simmie, 2008).

Some of the most important implications of the studies of Arthur were later developed by economic historian Paul David and gave rise to the theory of path dependence. This phenomenon is defined as:

> *"a property of contingent, non-reversible dynamic processes, including a wide array of processes that can properly be described as « evolutionary »"* (David, 2001, p. 15).

The theory of path dependence aims to understand the causes which lead to the dominance of a certain technology in a certain economic system, compared to other alternative routes.

The studies of Arthur and David are based on the analysis of two cases that have seen the predominance of a certain technology over more efficient alternatives. Arthur studied the case of videotapes market showing the emergence of VHS technology on Beta format, despite the latter was more efficient. David supports his thesis analysing the case of the QWERTY keyboard. This standard established itself as a universal model over time despite the existence of other superior alternatives in terms of efficiency.

The foundations of the theory can be identified in two distinct concepts:

- The idea of *lock-in,* according to which a technology is "locked" in a specific trajectory because of past events as a consequence of self-reinforcing effects[17], allowing the monopoly of a bottom technology.
- *Non-ergodicity* of system that refers to the inability of the processes of path dependence to move away from their own history. A system, therefore, evolves in relation to its own history, which cannot be reversed.

[17] These self-reinforcing processes depend on technical interrelatedness which create an effect of complementarity between the components of a technology and its use, economies of scale and quasi-irreversibility of investments (Martin and Simmie, 2008).

According to David (2000), in path dependence process, lock-in occurs when some particular historical events cause a sequence of subsequent events that have actually selected a certain path rather than another among the possible configurations of the emergent properties of a system. A technological path, therefore, is originated by random events or actions accidentally selected on the base of reasons not connected to the original event itself. Once it goes down this path, through the effects of self-reinforcement and various forms of externalities, the system is trapped in the technological path. The processes of the lock-in can only be interrupted by the occurrence of an external shock, which will lead to a phase of path dissolution or new path creation (Simmie, 2012).

The path dependence model can be described as a four-phases model of the evolution of the industrial sector of regions (Martin and Simmie, 2008). It is possible to distinguish the following:

- A first stage of pre-formation;
- A phase of path creation;
- A phase of path lock-in;
- A final stage of path dissolution.

In the first phase, a pre-existing context characterized by a certain technology, institution and industrial structure leads toward a range of possibilities in developing technology and new industries. The emergence of a dominant alternative brings to the path creation stage in which the new opportunity is selected among others by contingent circumstances or through the deliberate action of economic or institutional subjects and imply first-mover and entry cost advantages in the region. The development path will be established when a critical mass is achieved by the moving of new actors and a market influence is gained. In this phase of path dependence, phenomena of positive lock-in occur due to cumulative mechanisms and local self-reinforcement. A "rigidification" of the sector's internal structure can generate a negative lock-in and lead towards a phase of path dissolution. The dissolution,

however, can also be caused by external dynamics or voluntary abandonment of the path that occurs when local agents can renew and overcome the negative lock-in.

The path dependence is not comparable with historical determinism. On the contrary, it is similar to a probabilistic process in which, at any time in history, the future evolution of a system is conditioned by past and present events experienced by the system itself. This means that some paths are preferred to others (Martin and Sunley, 2006).

Both resilience and path dependence approaches applied to a multiplicity of different disciplines, are a source of continuous academic discussion and have not yet been determined. In terms of evolution of regional economies analysis, however, the two concepts have a number of links which could lead to important reflections. The same Holling (1973), on the other hand, recognized the importance of the history of a certain system in the moment in which he claimed that to understand the balance between stability and resilience you should observe the reactions to shocks that the systems had in the past.

The most evident junction point is the role of the shock: on the one hand, resilience is the ability of a system to respond to an external disturbance while, on the other hand, the path dependence is a process that requires a shock to release a certain system from the path in which it is trapped or to generate innovation that can create new technological pathways. The disruption, seen as a disturbance which puts pressure on the system, is an event closely connected with the process of change of the system (Dawley *et al.*, 2010). Regions that are more or less resilient may, therefore, provide different answers in the presence of lock-in and path dependence.

At the same time, the relationship between resilient economies and processes of path dependence can be interpreted differently if we consider the lock-in of the system in a positive or negative way. Martin and Sunley (2006) associate the phenomenon of positive path dependence to positive lock-in defining this stage as one in which increasing returns and positive externalities reinforce the

dynamism of local industry. During the negative path dependence, associated with a negative lock-in, however, processes, structures and configurations built because of the positive lock-in become a source of rigidity, undermine productivity, adaptability and competitiveness of region and promote the onset of diminishing returns.

Observing the way in which the system interprets the lock-in, is a central operation to understand how resilience manifests in terms of adaptation of the system. A first interpretation sees the economic resilience as the ability to overcome external shocks maintaining a certain path of development locked-in. This vision emphasizes the positive role of the lock-in and, similarly to the vision of engineering resilience, resilient systems can restore previous equilibrium. A second interpretation considers the phenomenon of lock-in in a negative way: a shock would allow the de-locking of the system by an underperforming situation and create new opportunities. When this situation occurs, "negative lock-in" can be detected only after the occurrence of the external shock. Moreover, negative path dependence could weaken the potential economic resilience and make places, regions or systems more vulnerable to external perturbations and less able to absorb shocks (Martin, 2012).

Not only the interpretation of lock-in helps us to understand resilience but also a general focus on path dependence contributes toward this aim. In case of positive path dependence, if the mechanisms of self-reinforcing push toward a particular path, the resilience to external disturbances will be strong. On the contrary, when the phenomenon of positive path dependence starts to decline in favour of lock-in processes, coming from the rigidity related to obsolete technology or institutional inertia, resilience will weaken making the systems more prone to disturbances (Martin and Sunley, 2015).

Finally, path dependence can be considered a limitation or an opportunity to support or counter the regional economic adjustments in response to a shock. The evidence, in fact, often shows that new paths of development are shaped by old trajectories. Many of the causes of resilience can relate to the history of

a certain system: resilience, in fact, reflects the previous models of growth and development and at the same time, history influences local expectations and attitudes as regards the resistance and recovery from the shock (Martin and Sunley, 2006).

The new trajectories often originate from local conditions due to pre-existing resources, skills, abilities and experience inherited from past patterns of development. The emergence of new technology or a new industry in a certain place may result from the characteristics of the local environment inherited from previous routes able to stimulate innovation. Contrary, new paths of development do not occur in those places in which specificities resulting from history may hinder innovation (Simmie and Martin, 2010).

Path dependence can then help to stimulate or restrict regional economic adjustment in response to a shock in terms of innovation capacity. Regional response can affect the ability of economies to generate incremental and radical innovations (Simmie, 2012). If a more or less resilient environment influences the generation of innovation and new trajectories of technological development, the understanding of the relationship between innovation capacity and resilience is essential to find the factors which favour the first and increase the second.

At the same time, if resilience derives from local circumstances, it will be important to study the evolution of places in the long run in order to identify which factors have influenced the local historical adaptability. The study of resilience, innovation and local feature proves essential in order to clarify the origin of new technological trajectories but this subject has not been studied thoroughly and its discussion in social science is still open.

Despite the increasing importance of path dependence theory in explaining evolution in systems, the theoretical precepts on which this theory is founded have been criticized and revised. Major criticisms can be summarized in the following points (Martin and Sunley, 2006; Martin, 2010).

First, scholars have wondered whether it is possible to distinguish different types or degrees of path dependence. The answer to this question was provided

by the same David, who distinguishes three degrees of impact of history on systems: weak, moderate and high (David, 2001). The presence of path dependence can be associated only with cases of high history. Thus, different degrees of path dependence are not distinguished but there is a certain connection between the processes of path dependence and systems in which the historical process is highly impacting.

Second, the relationship between path dependence and the evolutionary economy has several ambiguities. Although the path dependence has been elected to be the cardinal principle of the evolutionary economy, the concept of lock-in, adopted in its canonical form has static rather than dynamic characteristics. This concept is linked to continuity and stability of a certain path and, therefore, it may be inappropriate if used in evolutionary studies, which require the use of dynamic constructs.

The models of Arthur and David lack the three key evolutionary concepts of variety, selection and retention. This implies that not all the path dependence processes can be evolutionary (Boschma, 2007). Furthermore, according to Witt (2003) evolutionary systems need the conditions of novelty and innovation to generate changes. Theory of path dependence does not provide any explanation of the formation of development of new paths, ignoring important aspects such as the origin of the innovations and why a certain trajectory is preferred to another.

While the theory of path dependence has the merit of helping to discern between resilient and non-resilient economies, it has the limitation of not investigating the origin of the new paths in the adaptation of economic systems. David's original studies, in fact, identify the origin point of path dependence with causality of events, which involving sequential actions gives rise to path dependent phenomena. However, it lacks a historical explanation of how and why the new paths are created from the beginning. The theory of path dependence suffers from a curious paradox: on the one hand, it supports the importance of the historical process in shaping the development of new

technologies, new sectors and, in general, new paths; on the other hand, it does not recognize any role to history in the initial creation of development paths (Simmie, 2012).

Moreover, the theory of path dependence emphasizes the role of small external events to the system to initiate certain development trajectories. These events are comparable to serendipity or simple historical accident[18] and give rise to numerous possibilities regarding the development of a system. The sequence of events, however, plays no role in determining which new "historical accident" could occur and does not clarify whether such accident generates a new technical-economic path. This means that new paths emerge from a chaos of random events. This idea suggests that the emergence of new technology or new industries takes place only in a "virgin market" not influenced by market conditions inherited from the past (Martin and Sunley, 2006; Martin, 2010). However, the creation of new paths and innovations is itself path dependent and interdependent and it is rarely generated in "virgin markets" (Simmie, 2012).

Martin and Sunley (2006) identify three approaches to discuss the relationship between path dependence and new development trajectories.

According to a first approach, the new paths are originated from purely random events: it is what is claimed in the model of Arthur, when he states that the location of an industry is determined by an initial "historical accident" that leads this industry to locate in a certain region. However, this explanation, focused purely on "accident", does not take account of contextual and causal processes that allow certain events – that are considered trivial - to occur in a place rather than in another and create development trajectories that probably would not have occurred anywhere else.

[18] Arthur (1988) defines "chance" or "historical events" events or conditions not previously known by actors. These are related to actors' inability to predict the outcome of the adoption of a certain technology. Such accidents should not be confused with irrational or arbitrary actions of economic agents.

A second interpretation associates the birth of the new trajectories to a mix of limiting conditions and random events: a new industry does not often need specific resources in the emerging stage. New industries are free in terms of localization and can choose their location from a number of different places, all of which have the general necessary conditions to develop. Among these places, the firm will select where become localized in a random way.

Finally, a third alternative interpretation, gives the local context a significant role for the emergence of new trajectories. When this interpretation is proposed, the events that generate new paths are not purely random but may include elements relating to the deliberate actions of some persons belonging to the local context. In this context, path dependence is not necessarily an alternative strategic intentional action, on the contrary it can stimulate the action of local actors to take new paths. The success of their efforts may be partially random but depends in each case on a previous intentional action.

### 2.2.5 The theory of new path creation

The complexity of the topic has led many scholars to search for the origins of the new trajectories of development focusing on the phenomena of path creation (Garud and Karnøe, 2001; Garud *et al.*, 2010; Simmie, 2012; Simmie *et al.*, 2014).

Raghu Garud and Peter Karnøe offer an alternative to the theory of path dependence, which has its foundations in sociology and focuses on the study of path creation. According to Garud and Karnøe (2001), path dependence neglects the role of human activity and consequently it is unsuitable to explain "phenomena in the making". Their approach suggests a review of the stages of path dependence, emphasizing the role of the agents who consciously deviate from the current path helping to create new paths in which they are incorporated. Contrary to path dependence theory, initial conditions preceding accidental events that will drive to a certain path of development are not given

but are consciously constructed by the actors, who choose certain events from the past in search of possible new initiatives.

The central idea of Garud and Karnøe theory is that of "mindful deviations", deflections of local actors from historically established development paths. As the authors argue:

> "*mindfulness implies the ability to disembed from existing structures defining relevance and also an ability to mobilize a collective despite resistance and inertia that path creation efforts will likely encounter. Indeed, entrepreneurship is a collective effort where paths are continually and progressively modified as new technological fields emerges*" (Garud and Karnøe, 2001, p.2).

The emerging paths, therefore, are not random but given by the agents' ability to pursue certain courses of action and, at the same time, impede others. In this view, the phenomena of lock-in are not seen as processes that block the advance towards a new path waiting for an external shock but as a process of temporary stabilization of paths "in-the-making". Exogenous and endogenous elements within the system are not given but they will depend on how the actors define their borders. Hence, the birth of a new technology will be determined by the deviation of the actors embedded in a certain network and the interrelation that they will be able to establish.

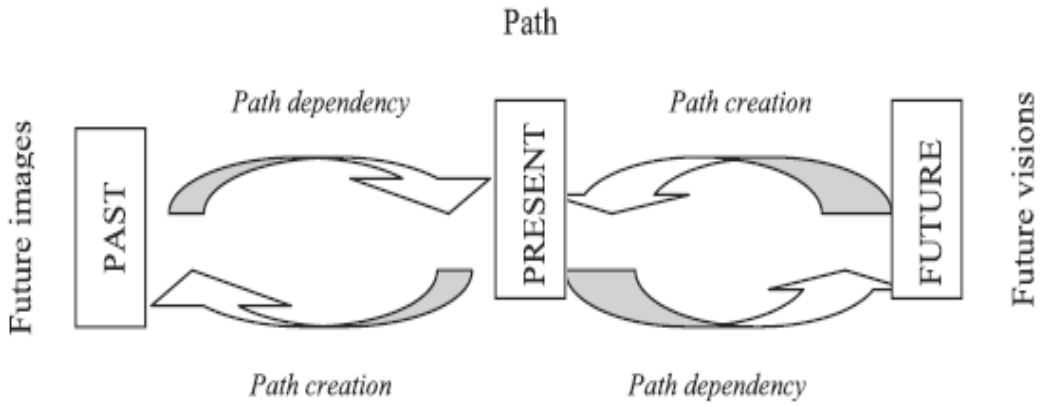
A further approach to path creation is offered by James Simmie (2012), which aims to overcome the limitations of the theory of path dependence and the new theory of new path creation laying the foundation for a hybrid theory between sociology and economy capable of analysing the contributions to the creation of new paths in the presence of path dependence.

If Garud and Karnøe distance their ideas from the theory of path dependence to offer an alternative perspective in understanding the emerging phenomena, Simmie wants to link evolutionary theories of path dependence with a sociological matrix able to explain the origins of the new technologies. Indeed,

both path dependence and new path creation theories are useful to study the long-term economic performance of regional and urban performance. The regional development path depends on the past but it requires at some point a renovation. Thus, existing pathways will be renewed or new pathways will be created (Martin and Simmie, 2008).

An interesting point of view analyses path dependence and new path creation as related phenomena (Gáspár, 2011). The theory of path dependence connects the past to the present and asserts that energies that guide the development of new paths come from past and, at the same time, influence future. Moreover, social and economic behaviours are influenced by expectations for the future. Therefore, the chances for the future and the resulting processes of path creation are influenced by the future itself (Figure 2.2).

*Figure 2.2 The double bond with present*




*Source: Gáspár, 2011, p. 95*

One of the central points in path dependence theory was the role of shocks in face of lock-in. Lock-in mechanism can be broken by external events, which contribute to path dissolution and the creation of new paths. However, such phenomena alone are insufficient to explain path creation. Hence, it is necessary to focus on a number of competent agents who can overcome the barriers that hinder the evolution of the systems through their action. According to Simmie

(2012), these barriers can be divided into barriers caused by mechanisms of self-reinforcement and accidental contingencies, related to the canonical theory of path dependence, and cognitive barriers due to technological paradigms, rules and regulations and continuing technological regimes.

The theory assumes that new pathways are not created by disembodied economic forces but derives from the action of a number of experienced and informed agents. In order to explain the actions of such agents is necessary to add a sociological dimension to the analysis of the process of new path creation (Simmie *et al.*, 2014).

Initial conditions of new trajectories are not a given but they are derived from the historical evolution of trajectories: the process of creation of a new path starts from the conscious action of certain actors who deviate from the established path. Such deviations are made consciously and they occur in specific niches not subject to the initial conditions and able to protect innovations from the barriers that hinder the development of new trajectories. Such niches can be defined as:

> "*an application context in which the new product or technology is temporarily protected from the selection standards and rules of the prevailing paradigm*" (Simmie, 2012, p.762).

However, the success of the new trajectory depends on the achievement of a certain critical mass required to provide them with legitimacy. Such critical mass is reached only when a sufficient share of economic agents is willing to switch to the new alternative.

The conflict between new path and existing barriers can lead to different scenarios:

- New trajectory will reach critical mass and becomes established in the market.
- Existing paths "locked" by the barriers will be "de-locked".

- Finally, cases of failure in the introduction of the trajectory may occur. Thus, the system continues to be "lock-in" in the previous process.

It is not possible to predict which of these results will emerge (Simmie *et al.*, 2014).

The hybrid theory of path creation leads to an important reflection about the relationship between the creation of new trajectories and path dependence. On the one hand, a sociological aspect is highlighted. On the other hand, new path creation theory aims to demonstrate that the technological landscape itself can be, alternatively, a force that contributes to the ongoing lock-in of a certain system into a specific trajectory or, on the contrary, the engine for the creation of a new path development.

## 2.3 A new approach to resilience: adaptive resilience, adaptation and adaptability

The discussion conducted so far underlines the weakness of the concepts of engineering and ecological resilience highlighting the need for a different definition to study regional economic resilience. Different approaches that have as a common element the will to explain the response of the system to shocks have been used to analyse regional economic resilience. This response contributes to the creation of new trajectories.

However, these approaches present several limitations and in many cases, refer to resilience as feature of the system. Such a view cannot be exhaustive. Moreover, they miss to consider in the relation between resilience and adaptive ability of the systems.

In fact, a key element in studying resilience and new trajectories is to understand the adaptive capacity of the system as response to pressures. From an evolutionary economic perspective, the adaptive capacity of the regions is the ability of labour forces, technology, institutions and policies to adapt to the

change deriving from external pressure. Thus, a convincing theory of resilience must explain how adaptive capacity develops in time.

Based on the consideration above, a third type of resilience is required to explain the evolution of the systems and the ability to adapt their structure and functions in face of traumatic events. In an evolutionary perspective, the analysis of the resilience will focus not only on what are the characteristics of a resilient economy but also on how an economy can adapt to shocks over time. Thus, the purpose will be to investigate the trajectories of change rather than the stability factors. At the same time, it is useful to identify the influence of structure, organization and behaviours of economic systems in the creation of resilience (Martin and Sunley, 2015).

Simmie and Martin (2010) argue that resilience involves:

> "*the ability of the region's industrial, technological, labour force and institutional structures to adapt to the changing competitive, technological and market pressures and opportunities that confront its firms and workforce*" (p. 30).

According to this vision, resilience refers to the adaptive capacity of the system and is related to the ability of the system to reorganize and evolve in order to minimize the impact of disturbances. Such new "adaptive resilience" (Martin, 2012) involves the possibility of a structural adjustment in response to shocks and has been defined by some scholars as "evolutionary resilience" as the focus lies with the system's ability to bounce forward rather than a simple recovery of previous functions (Simmie and Martin, 2010).

In this scenario, innovation capacity assumes a crucial role in fostering the "adaptive capacity" of the system that becomes "creative adaptive capacity" involving the ability to react to external pressures generating new ideas, innovations and change (Lazzeretti and Capone, 2015).

In the seminal work of Martin (2012), adaptive resilience is defined as:

> "*the capacity of a regional economy to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time*" and it "*will depends on the rate of entrepreneurship and new firm formation in the region, on the innovativeness of existing firms, and their ability and willingness to shift into new sectors and product lines, on access to finance for investment, on the diversity of the region's economic structure, on the availability of labour of the right skills, and similar factors*" (pp. 10-11).

This definition of resilience aims to investigate the emergence of new trajectories after the occurrence of external disturbances. It is an alternative to the engineering and ecological definitions and it can be considered as a generalization of the regional economic resilience's definition.

Thus, resilience appears more as a process than a feature of the system. It may explain the evolution of the system clarifying the attitude of some regions to renew, re-organize and develop to design a sustainable future (Lazzeretti and Cooke, 2015).

The evolution of definition of resilience from its original context of ecological system to that of new evolutionary approach can be summarized in the table 2.1.

Within such process, Martin (2012) recognizes four dimensions of resilience: the *resistance* or the degree of sensitivity of the system to the shock; the *recovery* that is the ability of the system to recover from a shock that can be measured by the speed or the degree of recovery; the *reorientation* that occurs when a shock accelerates existing paths or favours transformations in the economic structure and finally, the *renewal* that could involve a restoration of the pre-shock growth path or a move toward new growth trends (Figure 2.3). Although these phases can appear a rigid and formal conceptualization, different phases can be inter-

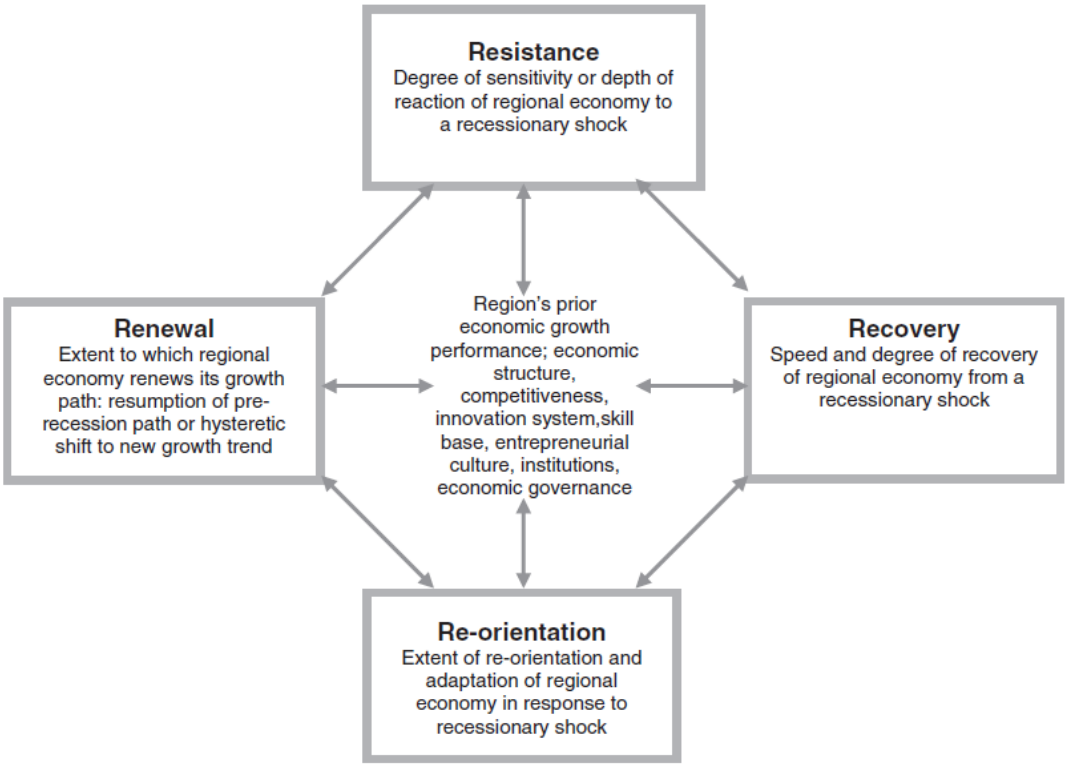
connected (Hu and Hassink, 2015). Moreover, the phases of re-orientation and re-new involve change and evolution in the system in face of external pressures.

*Table 2.1 Equilibrium and non-equilibrium based definition of resilience*

| Typology | Context | Author | Definition |
|---|---|---|---|
| Equilibrium based definitions | Engineering resilience | Holling (2001) | Engineering resilience is the ability of a system to endure shocks and is measured by the speed with which the system returns to its pre-existing equilibrium. |
| | Ecological resilience | Holling (2001) | Ecological resilience is the ability of a system to adapt to shocks and move to new schemes differing from the previous equilibrium. It can be measured from the amount of noise absorbed by the system before the change of its structure. |
| | Socio–ecological systems | Walker *et al.* (2002) | The ability to maintain the functionality of a system when it is perturbed or the ability to maintain the elements required to renew or reorganise if a disturbance alters the structure of function of a system. |
| Non-equilibrium based definitions | Urban and regional economic resilience | Simmie and Martin (2010) | The ability of the region's industrial, technological, labour force and institutional structures to adapt to the changing competitive, technological and market pressures and opportunities that confront its firms and workforce. |
| | Adaptive resilience | Martin (2012) | Adaptive resilience is the capacity of a system to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time. |
| | Regional economic resilience | Martin *et al.* (2013) | The capacity of a regional or local economy to withstand or recover from market, competitive and environmental shocks, possibly by undergoing adjustments among its firms, workers, institutions and infrastructures, and where those adjustments may be influenced by policy intervention, so that the region or locality is able to maintain or restore the full and productive use of its physical, human and environmental resources and the standard of living/quality of life of its population |

*Source: Author's elaboration*

*Figure 2.3 Four dimension of regional economic resilience*




*Source: Martin, 2012, p. 12*

In studying the adaptive capacity of the system, these two phases can be linked to the concepts of adaptation and the adaptability of the system in response to shock. These notions can be useful to explain changes related to resilience and how new trajectories have been developed. The concepts of adaptation and adaptability help to find the different influence of the resilience within regions and can explain roots of new pathways.

The origin of such concepts is ascribed to Grabher (1993) but they re-gained attention to explore the process of regional and urban resilience (Christopherson *et al.*, 2010; Pike *et al.*, 2010; Porter *et al.*, 2013; Simmie, 2014a).

Adaptation, related to the phenomenon of path dependence and resilience, depends on the ability of economic regions to reconfigure and reorganize assets historically accumulated in a territory. It is the ability of an economy to respond to a shock going back to a path already conceived. Grabher (1993) defines adaptation as the propensity of the system for the specialization of resources

and the replication of existing structures characterized by strong and tight relation between systems actors.

In view of adaptability, the measuring stick of "success" of an economy in the face of an external shock is not its ability to return to an existing equilibrium but if it can create new pathways. Adaptability expresses the capacity of social-ecological systems for learning, combining experience and knowledge, in order to adjust its response to pressures (Folke *et al.*, 2010). Such learning capacity derives from loose and weak ties between internal agents that would favour opportunities to interact with external agents and to share such new experiences within the local network. Similarly, adaptability is the capacity of actors in a system to influence resilience (Walker *et al.*, 2004).

Simmie (2014a) associates adaptation and adaptability to the concept of re-invention and replication of urban and regional economies. On the one hand, re-invention involves the ability to continually re-invent new firms. On the other hand, replication pertains to the capacity of reproducing existing components of the economic scenario of urban and regional economy. The attitude to promote the first or the second direction can influence the response of systems to exogenous shocks[19] .

This implies that different characteristics of adaptation and adaptability can contribute to understand the integration between the components of a system and to explain the complexity of resilient process. Moreover, adaptation and adaptability are useful concepts to go forward in defining resilience through an evolutionary viewpoint and in a regional context.

Some scholars consider adaptation and adaptability as excludable concepts highlighting a dualism between the two notions:

[19] According to Simmie (2014a) "*the adaptation of existing industries may prolong their life-cycles but sooner or later they will come to the end of these life-cycles. External shocks can hasten this process of destruction. In contrast, the continual re-invention of new economic activities can ensure that as one industry nears the end of its life-cycle others have already been started that can take its place. In this case, external shocks may both hasten the destruction of old industries while at the same time facilitating the creation of new ones"* (p.10).

> *"Adaptation endangers adaptability through processes of 'involution'. Adaptation leads to an increasing specialization of resources and a pronounced preference for innovations that reproduce existing structures. And while the system optimizes the 'fit' into its environment it loses its adaptability"* (Grabher, 1993, p. 265).

Reflecting such dualism on the resilience framework, a low level of resilience is related to adaptation while a high level of resilience is associated to adaptability.

In the recent literature, however, interesting opposite approaches have emerged suggesting the possibility of an interaction between the concept of adaptation and adaptability. Hu and Hassink (2015) define the concept of adaptation as:

> *"an on-going and never-ending process, by which a regional economic system responses to a succession of challenges and disturbances, in order to become fitted to its varying environment. It refers to both the current function/performance of being maintained and to the potentials for regional dynamics" (*p. 13).

On the contrary, adaptability is defined as:

> *"ability to create new and/or change old actors, institutions and resources in a regional economy, which involves an action of innovation. It is a result of adaptation in which some actors intentionally or unintentionally adapt to environments. In a long-term perspective, adaptability should aim to strive for alternative modes of doing things, rather than maintaining the existing functions and structures"* (p. 14).

The authors suggest that the relationship between adaptation and adaptability can assume several forms in relation to resilience.

A first form relates to a conflict between the two concepts. Adaptation and adaptability act one against the other: in this case, it may happen that the adaptability is achieved at the expense of adaptation or, on the contrary, adaptability is not achieved because of adaptation. This is the case of competition between old and new firms in the same area after the occurrence of a shock.

A second case involves the parallel development of adaptation and adaptability. This idea occurs when existing industries are not able to renew but they continue to stay in the area. In this case, adaptation may occur through the introduction of external resources while adaptability is related to the creation of completely new industries. The new industries do not interact with the existing industries and are not coordinated together. This scenario can enfeeble the resilience in the long-term.

A third vision is related to the ability of adaptation in fostering adaptability. Local actors involved in adaptation consciously use endogenous or exogenous resources to promote adaptability. In the first case, they mobilize existing industrial assets for new uses. In the second case, local dynamics are improved through extra-local resources. Although the model positively affects the creation of new trajectories, it fails to consider the adaptation of the system. This means that local actors consciously promote new industries but they fail to restructure existing economic models.

On the contrary, in the fourth model adaptability facilitates adaptation. Adaptability can influence adaptation by a random contingency that is poorly correlated with the phenomena. Some innovation can generate an unexpected change and a de-lock of existing paths. In this way, adaptability can reshape the form of adaptation.

Finally, a fifth vision considers adaptation and adaptability as mutually complementary. The two are positively correlated and complement each other. Local actors consciously exploit local resources for new uses and at the same

time involving new elements in existing industries. Therefore, adaptability is positively influenced by adaptation and foster a change in process of adaptation.

> *"In other words, adaptability not merely benefits from the existing adaptation process, but also pump transformative stimuli into the existing process of adaptation. It brings a co-evolution process towards coherent and incremental regional restructuring"* (Hu and Hassink, 2015, p. 17).

According to this interesting idea, the complementarity between phenomenon of adaptation and that of adaptability can foster the long-term regional resilience. Thus, mutual complementarity between processes of adaptation and adaptability may foster an ideal and sustainable resilience.

## 2.4 **Measuring regional economic resilience in EEG**

The discussion conducted so far underlies approaches and definitions of resilience in EEG. Although the evolutionary vision of adaptive resilience can contribute to overcome the limits of engineering and ecological definitions defining a framework able to explain ability of the past to influence future and possibilities to the development of new trajectories through concepts of adaptation and adaptability, EEG fails in identifying a unique measure of resilience. Thus, this paragraph represents a partial discussion of measurements of resilience proposed in literature.

Methods to measure resilience are several and they depend on the field of study, on the nature of the shock and on the aspects which the researcher wants to capture. Although the concept of resilience has increased its importance in several disciplines, including studies in regional and local economies, there is still no agreement on methodology for its measurement. The absence of a single measurement methodology comes mainly from the absence of a clear definition. Application of the concept in fields as far apart as science, psychology or

economics and several measures of resilience proposed within the same discipline can increase difficulties in evaluating resilience

In relation to the study of socio-ecological systems, the Resilience Alliance (2007) proposed a general framework to evaluate resilience. This framework is based on several stages of the assessment procedure to evaluate resilience: (1) defining and understanding the system object of the study; (2) defining the scale of measurement of resilience; (3) identify the implication of the assessment of resilience on management and policy; (4) revising the model and include what has emerged in the analysis

In the field of environmental economics, Rose (2004) used the model of Computable General Equilibrium (CGE) to analyse natural hazard impacts and policy responses. The CGE is a multi-market simulation model based on the simultaneous optimizing behaviours of individual consumers and firms, subject to economic account balances and resource constraints. The author argues that the model is the only approach which incorporate micro, meso and macro levels and consequently it results useful to the study of resilience.

In studying the economic vulnerability to exogenous shocks Briguglio *et al.* (2009) proposed an index to measure economic resilience through a series of variable which capture macroeconomic stability, microeconomic market efficiency, good governance and social development[20].

Finally, several interesting studies have tried to overcome the relation of resilience to the occurrence of single shock and proposed a measurement which would take into account several dimensions of resilience to build a framework in helping regions and cities to cope with a more general unbalanced and uncertain world. Such measurements accord to an institutional vision of the

[20] Macroeconomic stability is measured by fiscal deficit-to-GDP ratio, the sum of employment and inflation rate, the debt-to-GDP ratio. Microeconomic market efficiency is given by the component "regulation of credit, labour and business" *Economic Freedom of the World Index* of Gwartney and Lawson (2005). Good governance is measured by the component of "legal structure and security of property rights" of the *Economic Freedom of the World Index*. Social development component consists of the education and health indicators utilized to construct the UNDP Human Development Index (HDI) (Briguglio *et al.*, 2009).

resilience and would be associated to top-down strategies to promote resilience and increase territorial competitiveness.

International institutions and research centres have tried both to find main categories of interest in measuring resilience and to propose indices to estimate and summarize different variables. Such studies try to create a framework to study resilience in a holistic and multi-level perspective. Two examples are the OECD project for Resilient Cities and the City Resilience Index developed by ARUP.

The OECD Report "Resilient Cities" tries to understand how cities can increase their resilience. Resilient cities can absorb, recover and prepare for future economic, environmental, social and institutional shocks. OECD uses four key areas for resilience and identify a series of indicators to evaluate resilience. Such areas involve economy, society, environment and institutions (OECD, 2016).

ARUP developed the City Resilience Index with the support of the Rockefeller Foundation. It is an index which use both qualitative and quantitative data to create 52 indicators to measure resilience (ARUP, 2016).

Concerning studies in Economics, the main objects have been consequences and response of systems to external shocks. Scholars in Evolutionary Economic Geography (EEG) have mainly focused on recovery from economic shocks following cyclical periods of growth and recession. The main idea was to understand the performance of local and regional economics during periods of crisis. They tried to explain why some regions can better cope with shocks, showing a positive response to crisis and the interacting and multiple causes of such response (Martin *et al.*, 2015).

Investigations have concerned long-term analysis on a single country (Cellini and Torrisi, 2014; Lagravinese, 2015; Bell and Eiser, 2016) or comparison between different regions of Europe (Cuadrado-Roura *et al.*, 2016; Sensier *et al.*, 2016). The objects of the measurements have often been comparable macroeconomic variables such as GDP, output and employment. In other cases,

they have tried to explain resilience to economic shock through difference in the innovation system of regions (Simmie, 2014b).

Another part of scholars concentrated efforts in evaluating the resilience of systems in response to other types of disturbances. In the field of innovation, some studies have focused on technological aspects and patents to understand consequences of technological shocks in regions (Balland *et al.*, 2015). Fritsch *et al.* (2016), analysing the entrepreneurship, tried to recompose the evolution of regional economies in a very long-term period to highlight how regions coped with the Second World War and the slow establishment of a market economy.

Finally, methodologies of measurement have been several. A part of analysis used qualitative methods, as description of case studies to highlight trajectories of change and identify the response of regions in the long-term (Simmie and Martin, 2010; Hu and Hassink, 2015), others built indicators to measure resilience (Martin, 2012) and, finally, a part used quantitative methodologies as regressive analysis (Fingleton *et al.,* 2012).

Despite the measurement is an issue still widely debated, in the field of EEG a methodology largely applied has been the recovery and the resistance indices theorized by Martin (2012). However, such kind of measurement has been confined to the evaluation of the resilience in response to recessionary shock.

## 2.5 **Conclusions**

This chapter wanted to critically discuss resilience in regional science and the different approaches proposed to study it, leading toward a new approach to study the evolution of the system through the adaptive notion of resilience and concepts of adaptation and adaptability.

The aim of the discussion was to highlight the evolutionary aspects of resilience suggesting that the study of the response of a system to a shock cannot avoid to explain the origin of processes of adaptation and adaptability. Conversely, the adaptive capacity of the system is a key element to identify resilient regions.

Despite the advancement of studies of resilience in the regional sciences, many questions are still unresolved and the complex framework of the topic has not been untangled. Regional sciences have addressed the topic based on the theoretical meaning available, studying resilience through the tools of evolutionary theory.

However, the multitude of definitions of resilience coincided with the develop several methodologies in evaluating resilience.

An interesting step forward in building an exhaustive theory of resilience could be to enlarge the framework of EEG to other types of disturbance. In the next chapter, it will be proposed the research design of the thesis in order to connect the idea of adaptive resilience to effects and response to natural shocks.

# 3 Research design and methodology

## 3.1 Introduction

The literature review conducted so far has concerned definitions and methodologies to evaluate resilience. The analysis evidenced that resilience is a multidisciplinary concept and the rising of definitions and measures contribute to increase the fuzziness of the notion.

The literature review constitutes the starting point to discuss resilience in response to exogenous shocks. Following this revision, in the next part of the thesis, a framework to analyse the adaptive resilience referred to natural disasters will try to be constructed. Such a framework will be applied to the case of major earthquakes occurred in Japan.

Japan represents an interesting unit of analysis considering the frequency of earthquakes and the ability, not only to be prepared to these shocks, but also to recovery and promote trajectories of economic revitalization after disasters.

In this chapter, the research design of the thesis will be discussed presenting the interpretation of the literature in order to build a framework to study resilience. The literature review has led to underline the research gaps of the resilience theory. On the base of these gaps, specific research questions emerged while the interpretation of the literature contributed to develop the hypotheses of the research.

Finally, the methodology applied to study resilience. will be discussed. Despite the interest in capturing different aspects of resilience through different measurements, the lack of a single methodology may decrease the effectiveness and the power of the theoretical concept. However, finding an appropriate measure of the resilience of systems presents some difficulties and critical points. These difficulties will be analysed to evaluate resilience showing that research should consider different aspects in choosing the appropriate methodology. Furthermore, to achieve the scope of this work, attention will be

paid to the methodologies proposed in order to evaluate impacts and effects of natural disasters, particularly earthquakes.

## 3.2 **Research questions and hypotheses**

Based on the literature review, the thesis wants to apply the theoretical framework of regional economic resilience theorized in EEG to the phenomenon of natural shocks. The thesis will refer to the definition of adaptive resilience. This choice is due not only to the criticism highlighted in relation to engineering and ecological resilience but also to the need to study the ability of systems to evolve in relation to an external shock. This implies that an analysis of the impact and reactions of urban and regional economies in the face of exogenous shocks cannot have a short-term character but it should be conducted over the long time.

Despite the extent of scholars in EEG to find a theoretical framework of resilience through an evolutionary perspective, it still remains underdeveloped and three main gaps can be highlighted.

First, a unique methodological framework to evaluate resilience is not yet defined. Martin (2012) identifies different phases through which economic systems resiliently respond to shocks: resistance, recovery, reorientation and renewal. Thus, evaluating resilience requires both to investigate short-term response and long-term adaptability. Phases of resistance, recovery, reorientation and renewal may be considered as a solution to the debate on "dynamic versus static" resilience. While resistance and recovery phases can be applied in relation to short-term analysis to consider the system's ability to return to a state of "normality", the reorientation and renewal phases can be linked to dynamic processes related to adaptation and adaptability. In relation to the evaluation of resilience, Martin (2012) proposed two indices to test the ability of regions to resist and recovery to external shocks. Processes of reorientation and renewal need a long-term analysis to be understood.

Thus, a further investigation to short-term and long-term process of resilience is required (Martin *et al.*, 2015).

> "*How regional economies adapt over time, and why some regions appear more successful in respect than others are largely unresearched topic*" (Martin, 2012, p. 11).

In this context, the role of past conditions and possibilities to develop new trajectories needs a larger investigation. A wide part of the literature considers past conditions of the system as factors that can limit resilience (Boschma, 2014; Balland *et al.*, 2015). However, interpretations of positive and negative lock-in in relation to resilience should be investigated. Moreover, despite the important contribution of the theory of new path creation in identifying origins of new trajectories (Garud and Karnoe, 2001; Simmie, 2012), inter-connections between the creation of new industries and the re-organization of the existing resources after exogenous shocks needs a further development. Concepts of adaptation and adaptability can contribute to this aim. Such notions could constitute a starting point to synthesize the theoretical debate of resilience concerning adaptation of past conditions and creation of new trajectories. Furthermore, they could offer a synthesis between path dependence and new path creation theories explaining both origins of new paths and processes involving paths historically belonging to the system. In addition, the possibility of a complementarity between adaptation and adaptability (Hu and Hassink, 2015) could reinforce the idea that the new development trajectories are not born in "virgin markets" but may have originated from a complex process involving both the reorganization and reproduction of existing resources and the introduction of new ones.

Second, the definition of regional economic resilience evidences that different typologies of shocks - market, competitive or environmental - may affect regional and urban systems. However, an analysis of the literature in the

field of EEG shows that the effects and the evolutionary dynamics of natural shocks are still an under-researched topic. Indeed, most of the studies of resilience in EEG mainly focus on changes in regional and urban economies as a result of economic shocks, such as recessions or processes of deindustrialization. Poor attention has been paid on consequences and responses in relation to natural disasters. However, environmental shocks can have strict repercussions on economic growth, not only due to the losses in physical and human capital (Toya and Skidmore, 2005) but also as a result of the inability of firms, institutions and communities to respond to the shock by activating new and alternative growth paths. In other words, the inability of actors to reinvent or to facilitate process of adaptability. This can create situations in which economic performance, measured in terms of GPD or employment, may be unable either to return to pre-disaster levels or to move on higher levels.

Finally, what is still missing in the theory of resilience is a concrete idea of which behaviours and attributes of systems can contribute to shape resilience. Role of both actors and resources of the systems in affecting resilience has a limited explanation.

Concerning the first issue, Martin and Sunley (2015) recognize a fundamental role to agency and decision-making processes in order to increase the ability of economic systems to resist to and recover from shocks. Bristow and Healy (2015) emphasize the role of policies in proactively responding to crisis. In new path creation theory, the role of human actions is fundamental in creating opportunities to generate new paths. "Mindful deviation" of actors can influence development of new trajectories (Garud and Karnoe, 2001). Despite the literature looks at the lack of considering the human dimension – institutional, political, economic and social - as one of the major criticism of the ecological definition of resilience, also scholars in EEG have not discussed the topic enough.

In relation to the role of resources in contributing to resiliently respond to shocks, literature gives different interpretations. A large part of it recognizes in embedded resources such as local culture, innovation capacity and cultural and creative resources, elements that may influence resilience. Huggins and Thompson (2015) refer to openness and diversity of local culture as a key element for increasing entrepreneurial resilience. According to Bellandi and Santini (2017), idiosyncratic cultural factors contribute to the success of industrial districts to cope with crisis. Simmie (2014b) highlights the role of specific features and capabilities of Regional Innovation Systems (RIS) in contributing to resilience and fostering economic growth. Cooke and Eriksson (2012) investigate resilience and innovation in the context of global change. Lazzeretti (2013) discusses how creative cities can exploit their material and immaterial resources to respond to external pressures and contribute to local development. Colombino and Vanolo (2017) underline how symbolic places that represent the heritage and the identity of a city can change and adapt to the evolution of urban conditions and economic conjunctures favouring the resilience of cities. Despite these contributions, the role of innovation, culture and creative resources in fostering resilience needs more consideration.

These theoretical problems can be summarized in the following gaps in the literature of EEG related to resilience. Generally speaking, there is not wide accordance among definitions and measurement of resilience. This contributes to the absence of a shared methodological framework to evaluate resilience. Furthermore, the framework of EEG presents these specific lacks:

1) There is still poor consideration of short-term and long-term processes of resilience. Furthermore, there is few interest in understanding how process of short and long term are interconnected and the role of past conditions in this process.

2) In the theoretical framework of resilience proposed by scholars of EEG in the last few years, it is still missing an enlargement of the theory of resilience to natural shocks.

3) There is a lack in understanding how actors, behaviours and resources both embedded in the system and newly introduced can contribute to explain the response of system to shocks.

Based on the these gaps in literature, the thesis wants to answer to a number of research questions.

A general question is proposed in order to achieve the aim of the research and investigate the relationship to resilience, natural disasters and economic change. In order to address such aim, the general research question is:

- *"What is the relation between resilience, natural disasters and the creation of new trajectories?"*

To contribute to answer to this general question, the thesis wants to address three specific questions related to the research gaps identified in the literature review:

- *"How can resilience in response to natural shocks be evaluated?"*
- *"Can new trajectories be created after a natural shock?"*
- *"Which is the role of social, institutional and economic actors and resources of the system in fostering resilience?"*

In order to provide an exhaustive answer to the research questions, some research hypotheses based on the literature reviewed will be discussed.

The approach of non-equilibrium based resilience proposed in EEG (Simmie and Martin, 2010; Martin, 2012; Martin *et al.,* 2013) can synthetize different approaches and methodologies applied to study resilience through the concept of adaptive resilience. This framework has been mainly applied to economic shock but can constitute a fundamental approach to study different typologies of shock. Based on this statement, the first hypothesis of the thesis is theoretical and suggests that:

*(1) adaptive resilience in EEG can be successfully applied to study of natural disasters in explaining evolution of economic structure as a consequence of environmental shocks.*

Based on definitions of adaptive resilience, urban and regional economies can be considered resilient in face of different types of shocks when they can adapt to changing circumstances. Furthermore, according to Hu and Hassink, (2015) sustainable resilience is stimulated by a complementary process of adaptation and adaptability. As a consequences, adaptation and adaptability are complementary part of the process of resilience and, at the same time, influence resilience. This involve that:

*(2) a system can be considered resilient when it is able to activate processes of both adaptation and adaptability in response to a shock.*

Process of adaptation and adaptability involve both the recombination of existing resources and the creation of new ones. According to the theory of new path creation, actors of the system contribute to develop new trajectories. Moreover, a part of scholars suggests that institutions and policies can activate processes of change after shocks (Bristow and Healy, 2015; Martin and Sunley, 2015). However, it can be assumed that is not the individual action of a single actor that can activate process of change but:

*(3) a synergic action between actors of the system – institution, firms and communities – can mobilize existing resources and creating new ones to contribute to adaptation and adaptability.*

In the next section, it will be discussed the methodology applied to study adaptive resilience in relation to natural disasters in order to try to respond to the research questions and fill the research gaps of the literature.

## 3.3 **Methodology**

The aim of the thesis is to investigate the relationship between resilience, natural disasters and economic change. To address this aim, the thesis proposes an empirical investigation of the case of Japanese earthquakes.

Earthquakes are not predictable in terms of when they strike but some areas are more likely to be hit. In relation to this consideration, Japan represents one of the most seismic risk prone areas in the whole world. At the same time, it is one of the country that has been able to better cope with earthquakes, both in physical and economic recovery and to foster innovative capacity in the field of earthquakes safe technology. For these reasons, testing the resilience of Japan in relation to earthquakes appear extremely interesting.

The first question of the thesis wonders how resilience natural disasters can be evaluate. According to Sensier *et al.* (2016), a good evaluation of resilience should not confuse the system capacity to influence the resilience and the product of the resilience of the system. A clear separation between the features of the system and the results of the recovery process can help to distinguish which characteristics affect resilience.

Martin (2012) identifies four interrelated dimensions of resilience that contribute to understand how regional economies respond to shocks. The first dimension is related to the *resistance* of the system and refers to its vulnerability to the shock. The second is the *recovery* of the systems and relates with the speed and the extent of recovery in response to a pressure. The third dimension involves a *reorientation* of the system that can offer a structural adjustment through adaptation. The final dimension concerns the *renewal* of the system, involving the coming back to an existing path or the creation of new paths. This dimension involves the attention to the role of past condition in affecting new trajectories. These different dimensions of resilience of regional economies can

provide a conceptual approach to understand phases performed by a system to positively respond to a shock[21].

According to such vision, the thesis wants to first analyse the processes related to the ability to resist and recover from an environmental shock and later how systems are able to reorganize and renew after a natural shock. This framework, generally applied to economic shocks, will be applied to the case of earthquakes in Japan. The empirical analysis will consist of two different parts.

In the first part, resistance and recovery will be analysed measuring two indices to evaluate the resilience of Japanese prefectures in response to earthquakes. In the second part, reorientation and renewal dimensions will be investigated referring to the concepts of adaptation and adaptability. The case study of the city of Kobe will be constructed in order to understand if new trajectories can emerge after natural shocks and how behaviours, resources and actors can influence resilience.

### 3.3.1 Criticisms in measuring resilience

Sensier *et al.* (2016) found several critical points in approaching the measurement of resilience. Four main points may be interesting in discussing how to measure resilience:

1) To find a reference state to measure the impact of the shock and the nature of recovery.

2) To identify comparable indicators and consider durable effects of the shock on regional growth paths.

3) To measure the resilience of the system in absolute or relative terms, related to a comparison to other regions or to a pre- disaster condition.

[21] These stages can be considered as a substitute for those theorized in Adaptive cycle. Adaptive cycle fact resilience is viewed as an added dimension to the process, along with connectivity and potential (Holling, 2001). In this context, resilience loses its connotation of characteristic of the system and becomes a real process, comprising a series of steps that with different degrees may contribute to the emergence of the resiliency.

4) To decide a scale of measurement, such as national, regional or city level and identify a specific period to verify resilience.

The first point concerns the problem related to the definition of resilience. Is resilient a system which goes back to previous state or the one which finds a new equilibrium? Here the discussion can be led through the equilibrium based definition of resilience and the adaptive one. As a consequence, in order to deep understand resilience, scholars need to identify a clear definition before focusing on its measurement.

Comparable indicators can give an idea of how a certain economy reacts to a shock. It may possible to measure resilience through economic macro-variables because of easiness in comparing performance between different regions. Anyway, macro-economic indicators can suffer of distortions in relation to the instability of economic measures due to the continuous adjustment of regional economies. To study resilience, effects of the shock and fluctuations due to the unpredictability of economic scenario should be separated. It is important to be careful in drawing conclusions and to analyse the general context of each region.

Resilience can be also measured by *ad hoc* indices related to crucial aspects of reaction and recovery. Such indices can be useful in evaluating aspects related to different levels of resilience and in giving a holistic vision of the issue. At the same time, these indices may be difficult to estimate due to the lack of available data or to difficulties in choosing crucial variables for the analysis.

The third point concerns the possibility to compare resilience in different systems or states of the system. A comparison based on a pre-shock and post-shock state can give the idea of the evolution of the phenomenon and how resilience acts to support or contain it. Indeed, a comparison between units can help in finding different characteristics that affect resilience. Different pre-shock frameworks, behaviours and decision process can differently affect responses of regions (Bristow and Healy, 2015).

Finally, in relation to the scale of measurement, according to Rose (2004) resilience can involve three levels of the economic system: a microeconomic

level, involving individual behaviour of firms, households or organizations; a mesoeconomic level which pertains sectors, markets or cooperative groups in coping with the shock; a macroeconomic level, a combination of all individual units and markets which interact in the whole economy. As a result, a measure of resilience in economic systems involves different levels of resources, behaviours and decisions and it may be difficult to establish a single framework which groups actors of several levels.

Despite such theoretical problems, in the last few years, several measurements of resilience have been proposed to capture the effects of shocks through a focus on distinctive objects of measurement.

According to the critical point highlighted by Sensier *et al.* (2016), we have tried to overcome them as follow:

1) According to the definition of adaptive resilience as "*the capacity of a regional economy to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time"* (Martin, 2012, p. 10), we refer to a reference state evaluating the ability of the system to come back to a pre-disaster level or to back forward to the pre-disaster level. Particularly, we are interested in the resistance and the recovery phases of resilience as descripted by Martin (2012), namely, the degree of sensitivity of the system's economy to the shock and the degree of recovery. In the second empirical application, resilience in accordance with adaptation and adaptability will be evaluated in order to investigate dimensions of reorientation and renewal.

2) To measure resilience, the variable selected relates with data of employment in regions. Such decision depends on some theoretical reflections. To study environmental shocks, an economic measure of resilience based on GDP can distort perceptions of recovery due to a possible growth of GDP caused by investments in reconstruction. On the contrary, a measurement based on employment can give a clearer

idea of the ability of the region to react to a shock. It can be a comparable indicator between regions and it can represent a measure of national and regional well-being (Sensier *et al.*, 2016).

3) We have carried out a relative analysis of resilience. First, we analyse resistance to the shock and resilience after its occurrence through a comparison between different units to evaluate levels of resilience and to identify the most resilient areas. Second, we analyse the single event and the ability of each region to cope with the shock. This analysis involves a comparison between the pre-disaster level of employment and changes in the following years.

4) In our analysis, we use the prefectural scale to evaluate resilience to natural shocks. Such scale is equal to the Territorial level 3 (Tl 3) of OECD classification. Prefectural scale seems to be the more adequate scale to evaluate impact of natural disasters because of damage related to earthquake is territorial centred.

### 3.3.2 Resistance and recovery indices

In order to measure resilience, we propose an analysis of major earthquakes occurred in Japan, in the proximity of urban areas, between 1995 and 2011. The aim of this analysis is to evaluate economic damage for such disasters and identify changes in employment to understand the ability of the different areas to cope with earthquakes. The main idea is to analyse resistance and recovery dimensions in the dynamic process of resilience identified by Martin (2012).

Before to describe in details methodology applied to evaluate resistance and recovery, a discussion concerning methodologies applied to study economic impacts of natural disasters is proposed.

In studying economic aspects of shocks, a part of literature has paid attention to the capacity of regions to cope with natural shocks, as massive natural disasters or climate change. In studying the relationship between resilience, natural disasters and economic change different analysis have been proposed.

In general, poor attention is paid to the long-term economic effects of natural disasters and short-term analysis are preferred because of difficulties on identifying and isolating the long-term economic effects of natural shocks (Benson and Clay, 2004).

A large part of analysis of natural disasters are focused on evaluating the impact of the shock through a measure of the decrease in physical capital and the amount of financial damage.

To evaluate response and evolution in the economic scenario as a consequence of natural disasters, a part of scholars used macroeconomic indicators to understand economic performance of systems in relation to shocks. In general, indicators adopted are gross domestic product (GDP) and its annual growth. An example is the work of Skidmore and Toya (2002) focused on the positive association between disaster frequency and long-run GDP growth. According to the authors, the growing of GDP depends on the push in developing new technologies given by the occurrence of the disaster. However, major effects of growth of GDP may do not depend on natural disasters. According to Horwich (2000), a measure of GDP can distort perceptions of the disaster impact by the amount of the capital invested in the reconstruction and debris removing activities. Also, effects on macroeconomic variables, tend often to be imperceptible because of resource substitutions, allowing positive forces to increase GDP.

Through the wide field of natural disasters, some scholars focused attention on impacts and responses of regions and cities to earthquakes. Ferreira and Karali (2015) propose an analysis to understand if major earthquakes have effects within the global market. duPont IV *et al.* (2015) use the synthetic control method to study the socio-economic impact of earthquake in Kobe in 1995 estimating a counterfactual based on data of town and cities not damaged by the quake. Variables used for measurement are among others demographic, environmental, economic, institutional and spatial-economic. Through a

counterfactual analysis, Pagliacci and Russo (2016) estimate the macroeconomic effects of the 2012 earthquake in Emilia-Romagna using municipality level data.

Chang (2010) builds a theoretical framework to develop indicators to evaluate recovery for earthquakes based on recovery in population, number of business, gross regional product (GRP) and traffic port. Resilience is measured as the amount of time needed to reach a new normality after the occurrence of the disturbance.

Other studies of resilience in face of earthquakes try to link effects of natural disasters to changes in the labour market and employment. Fabling *et al.* (2016) measured the response of Christchurch region, in New Zealand, to Canterbury earthquake, in 2011, through an analysis of jobs and accumulated earnings for workers. Porcelli and Trezzi (2016) compare provincial data for 22 earthquakes occurred in Italy between 1986 and 2011 through an empirical investigation considering two alternative dependent variables, the rate of change of provincial output and the employment rate. Merehgan *et al.*, (2012) use a shift-share analysis to estimate long-term impacts of disasters on employment and to find changes in the structure of employment due to the earthquake.

This brief survey of methods to evaluate the impact of natural disasters on the economy shows that there is not accordance in measurement methods. Based on this consideration, the thesis tries to combine the approach proposed to study regional economic resilience in the field of EEG with the analysis of impact and recovery in response to the disaster.

The analysis is composed of two main phases:

- The first step of the analysis involves the application of the indices of Martin (2012) of resistance and recovery to investigate the response of Japanese prefectures to major earthquakes and to understand if a measurement based on economic macro-variables can be meaningful to study resilience in face of natural disasters.
- The second step has been to analyse the change in employment rate in each prefecture and in relation to the earthquakes to identify economic

response to the shocks. Such measure is compared to the respective indicators for national level. This may give an idea of the evolution of employment in relation to the shock. The national economy can be considered a benchmark to evaluate resilience.

Data of earthquakes have been selected from the "Global Significant Earthquake Database" of the National Oceanic and Atmospheric Administration (NOAA) distributed by the National Centre for Environmental Information (NCEI). The database collects historical information of earthquakes related to date, time, location, focal depth, magnitude, intensity and socio-economic data, such as the total number of fatalities, injuries, houses damaged and destroyed and US dollar damage estimates when available.

Such data have been compared to the data of the International Disasters Database released by the Centre for Research on the Epidemiology of Disasters (CRED) of the Université Catholique de Louvain (UCL) in Brussel. The database collects information of natural disasters providing data of the human impact of disasters, the disaster-related economic damage estimated and disaster-specific international aid contributions. For each earthquake, we analyse latitude and longitude to identify the epicentre of the quake and the area involved by the damage.

First, historical data on Japanese earthquakes from 1900 to 2015 have been preliminary selected. Then, we have listed earthquakes from 1995 to 2011 and we have chosen major earthquakes occurred. According to NOAA database, significant earthquakes are those which have a magnitude greater than or equal to 7 on Moment Magnitude Scale (Mw) and/or an amount deaths greater than or equal to 10 people and/or a damage greater than or equal to 1 million of dollar. The prefectures in which the earthquakes occurred have been detected looking at the data on the latitude and the longitude of the singular earthquake's epicentre.

A second selection occurred to skim earthquakes in relation to availability of data and proximity of the epicentre to an urban area. In relation to the former,

the recovery time of four years imposes to evaluate only earthquakes for which the data was available. In relation to the latter, we analyse data of earthquakes occurred close to urban centres. Indeed, some of the major earthquakes in Japan have their epicentre in the ocean and often no damage to people or buildings have been recorded.

In the end, the analysis conducts to the selection of 6 major earthquakes occurred between 2003 and 2011 with a direct impact on 10 Japanese prefectures (Table 3.1)

*Table 3.1 Selection of major earthquakes* occurred in Japanese Prefectures between 1995 and 2011*

| Year | Prefecture | Mag. | Deaths | Injuries | Damage** |
|---|---|---|---|---|---|
| 2003 | Iwate Miyagi Yamagata Akita | 7 | - | 143 | 233 |
| 2003 | Hokkaido | 8.3 | - | 755 | 90 |
| 2004 | Kyoto Wakayama Osaka | 7.4 | - | 40 | - |
| 2007 | Niigata | 6.6 | 9 | 1,088 | 12,500 |
| 2008 | Tokyo | 6.9 | 13 | 357 | - |

**(Mag. ≥ 7 or Num. Deaths ≥ 10 or Damage ≥ 1 million $)*
***Damage is evaluated in Million US $*
*Source: Author's elaboration on data from NOAA database, 2016*

Then, to estimate the resilience of Japanese prefectures to earthquake, we calculate two different indices starting from resistance and recovery indices theorized by Martin (2012). The author proposes these two different indices to evaluate the ability of the regions to resist to recessionary shocks and recovery in a post-recession period.

The resistance index is calculated as the change in employment in the region compared to the change at national level in the shock period. The resistance index gives an idea of the ability of a region to cope with a shock. The recovery index can help to demonstrate the recovery capacity of a region through a growth in employment in the period following the shock.

The resistance and recovery index will be namely $\beta_{res}$ and $\beta_{rec.}$ We formalize such index as follow:

$$\beta_{res} = (\Delta E_r/E_r)/(\Delta E_n/E_n)$$

If $\beta_{res}$ is greater than 1, the region has a low relative resistance to the shock. On the contrary, if $\beta_{res}$ is lower than 1, the region has a high relative resistance to the shock.

$$\beta_{rec} = (\Delta E_r/E_r)$$

The recovery index is measured as the change in employment in the region in the post-crisis period and shows the ability of the region to grow after a shock.

The sensitivity indices of Martin (2012) has been applied to several studies, mainly to evaluate the capacity of regions and systems to cope with recessionary shocks.

Lagravinese (2015) used a modified version of the index to measure the different effects of the economic crisis occurred in Italy between 1970 and 2011. According to the author, resistance index is βres= [(ΔEr/Er)-(ΔEN/EN)] / |ΔEN/EN|. A positive value of βres is an indication of the major resistance of the region to the shock. A negative value of βres indicates a worst performance of the region compared to the national level.

In a recent work, Faggian *et al.* (forthcoming) use a revised version of the sensitivity index proposed by Martin (2012). In their work, resistance is measured by the sensitivity index (SI), that is SI= (Er,t/Er,t-1) / (En,t/En,t-1) where Er is the total employment in the region and En is the total employment in the nation. The period (t) represents the recessionary period and the period (t-1) represents the pre-recessionary period.

The authors applied resistance and recovery indices to the Italian local labour system (LLS) to measure regional economic resilience to recessionary shock.

### 3.3.3 Case study analysis

The case study analysis is proposed in order to analyse dimensions of reorientation and renewal. According to the vision of adaptive resilience proposed by Martin, (2012), a system is resilient when it is able:

> *"to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time*" and it "*may well depend on the nature of the region's pre-existing economy; that is, adaptation is likely to be a path dependent process […], shaped by the region's industrial legacy and the scope for re-orientating skills, resources and technologies inherited from that legacy*" (pp. 10-11).

Furthermore, Simmie and Martin, (2010) argue that a convincing theory of resilience needs to keep in mind the:

> *"[…] industrial 'mutation' that takes place via process of 'creative destruction"*' (p. 30).

These arguments suggest that both ability to reconfigure existing resources and process to create new resources matter for the constitution of the resilient process. In this scenario, analysis of adaptation and adaptability is crucial to understand the ability of economic systems to withstand exogenous shocks. An analysis of such processes requires a long-term perspective and an accurate description of changes occurred in regions after s shock.

In order to achieve this aim, the second empirical analysis proposed is a case study analysis of an urban region destroyed by a damaging earthquake. This is the case of the city of Kobe stricken by the Great Hanshin Earthquake of 1995. Thanks to a proactive action of local government, firms, institutions and community the city was able to recovery from the earthquake and proposing a new imagine of innovative and creative city.

The *Case Analysis* is a research tool widely used in academic studies of economic and managerial level (Yin, 1981; Eisenhard, 1989; Yin, 1994)[22]. The purpose to use the case study analysis to analyse the processes of adaptation and adaptability in Kobe derives from the nature of the problem and is related to the research questions. Understanding the creation of new trajectories and role of actors and resources in affecting resilience requires a deep investigation that can be unlikely provided using quantitative techniques. The case study is paradigmatic of complex dynamics that occur in regional and urban systems after an external shock and represents an application of the theoretical framework of evolutionary resilience[23]. Indeed, in literature, the adoption of a single case study is justified to meet some specific needs of the researcher and it may find application when the case in question is a critical test of an existing theory (Yin, 1994)[24].

The case study analysis has been successfully applied both to the EEG and to the study of natural disasters. In the EEG, examples of the use of the methodology are related to analyses of regional response to economic crisis (Bristow and Healy, 2015), to identify origins of new trajectories and technologies (Simmie, 2012) and to study evolution and change of economic structure of urban systems (Simmie and Martin, 2010). In studying natural disasters, some scholars proposed the case study analysis to identify response

[22] The methodology of the study of cases finds its origins in ethnographic studies conducted since the fifteenth and sixteenth century with the aim of studying the populations industrially undeveloped and, therefore, considered by Western "primitive". These studies were aimed at identifying the links between Western culture and its prehistoric origins (Stake, 1994).

[23] In general, five different applicative purposes are in studying cases (Yin, 1994). Explanation, if the case aims at explaining the bonds which occur in the real context, which is too complex to be studied with other methods of investigation. Description, if the method lends to describe a series actions and the context in which they originate. Illustration, if the case illustrates certain topics through a description. Exploration, if it wants to explore situations for which the actions to be evaluated are not clear. Meta-evaluation, if the research and analysis are carried out on a prior evaluation study.

[24] Stake (1994) distinguishes three possible types of case studies. One of these categories is represented by *instrumental case study*, aimed to perfecting a theory. In this sense, the role of the case study is to provide a support for scholars to make more understandable the phenomenon.

and recovery of cities to natural disasters (Vale and Campanella, 2005; Edgington, 2010).

The case of Kobe and the Great Hanshin earthquake has been developed during a visiting period at the Urban Research Plaza at the Osaka City University, from October 2015 to January 2016. The visiting period gave the opportunity to visit the city of Kobe to collect information, documents and interviews.

The process of development of the case study involved several stages in accordance with the literature of case analysis methodology (Yin, 1994; Stake, 1995). A series of phases can be identified:

1) design of the case study;
2) preparation for data collection;
3) field data collection;
4) analysis of collected data;
5) preparation of the final report.

In the design phase, the aim of the analysis was defined in accordance with the literature. During the preparatory phase, primary and secondary sources of information were identified and interviews were set. A list of research institutions, universities and public administration involved in the field of earthquakes prevention and recovery was collected. Following, eleven institutions were contacted in the areas of Kobe, Osaka and Kyoto to collect interviews but only five institutions were able to give an interview. The data collection phase involved the search of primary sources and secondary sources.

Primary data counts of in-depth interviews with professionals, academics and representatives of public institutions. In-depth interviewing is a research technique in which a small number of respondents gives intensive individual interviews to explore their perspectives on a specific phenomenon

(Bauer,1996)[25]. The method of depth-interviews was used to have a non-influenced response from the subjects and a comprehensive understanding of the most innovative changes perceived after the earthquake. Such a methodology was useful to identify trajectories of economic development created in the long-term.

The in-depth interview involved face-to-face unstructured interview with a limited number of questions. These questions should constitute an input for stimulating the interviewed and regard the general topic (Ritchie and Lewis, 2003). To reconstruct the case of Kobe, the outline of the interview centered around the personal experience of the subjects and they lasted from two to three hours. Few and general questions concerned the memory of the earthquake, the differences between the city of Kobe in the period before the earthquake and the present structure and organization and a comparison between the case of the Great Hanshin Earthquake of 1995 and the Tohoku Earthquake of 2011.

A part of actors was involved in the study of the recovery after earthquakes in different fields. Another part was directly involved in the earthquake of Kobe in 1995. The first part of interviews focused on theoretical aspects of the reconstruction, seismic effects of earthquake, analysis of economic damages and policies of recovery. The second part comprehended a series of narrations of the experience of the earthquake. The subject interviewed were two professors of the Department of Engineering and Architecture (Osaka City University, University of Osaka), a professor of the Department of Economics (Doshisha University), an architect and professor of Hyogo Prefecture and the Manager and the Assistant Manager at Planning and Coordination Bureau of the city of Kobe.

The method of in-depth interview provides the opportunity to have a spontaneous narration of the events related to earthquake based on the personal experience of each subject.

[25] In-depth interview is a narrative interview characterized by an unstructured form and classified among the qualitative research methods.

The second part of data collection involved the collection of secondary data. This second activity of data collection was necessary to compare multiple sources of data in order to improve the quality of the case study through triangulation[26]. Secondary data were based on the main statistics released by City of Kobe, Prefecture of Hyogo and national statistics. These are Kobe City and Hyogo Prefectural Statistics (from 1994 to 2014); The Great Hanshin-Awaji Earthquake: statistics and restoration progress (2014)[27]; Pocketbook Statistical Data of Kobe (2013-2014-2015)[28]; Comprehensive Strategy for Recovery from the Great Han shin-Awaji Earthquake (2010)[29]; Census of Japanese employers and establishment (1999 and 2001)[30]. The secondary data, moreover, involved scientific publications and international reports about the case of the Great Hanshin Earthquakes.

The phase of analysis of data involved the reconstruction of the interviews and the analysis of secondary data. In this phases, interviews were send to the subjects in order to correct errors and validate the process.

Finally, the phase of reporting concerned the preparation of a first report of the case study developed comparing both primary sources and secondary sources. In the final phase, such a report was analysed in accordance to the literature review in order to obtain a scientific validation and to prepare the drafting of the case study chapter.

## 3.4 **Conclusions**

This chapter discussed the research design of the thesis and constitutes a bridge between the theoretical chapters and the empirical part of the thesis.

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[26] Triangulation is a method that allows to compare the data obtained from multiple sources in order to corroborate a certain fact.

[27] City of Kobe, (2014a), *The Great Hanshin-Awaji Earthquake: statistics and restoration progress*, Kobe.

[28] City of Kobe, (2013), *Pocketbook Statistical Data of Kobe*, Kobe; City of Kobe, (2014b), *Pocketbook Statistical Data of Kobe*, Kobe; City of Kobe, (2015), *Pocketbook Statistical Data of Kobe*, Kobe

[29] City of Kobe, (2010), *Comprehensive Strategy for Recovery from the Great Hanshin-Awaji Earthquake*, Kobe.

[30] Statistics Bureau of Japan, (2001), *Establishment and enterprise census of Japan*, Tokyo: Portal of Official Statistic of Japan.

In the first part of the chapter, the interpretation of the literature review is discussed in order to study the response of Japanese economies to earthquakes. First, gaps in literature are analysed; second, based on these, research questions and hypotheses are formulated.

The application of the theoretical framework of regional economic resilience based on the dynamic process of resistance, recovery, reorientation and renewal is proposed in order to analyse both the short-term impact of earthquakes on employment and the long-term trajectories that may be possibly developed after the occurrence of an earthquake.

In the second part of the chapter, it is discussed the methodology proposed to achieve this aim comprehending the measurement of resistance and recovery indices to evaluate resilience of Japanese prefectures and the analysis of process of adaptation and adaptability through the case study analysis of the Great Hanshin Earthquake occurred in Kobe in 1995.

In relation to indices, the discussion about methodology tries to underline the main criticisms related to the identification of a measure of resilience and how these problems are overcome in the study proposed. Moreover, an analysis of measurement proposed in literature to evaluate the impact of natural disasters allows to understand variables and methodologies applied to the study of environmental shocks.

Concerning the case study analysis, a detailed explanation of the development of the case study contributes to identify the main steps of case analysis. Sources of data and processes executed to validate the analysis of the case of Kobe is discussed.

In the next part of the thesis, empirical application to evaluate resilience in relation to earthquakes will be discussed. The fourth chapter will refer to the analysis of indices and the fifth chapter will concern the case study of recovery of Kobe after the Hanshin earthquake.

# 4 Resistance and recovery indices: an analysis of major earthquakes in Japanese prefectures

## 4.1 Introduction

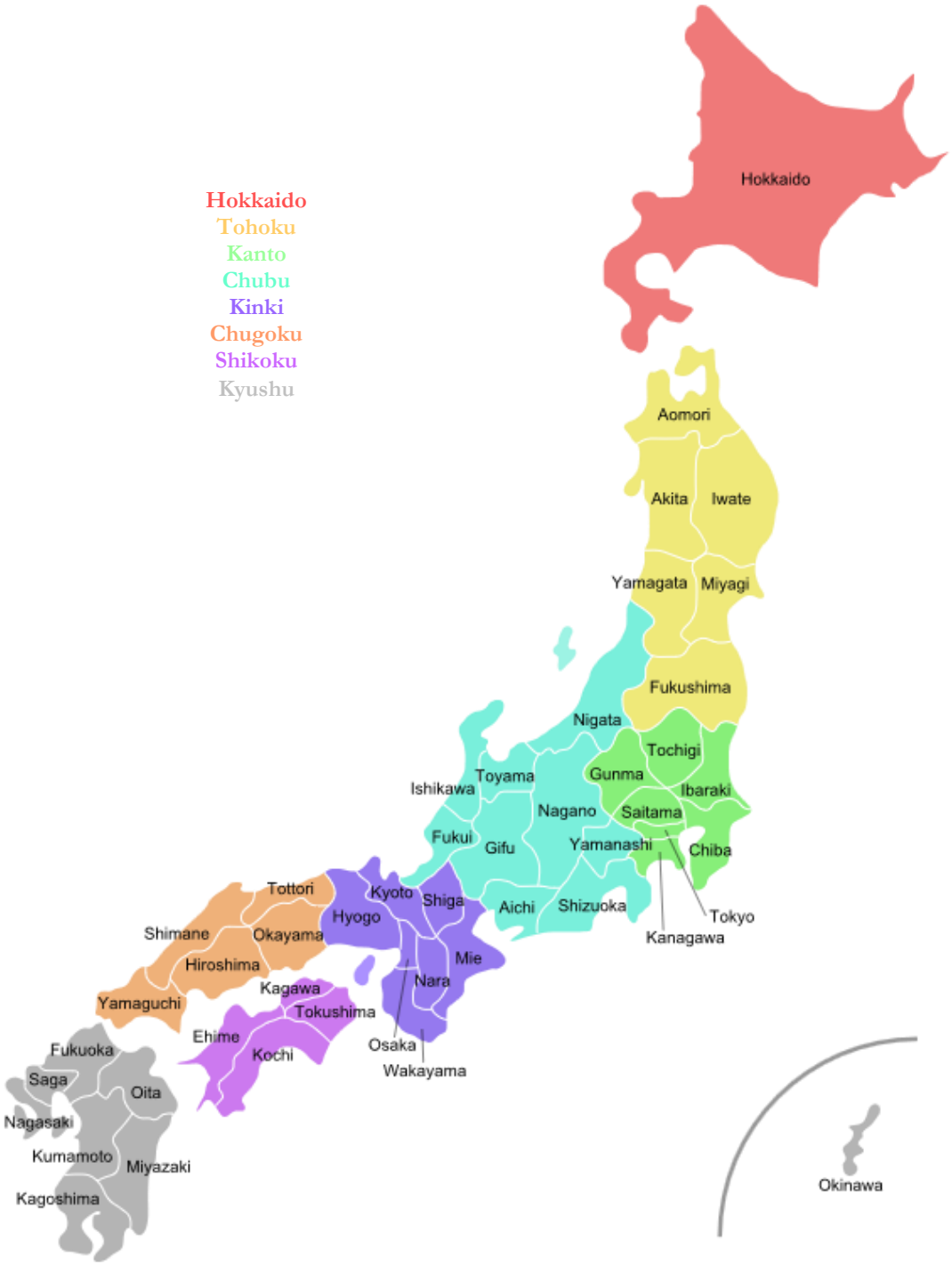
Japan is a stratovolcanic archipelago of 6,852 islands located in the Pacific Ocean. Its area covers 377,944 square km and its population amounts to 127 million people with a density of about 343 persons for square km. It has four main largest islands, Honshu, Hokkaido, Kyushu and Shikoku and it is divided in eight regions and forty-seven prefectures[31] (Ministry of Internal Affairs and Communication, 2015), (Figure 4.1).

Japanese islands are in a volcanic zone on the Pacific Ring of Fire and a large part is covered by mountains of moderate altitude[32]. Geographical features of the Japanese landscape in part explain its urban morphology characterized by a continuous urbanization located in the coastal areas and infiltrating in the hinterland, until reaching slopes of mountains. Such geography, not only limited the possibilities for urbanization but also hardly affected configuration of metropolitan areas. Limited zones for population involves the need to find a balance between urban and natural life.

[31] In Japanese, the suffixes "To-Do-Fu-Ken" are used to indicate prefectures. They are in turn divided in cities (Shi), towns (Cho) and villages (Mura).

[32] The Ring of Fire is a tectonic plate in the Pacific Basin responsible for 90% of the world's earthquakes and 81% of the world's strongest quakes. On top of its prolific tectonic activity, Japan hosts 452 volcanoes and it is the most disruptive geographic location in terms of natural catastrophes.

*Figure 4.1 Map of regions and prefectures in Japan*




*Source: Wikipedia.it*

Natural aspects have so deeply affected the history of Japan that it is difficult to separate such history from the history of natural disasters. At the same time, it is hard to understand Japanese society without including its relationship with

nature and observing the efforts of Japanese people to live in a balance with nature. It is a unique relationship: nature and society have proceeded hand in hand in the history of Japan.

The lack of possibilities for a large urban development explains density in population and constructions characterized by a maximum use of spaces.

Moreover, the need to coexist with natural disasters influences the choice of materials and technology in constructions. Technology to protect against disasters is something related to history and architecture and originated in the culture of Japan. It is not a coincidence that the Japanese word for the technology (*gijutsu*) is more similar to the Japanese word for art (*bijutsu*) rather than science (*kagaku*) (Clancey, 2006). This is the vision of technological innovation in Japan, a creative process similar to the product of an artist.

Thus, technological recovery after earthquakes became an "art": in the construction of traditional wooden houses, the groove of beams and columns not only gives to the houses their characteristic aspect but allows flexibility of the structure in case of vibration (Bock *et al.*, 2011). In Japanese pagodas (*tō*), the unique element of *shimbashira*, a central pillar of Japanese cypress, is thought to be one of the key elements for earthquakes resistance as demonstrated in the case of five-store pagoda at the Tō-ji Temple in Kyoto, the tallest wooden tower in Japan (Nakahara *et al.*, 2000).

Natural disasters have not just involved improvement in technology but have also favoured changes in social and institutional levels. Nature modified the urban configuration of cities but it also shaped communities and social behaviours. The strong recognition of fragility of human life compared to the power of nature is a feature of Japanese culture. Community has become able to manifest silently and deeply itself when adversities come, in the form of aid and volunteering. The need to create tides is one of essential elements in the structure of Japanese society. Japanese word *setsuzoku* literally, ties, connections, has become a watchword for the reconstruction of local communities affected by the Tohoku earthquake in 2011.

The reconstruction after disasters and the management of the urban areas have influenced and, in the meantime, are influenced by aspects linked to social customs and behaviours. There are two different approaches in urban planning of Japanese cities.

The fist, *toshikeikaku*, literally means urban planning and refers to administration initiatives focused on the physical structures and the layout of the cities. The second is the *machizukuri*, approach, literally community-building, that involves citizens and communities in the design of urban areas. Although these approaches can be considered opposite, they co-exist in a large part of Japanese cities and characterize the exterior aspect of urban centres (Hein, 2001).

Finally, natural disasters are a part of the Japanese identity and influenced culture and tradition. An ancient Japanese legend tells of a giant catfish, Namazu, who lives in the mud under Japanese archipelago and it seems to be the responsible for earthquakes. The giant catfish, was a creature controlled by the god Kashima, a Shinto god who must guard the fish generator earthquakes and tsunamis, restricting its movements through a large stone in his control. When Kashima leaves his position, the catfish wiggles causing earthquakes (Piccardi and Masse, 2007).

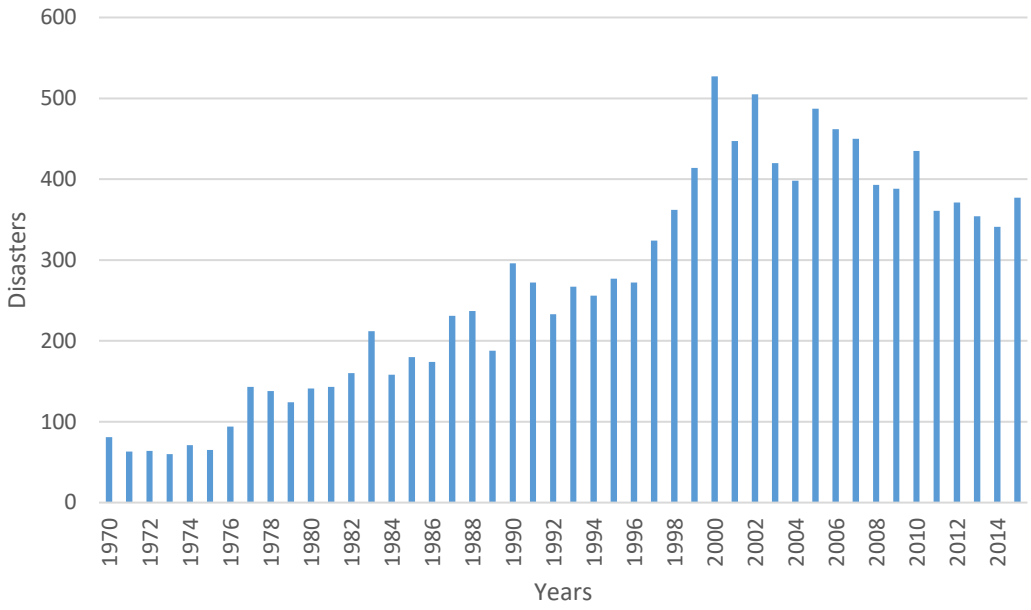
## 4.2 **Natural disasters and earthquakes in Japan**

Looking at statistics related to natural disasters, earthquakes are at the top of the list in Japan. Impressive numbers have made the country one of the most proactive not only in the aspects of aseismic technology but also in the process of prevention, recovery and hazard mitigation.

According to the Asian Disaster Reduction Centre (ADRC), the amount of natural disasters occurred between 1975 and 2000 has increased in accordance with changes in population, urbanization, deforestation and desertification (ADRC, 2002). Figure 4.2 and Figure 4.3 show the amount of total natural

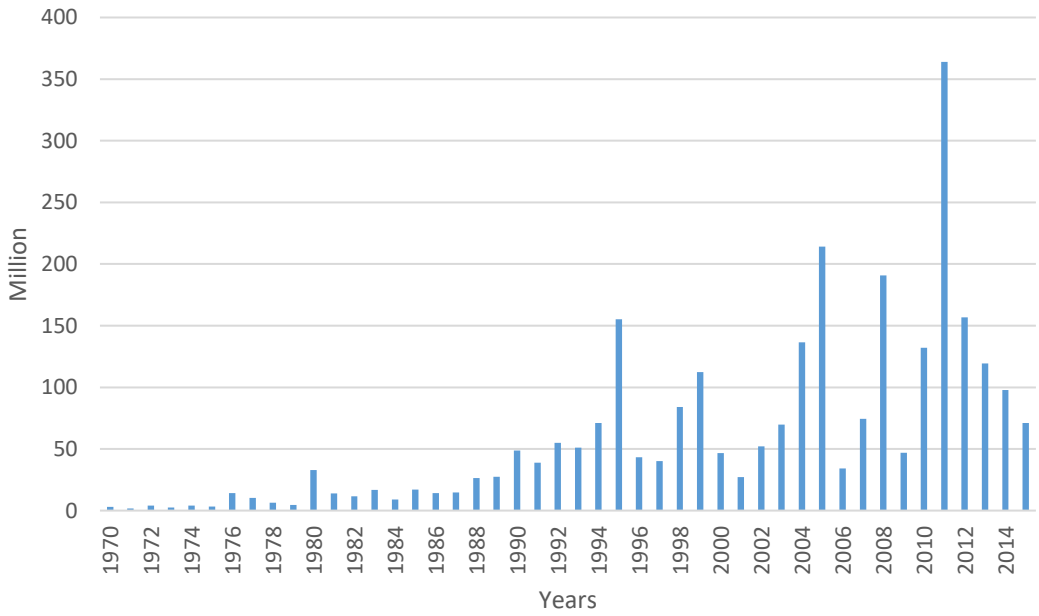
disasters occurred in the whole world between 1970 and 2015 and the total economic damage.

*Figure 4.2 Number of disasters occurred in the world (1970-2015)*




*Source: Author's elaboration on CRED, EM-DAT database*

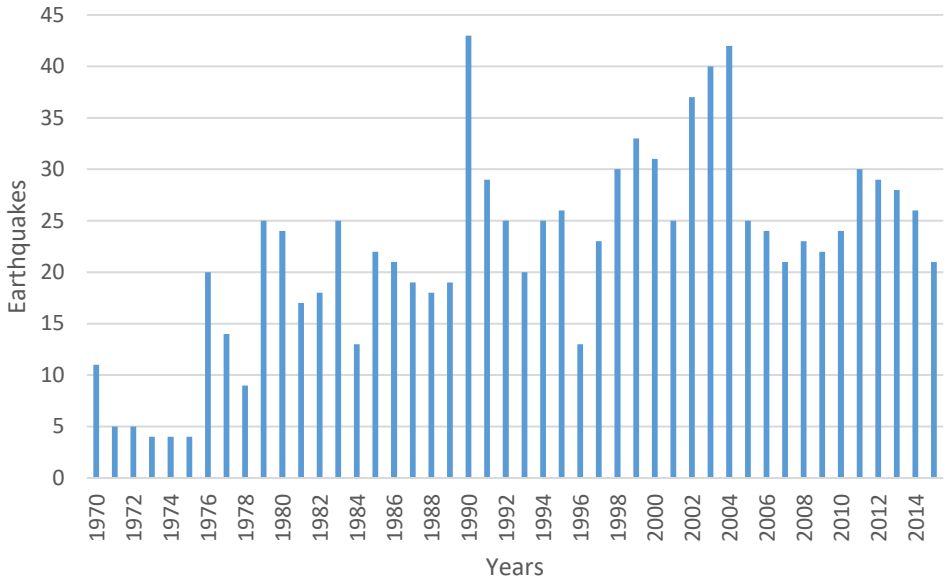
*Figure 4.3 Number of total economic damage caused by natural disasters in the world (1970-2015)*




*Source: Author's elaboration on CRED, EM-DAT database*

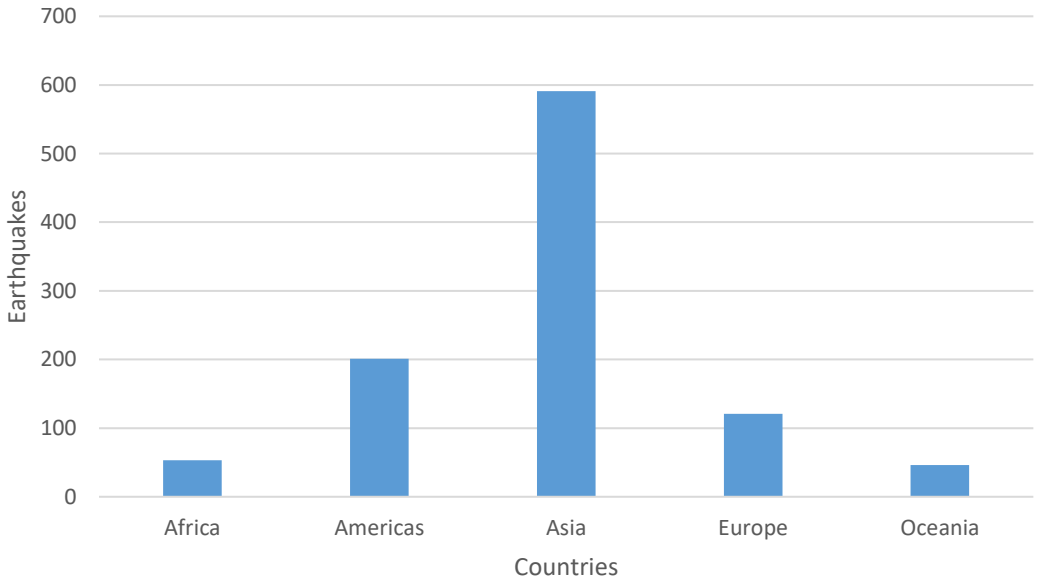
A special focus on earthquakes shows a general increasing trend in number of earthquakes occurred around the world (Figure 4.4) and a concentration of such disasters in Asian regions (Figure 4.5).

*Figure 4.4 Number of earthquakes reported in the world (1970 and 2015)*




*Source: Author's elaboration on CRED, EM-DAT database*

*Figure 4.5 Number of earthquakes occurred by country (1974-2003)*




*Source: Author's elaboration on CRED, EM-DAT database.*

Finally, according to data provided by the Centre for Research on the Epidemiology of Disasters (CRED), Japan suffered of a total amount of 59 significant earthquakes[33] in the years between 1900 and 2015.

Dimension and frequency of earthquakes are the cause of a massive research in seismic events in different disciplines. Japan became one of the most advanced countries in studying prevention and hazard mitigation in earthquakes. Amount of universities and institutions dedicated to earthquakes and disasters reduction confirms interest in these fields. According to our first survey, it is possible to distinguish 51 research institutions in the whole country involved in the study of earthquakes through different approaches, ranging from engineering, seismology, hazard mitigation, computer science and so on.

Moreover, evidence of intellectual property production in the field of resistant earthquake constructions confirms the importance of earthquake recovery field. A first analysis based on esp@cenet[34] database highlights a percentage of about 66% of patents in earthquake proof buildings belonging to Japanese inventors.

## 4.3 **Resistance and recovery indices of Japanese Prefectures**

Starting from the data on employment of the OECD for the Japanese prefectures in which major earthquakes occurred, we used the indices of Martin (2012) as the basis to build two different indices to evaluate the ability of Japanese prefectures to resist and recover after the occurrence of the earthquakes.

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[33] According to the explanatory note of CRED database to select major earthquakes, one of the following criteria must be fulfilled:

- Ten or more people reported killed.
- Hundred or more people reported affected.
- Declaration of a state of emergency.
- Call for international assistance.

[34] Esp@cenet is a database of European patent office and offers free access to information about inventions and technical developments from the 19th century right up to today. It is available at http://www.epo.org/index.html.

To evaluate the resistance of the prefectures to the earthquake we used the revised version of the sensitivity index proposed by Faggian *et al.* (forthcoming). This version overcomes the possibility of problems relative to the concordance or discordance of signs as suggested by the authors. Our new indices are formalized as follow:

$$\beta_{res} = (E_{pt1}/E_{pt0})/(\Delta E_{wt1}/E_{wt0})^{35}$$

with:

$t_1$ as the year of the earthquake

$t_0$ as the year before the earthquake;

p as the single prefecture stricken by the quake;

w as the whole of the prefectures stricken by major earthquakes.

Thus, $E_{pt1}/E_{pt0}$ represents the ratio of the employment of the prefecture in year of the earthquake and the year before the $E_{wpt1}/E_{wt0}$ is the ratio of change the employment for all the selected prefectures between the same periods.

If $\beta_{res}$ is greater than 1, the region has a high relative resistance to the shock; on the contrary, if $\beta_{res}$ is lower than 1, the region has a low relative resistance to the shock.

To evaluate the recovery after the earthquakes, we build the recovery index as follow:

$$\beta_{rec} = (\Delta E_p/E_{pt0})$$

[35] To improve the robustness of the index, resistance has been evaluated on the basis of the formula proposed by Lagravinese (2015). The results are shown in Appendix 1. The performances of the single prefectures confirm the value and it is possible to evidence small changes in the relative positions of the value inside each quadrant.

with

$t_0$ as the year of the earthquake;

p as the single prefecture stricken by the quake;

w as the whole of the prefectures stricken by major earthquakes.

Recovery Index measures the ratio of variation in employment occurred in the prefecture between the fourth year[36] after the earthquake and the year of the earthquake ($t_0$).

The values of resistance and recovery are shown in Table 4.1 and Table 4.2.

*Table 4.1 Resistance Index for 10 Japanese prefectures stricken by major earthquakes*

| Prefecture | Year | Resistance |
|---|---|---|
| Hokkaido | 2003 | 0.9942 |
| Iwate | 2003 | 0.9589 |
| Miyagi | 2003 | 0.9878 |
| Akita | 2003 | 0.9778 |
| Yamagata | 2003 | 0.9861 |
| Kyoto | 2004 | 0.9956 |
| Osaka | 2004 | 1.0030 |
| Wakayama | 2004 | 1.0137 |
| Niigata | 2007 | 0.9859 |
| Tokyo | 2008 | 1.0119 |

*Source: Author's elaboration*

[36] The four-year period is choose reflecting on the possible implication of investments in reconstruction occurred in the years immediately after the earthquake. As highlighted by Horwich (2000) a measure based on macro variables can distort perceptions of the disaster impact by the amount of the capital invested in the reconstruction and debris removing activities. Moreover, a period superior to four year can cause overlapping of earthquakes in the same prefecture, especially in countries frequently subject to seismic event as Japan is. Finally, in evaluating economic resilience Hill *et al.* (2011) suggests that a considerably short period of four year to return to pre-shock levels should pass in order to define a region as resilient.

*Table 4.2 Recovery Index for 10 Japanese prefectures stricken by major earthquakes*

| Prefecture | Year | Recovery |
|---|---|---|
| Hokkaido | 2003 | -0.0071 |
| Iwate | 2003 | 0.0103 |
| Miyagi | 2003 | -0.0008 |
| Akita | 2003 | -0.0325 |
| Yamagata | 2003 | -0.0225 |
| Kyoto | 2004 | 0.0047 |
| Osaka | 2004 | -0.0012 |
| Wakayama | 2004 | -0.0243 |
| Niigata | 2007 | -0.0362 |
| Tokyo | 2008 | 0.0066 |

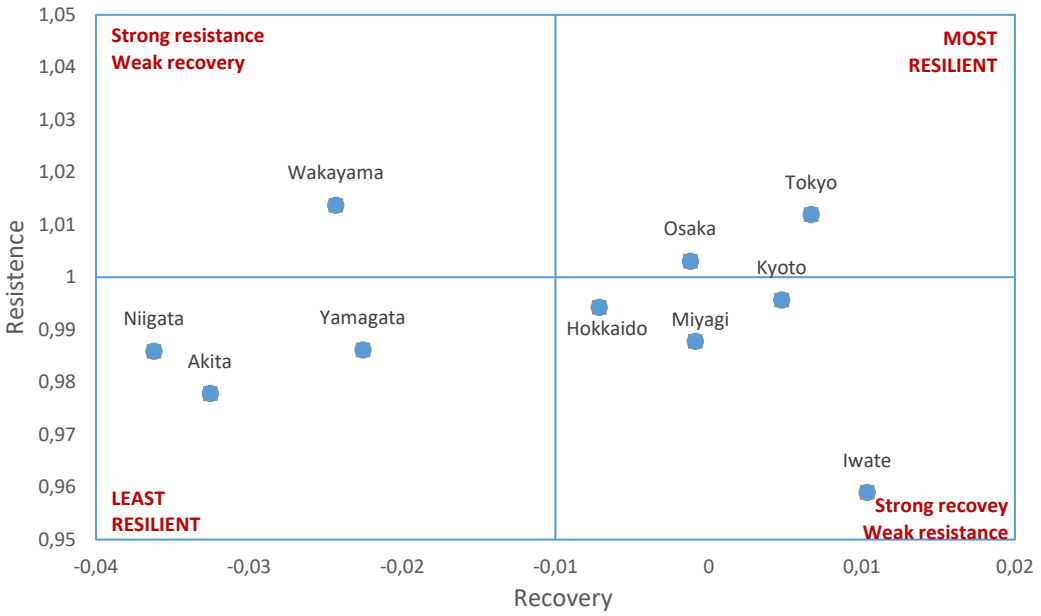
*Source: Author's elaboration*

A preliminary analysis of the indices shows that the lowest value for Resistance Index belongs to Iwate prefecture (0.9589), while the highest belongs to Wakayama prefecture (1.0137). Moreover, the lowest value of Recovery Index is that of Niigata prefecture (-0.0362), while the highest value belongs to Iwate (0.0103). This analysis suggests that Iwate prefecture had a high sensitivity to the earthquake but it was the prefecture that best performed in the fourth year after the earthquake showing the major increase in employment. Wakayama was the prefecture that had the best resistance to the earthquake. Niigata prefecture had the worst performance in the recovery period.

An interesting analysis can be done looking at the responses of the prefectures involved in the same earthquake. This was the case of the 2003 earthquake in Iwate, Miyagi, Yamagata and Akita prefectures and the 2004 earthquake in Kyoto, Osaka and Wakayama. In relation to the first earthquake, Miyagi was the prefecture that best resisted to the shock. Iwate had the best recovery and it was the only prefecture in which employment showed a positive change in four years following the earthquake. In respect to the 2004 earthquake, the prefecture of Wakayama best resisted to the earthquake but Kyoto was the prefecture that had the higher recovery and the only prefecture which had a positive change.

Comparing indices of recovery and resistance, we can understand which prefectures were the most and the least resilient (Figure 4.6).

*Figure 4.6 Resistance and recovery indices of Japanese prefectures calculated for the major earthquakes occurred between 2003 and 2008*




*Source: Author's elaboration*

According to the measurement of the indices, the prefectures that best resist and recover to the shock have been Osaka and Tokyo. We can define these prefectures as the most resilient; on the contrary, the prefectures of Akita, Yamagata and Niigata have the worst performance in resistance and recovery. Consequently, we can define them as the least resilient. Prefecture of Wakayama has a strong resistance but a weak recovery. Hokkaido, Kyoto, Iwate and Miyagi have a low resistance but a strong recovery.

Following an evolutionary idea of resilience, a second analysis will refer to the long-term evolution of employment of each earthquake. The main idea of this analysis is to contextualize changes in employment of each prefecture to the change in the national employment. Moreover, it allows to demonstrate if changes in employment during or following the shocks are a direct consequence of it.

However, a best understanding of the analysis of the change in employment should consider some specific feature of the employment system in Japan. To achieve this goal in the next section, a brief and not exhaustive synthesis of the main recent macro-economic trend in Japan and features of the labour market will be proposed.

## 4.4 **An overview of Japanese main recent macro-economic trends**

A critical discussion of changes in the employment rate of Japanese prefectures in relation to earthquakes, cannot be indifferent to the macro-economic aspects that affected the Japanese economy in recent decades and to a description of the main characteristics of the employment system.

After the Second World War, the country had an economic boom, often remembered as the "Japanese economic miracle", performing a 3.9 percent average annual growth rate of its domestic product (Saxonhouse and Stern, 2003). This apparently unstoppable growth, however, crushed against the economic bubble of the early 90s, which led the country into the "lost decade" of the Japanese economy (Flath, 2005).

This was a period characterized by a long-term stagnation of output and productivity. During the period between 1992 and 1999, GDP restarted to increase by 1% on average per year. The dimension of this growth, compared to the growth by 3.9% in the period between 1981 and 1991, assumed a low relative importance (Genda and Rebick, 2000). In the period between 2002 and 2007 an expansion of the output occurred and was mainly related to a growth in exports (OECD, 2009).

Another interesting point in the analysis of the crises in Japan is the response of the system to the economic and financial 2008 crisis. During the global financial crisis, while a decrease of the aggregate demand occurred, the decline of the level of the unemployment was slower. Moreover, unemployment rate responded better to the decrease in GPD than other countries.

Specific features of the labour market in Japan can partially explain the response to economic crisis. Japanese employment system originated in the post-war period and is characterized by a specific structure defined as "lifetime employment" system (*shūshin koyō*) (Hijzen *et al.*, 2015). Despite it has been reformed and revised over years, it is considered as a peculiarity of the Japanese economic system and appears to be a key element for both economic miracle and for the long period of economic stagnation.

One of the characteristics of the lifetime employment system refers to a law that prohibited firms to offer fixed contracts for multiple years. Thus, the possible typologies of contract to hire employers were indefinitely-term contracts and short and fixed-term contracts of a maximum of one year. This law was abolished with a revision of the legal standards for the labour market in 1998 making the market job more flexible but, at the same time, more sensitive to the economic fluctuations (Kambayashi and Kato, 2009).

A second characteristic of the lifetime employment is the propensity of firms to avoid the layoff of employers preferring a reduction in the working hours. This involve a higher maintenance of jobs for Japanese workers during periods of economic crisis. Moreover, salary increases with the age of the employer boosting workers to keep their jobs.

The features of the lifetime employment system influenced the response of the country in front of the different economic crisis. On the one hand, the system has been criticized as characterized by a strong "rigidity" constituting an impediment for change and recovery of the Japanese economy in the period of continued stagnation of 1990s; on the other hand, it has been regarded as an incentive to the creation of firm-specific human capital and the knowledge generation.

The period of prolonged stagnation experienced by the country changed some aspects of its structure favouring an evolution of the employment system, leading to the reduction of the regular employee and fostering flexibility of the

employment system. However, a negative impact is highlighted and it was major for specific categories of workers, such as women and less skilled workers.

Despite the reform of employment system, some key elements remained unchanged as the propensity to long-term relationship between firms and employers. In the years of the recent economic crisis, a general good recoverability of Japanese labour market is observed. Such positive response is associated with the features of the Japanese labour market and, particularly, its lifetime peculiarity and the tendency of Japanese employees to maintain jobs in a period of economic crisis (Hijzen *et al.*, 2015).

The structure of the lifetime employment system, thus, led with different responses of the Japanese economy against crisis. On the one hand, it encouraged workers to keep their jobs even if system is under external pressures favouring the stability of the labour market; on the other hand, despite it can be considered a reason of rigidity, the reforms of the past years favoured an adaptation of the system to the changed circumstances and made it more flexible to perturbances. However, flexibility may also increase the sensitivity of the system to shocks.

## 4.5 **Changes in employment during the major earthquakes in Japan**

### 4.5.1 The earthquake of Iwate, Miyagi, Yamagata and Akita in 2003

The earthquake occurred in 2003 in the north of Japan, in the Tohoku region struck the prefectures of Iwate, Miyagi, Yamagata and Akita (Figure 4.7).

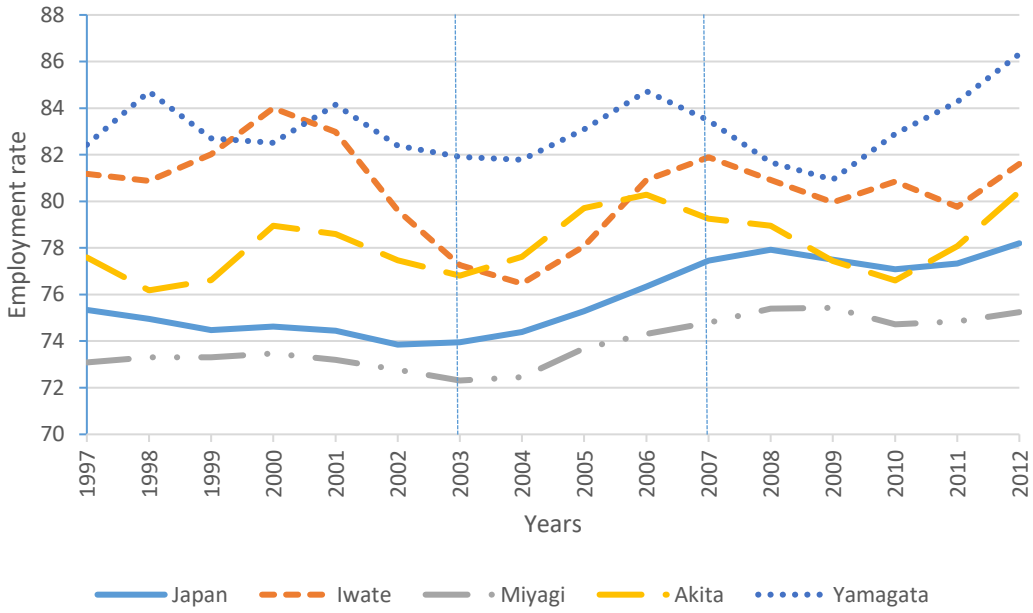
*Figure 4.7 Position of Iwate, Miyagi, Yamagata and Akita prefectures on the map of Japanese regions*


*Source: Author's elaboration from Wikipedia*

The earthquake caused about 143 injured people, 720 destroyed buildings and damage to many roads and water line in the entire district of Tohoku. Moreover, it caused a series of fires and landslides. It was recorded an economic damage of about 233 million US dollars.

An analysis of changes in employment around the different prefectures involved in the earthquake shows a different reaction of the prefectures to the shock (Figure 4.8).

*Figure 4.8 Employment rate growth paths in the prefectures of Iwate, Miyagi, Yamagata, Akita and Japan*




*Source: Author's elaboration on OECD statistics*

In the Iwate prefecture, employment rate decreased in the period between the occurrence of the earthquake and the fourth year after the shock, recording a trough around 2004 and a peak in 2007. The decrease already started before the earthquake.

In the Miyagi prefecture after the earthquake, one year of relative stability in employment rate occurred and an increase is recorded between 2004 and 2007. Again, a period of relative stability is observed until 2009. Before the earthquake, a low decrease of the employment rate started in 2000. The Miyagi prefecture showed the most similar trend to the national change in employment rate.

In the Akita prefecture, the year of earthquake corresponded to a trough in the decrease of the employment rate started in 2000. The growing trend is observed until 2006 and, then, again a period of decrease happened until 2010. Therefore, the recovery period is characterised by a former increase in the three years following the earthquake and a subsequent decrement of the employment rate.

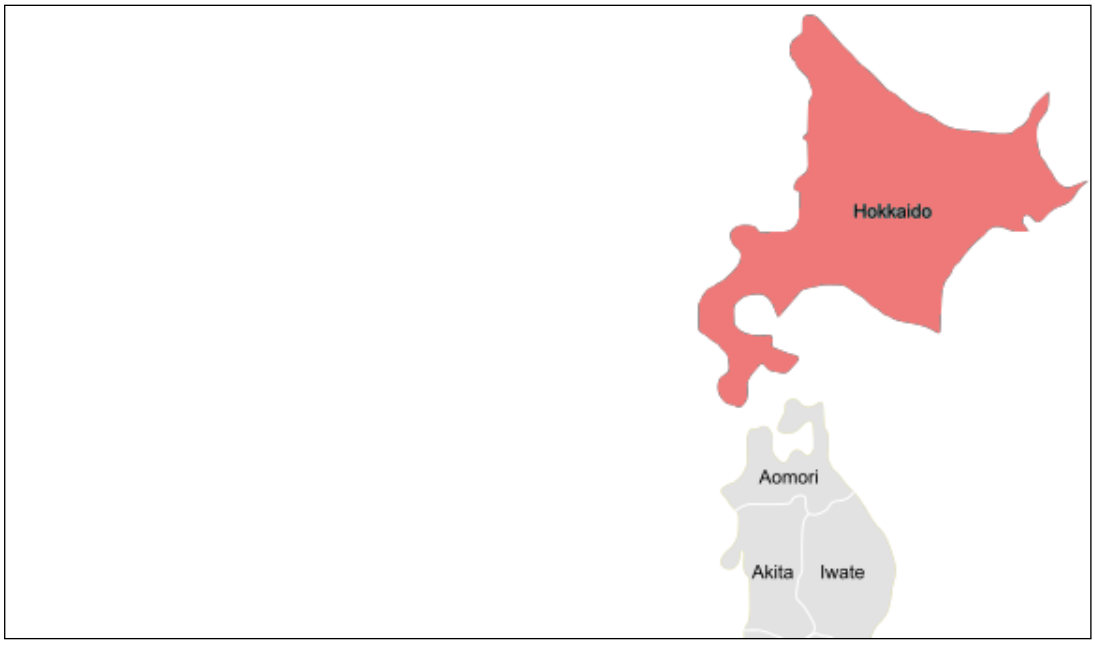
Finally, in the Yamagata prefecture, the earthquake occurred in a period of a relative slow decrease of the employment rate started in 2001. During the recovery period, a peak was in 2006 followed by a decrease recorded until 2009.

Generally, prefecture of Iwate, Miyagi, Akita and Yamagata recorded a fluctuating trend in the period between 2002 and 2007, a period characterized by a growth of the national accounts. The economic recovery started around 2003-2004, with a delay in respect to the national trend. It is possible to speculate that the delayed recovery can likely be caused by the occurrence of the earthquake.

### 4.5.2 The earthquake of Hokkaido in 2003

The earthquake occurred in 2003, in the Hokkaido region in the north of Japan and it struck the homonym prefecture of Hokkaido (Figure 4.9).

*Figure 4.9 Position of Hokkaido prefecture on the map of Japanese regions*



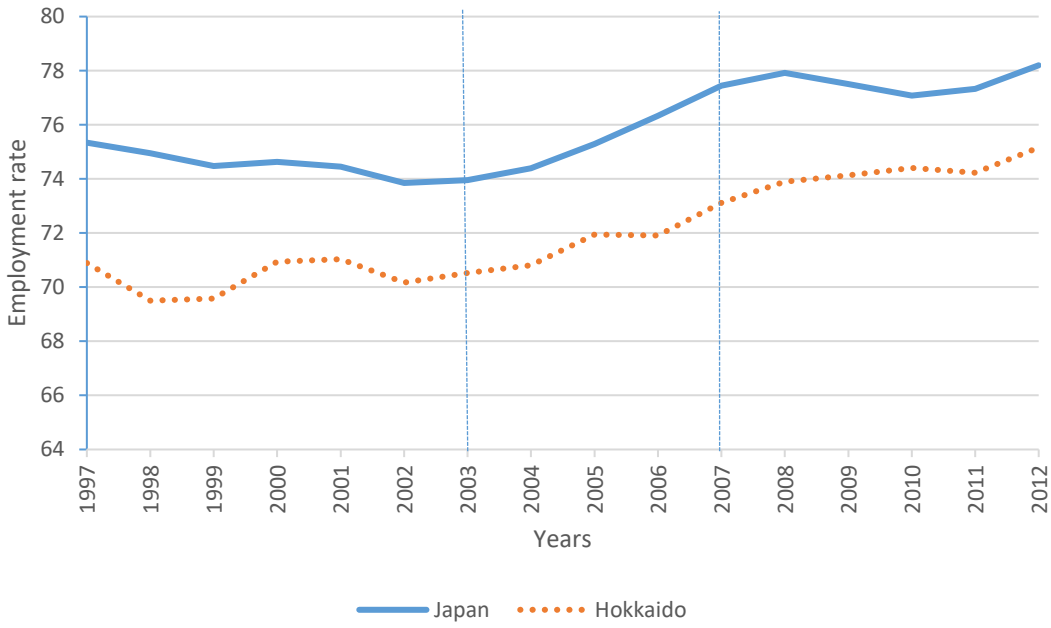

*Source: Author's elaboration from Wikipedia*

In 2003, Hokkaido was a region mainly supported by primary and secondary sector (Hokkaido Bureau of Economy, Trade and Industry, 2003).

During the earthquake, at least 755 injured persons were recorded. It caused some landslides and damages to power outages and roads. The estimated damage was 90 million US dollars.

A simple descriptive analysis of the employment changes occurred in the years after the earthquake reveals a likely low correlation between the earthquake and the evolution of employment rate. Figure 4.10 compares trends in employment rate for Hokkaido and Japan.

*Figure 4.10 Employment rate growth path in the Hokkaido prefecture and in Japan*




*Source: Author's elaboration of OECD Statistics*

The growth path of employment rate shows a similar trend with the national growth. An increase of the employment rate occurred between the year of the earthquake and the next four years. This trend not only is the same as the employment rate of Japan but it started one year before the earthquake. This anlysis reflects the difficulty to associate the growth in employment as a direct consequence of the earthquake.

The growth in employment coincides with the growth of output started in 2002, the year that signed the end of the lost decade so it is likely associated with the positive economic recovery which occurred between 2002 and 2007.

An effect that can be associated with the earthquake is the slower increasing rate of employement recorded by the Hokkaido prefecture compared to the national trend.

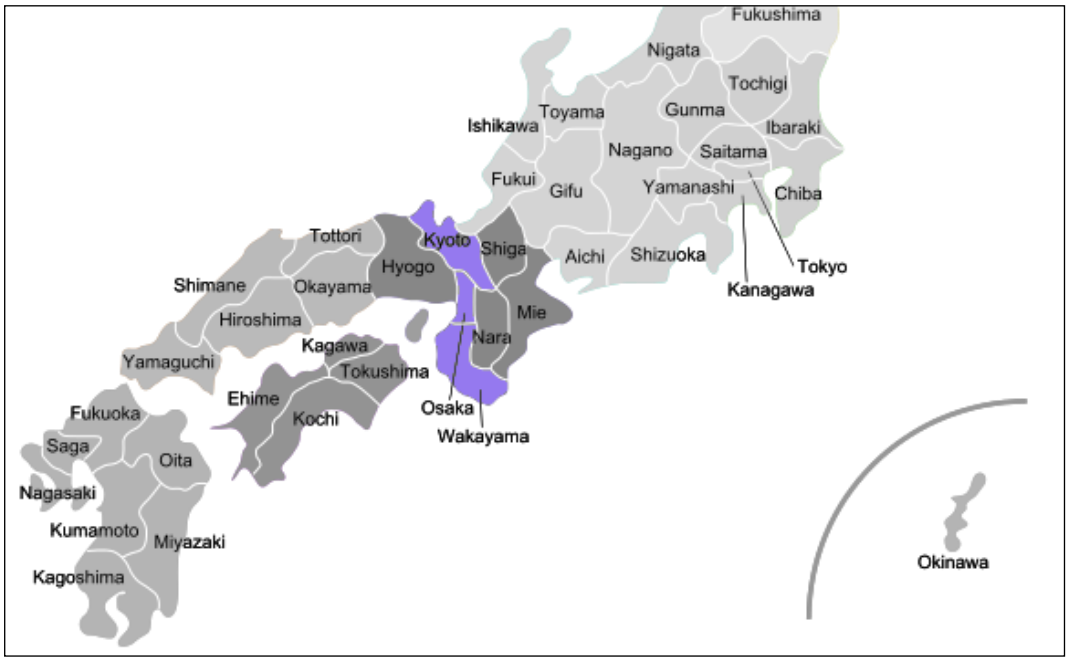
### 4.5.3 The earthquake of Kyoto, Wakayama and Osaka in 2004

The earthquake occurred in 2004 in the Kansai region affected the prefectures of Kyoto, Wakayama and Osaka (Figure 4.11).

The earthquake caused about 40 injuries, fires and damage to electricity lines. The quake generated a tsunami with waves of almost one meter high.

It is possible to analyse changes in employment rate in the prefectures stricken by the earthquake and compared the paths with that of the whole Japan (Figure 4.12).

*Figure 4.11 Position of Kyoto, Wakayama and Osaka prefectures on the map of Japanese regions*




*Source: Author's elaboration from Wikipedia*

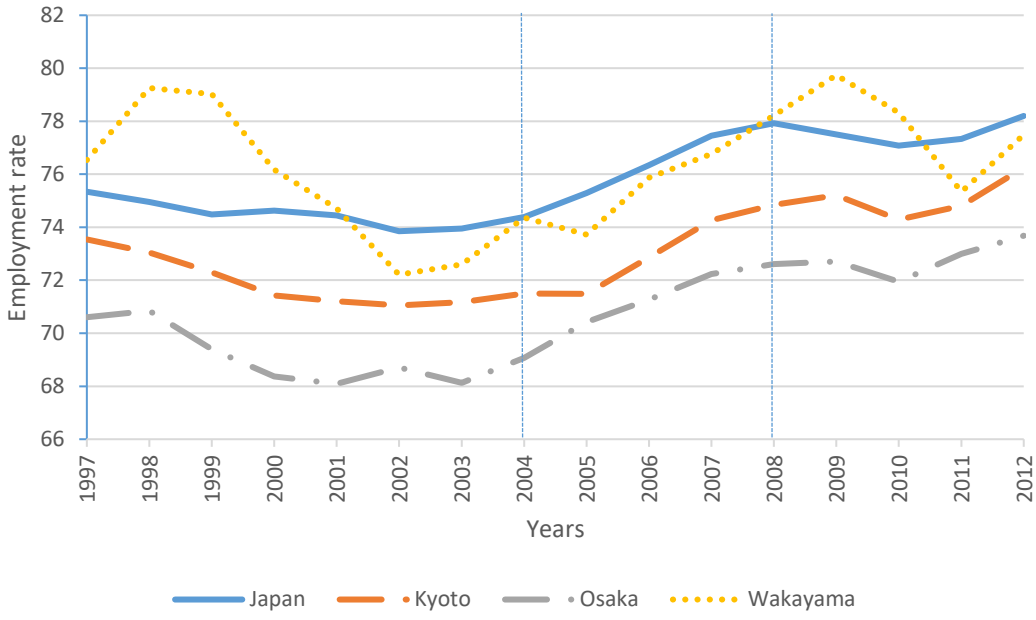
The prefecture of Kyoto recorded a decrease in the employment rate started in 2000 and a following increase from 2005 to 2009. The trend of the prefecture is similar to the trend of the whole of Japan.

In Osaka, it is possible to observe an increase of the employment rate started in 2003, the year before the earthquake. Such a positive trend is maintained until 2009.

The Wakayama prefecture had a peak in the year of the quake followed by a negative change in employment ending in 2005. A continued increase is observed until 2009.

In general, all the prefectures were in a positive trend when the earthquake occurred based on the growth favoured by the economic recovery of 2002-2007. However, in the year of the quake, a fall of the employment rate can be observed for Wakayama and Kyoto prefectures. Such effect could probably be related to the earthquake.

*Figure 4.12 Employment rate growth paths in the prefectures of Kyoto, Wakayama, Osaka and Japan*




*Source: Author's elaboration on OECD statistics*

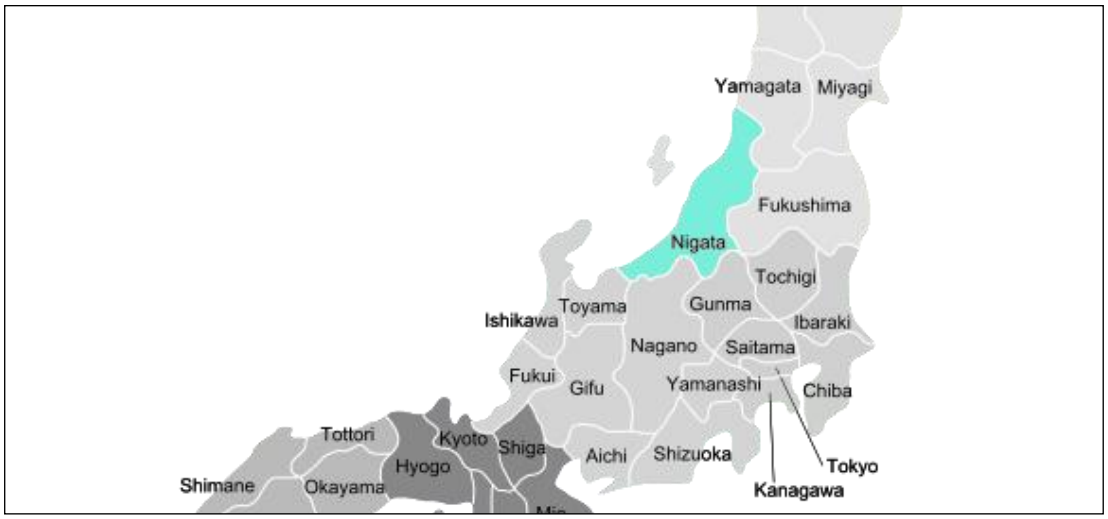
### 4.5.4 The earthquake of Niigata in 2007

The earthquake occurred in Chubu region in 2007 and affected the prefecture of Niigata (Figure 4.13).

The quake caused about 9 deaths, at least 1,088 wounded, damages to 875 houses, roads and bridges, and created landslides. The economic damage was about 12.5 billion US dollars.

In Niigata, the recovery period is characterized by a moderate and slow decrease in the rate of employment started in 2003. The changes in employment in the prefecture are similar to the trend observed for the whole Japan.

*Figure 4.13 Position of Niigata prefecture on the map of Japanese regions*

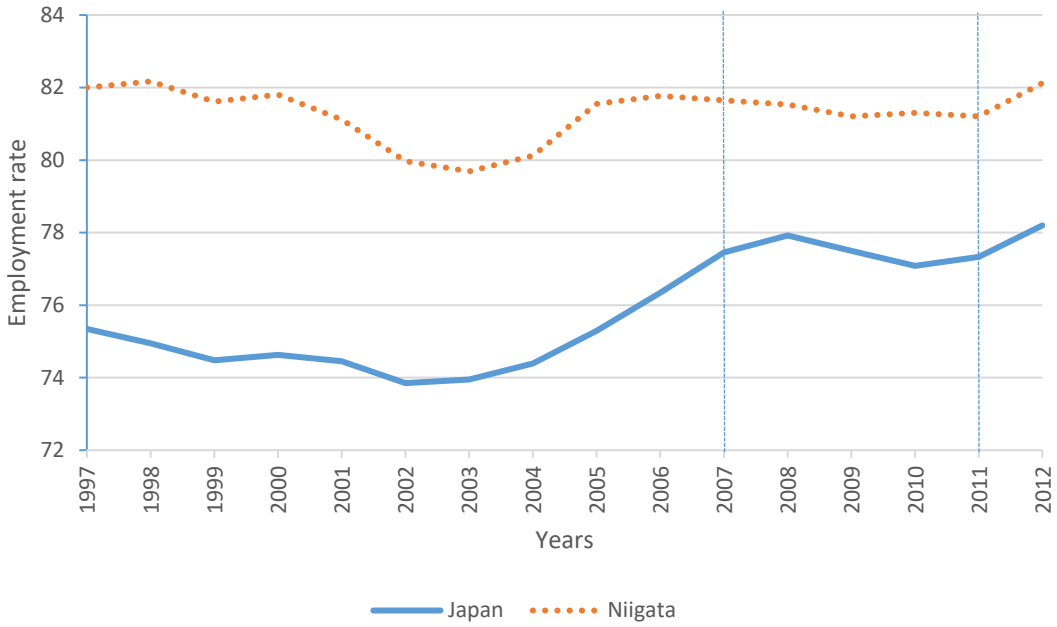



*Source: Author's elaboration from Wikipedia*

It is interesting to highlight that the prefecture recorded a previous big earthquake in 2004. It caused about 40 deaths, 3,183 injured and 6,000 destroyed buildings. There were landslides, fires and damage to roads and the pipes of gas, electricity and water. The estimated economic damage amounts to approximately 28 billion dollars. The resistance and recovery indices for the Niigata's earthquake of 2004 has not been calculated because the recovery period of four year overlaps with the earthquake which occurred in 2007.

As showed in Figure 4.14, a slower growth of employment rate occurred in Niigata compared to national path. This trend is confirmed both for the years following the earthquake in 2004 and the earthquake in 2007. It is possible to assume that the earthquakes caused a consequent slowdown of the economic recovery.

*Figure 4.14 Employment rate growth paths in the prefectures of Niigata and Japan*




*Source: Author's elaboration on OECD statistics*

### 4.5.5 The earthquake of Tokyo in 2008

The earthquake of 2008 occurred in the Tokyo prefecture in the Kanto region (Figure 4.15). The Kanto region is the richest region of Japan.

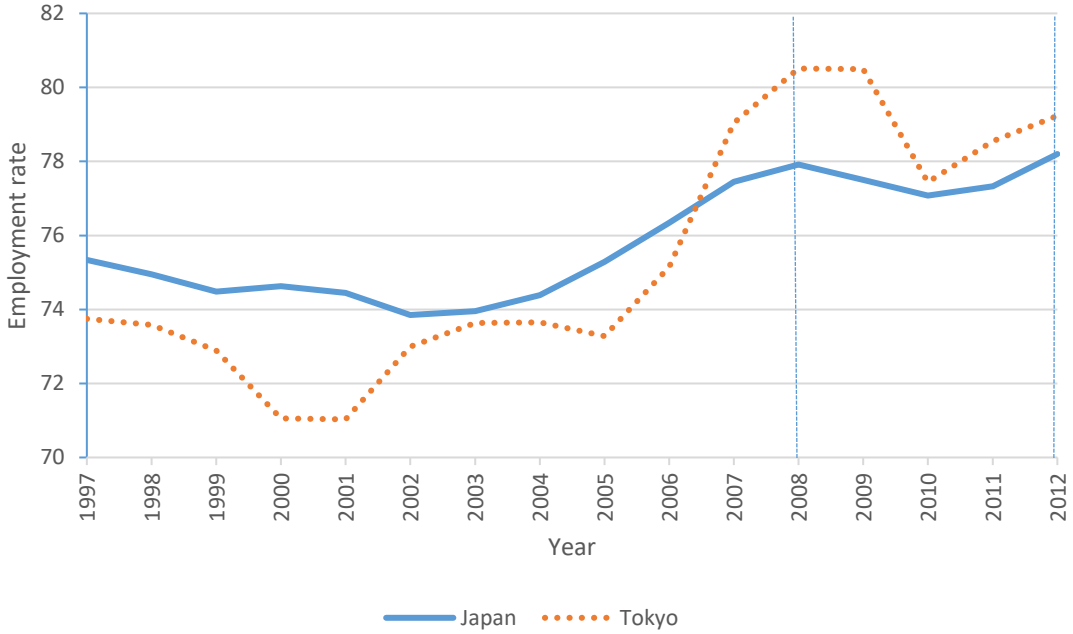
The earthquake caused 13 deaths, 357 injured and 614 damaged buildings. The epicentre was in north of Tokyo. Figure 4.16 shows the growth path of employment rate of Tokyo prefecture and the whole Japan.

Changes in employment likely depend on the occurrence of the crisis.

*Figure 4.15 Position of Tokyo prefecture on the map of Japanese regions*


*Source: Author's elaboration from Wikipedia*

*Figure 4.16 Employment rate growth paths in the prefectures of Tokyo and Japan*




*Source: Author's elaboration on OECD statistics*

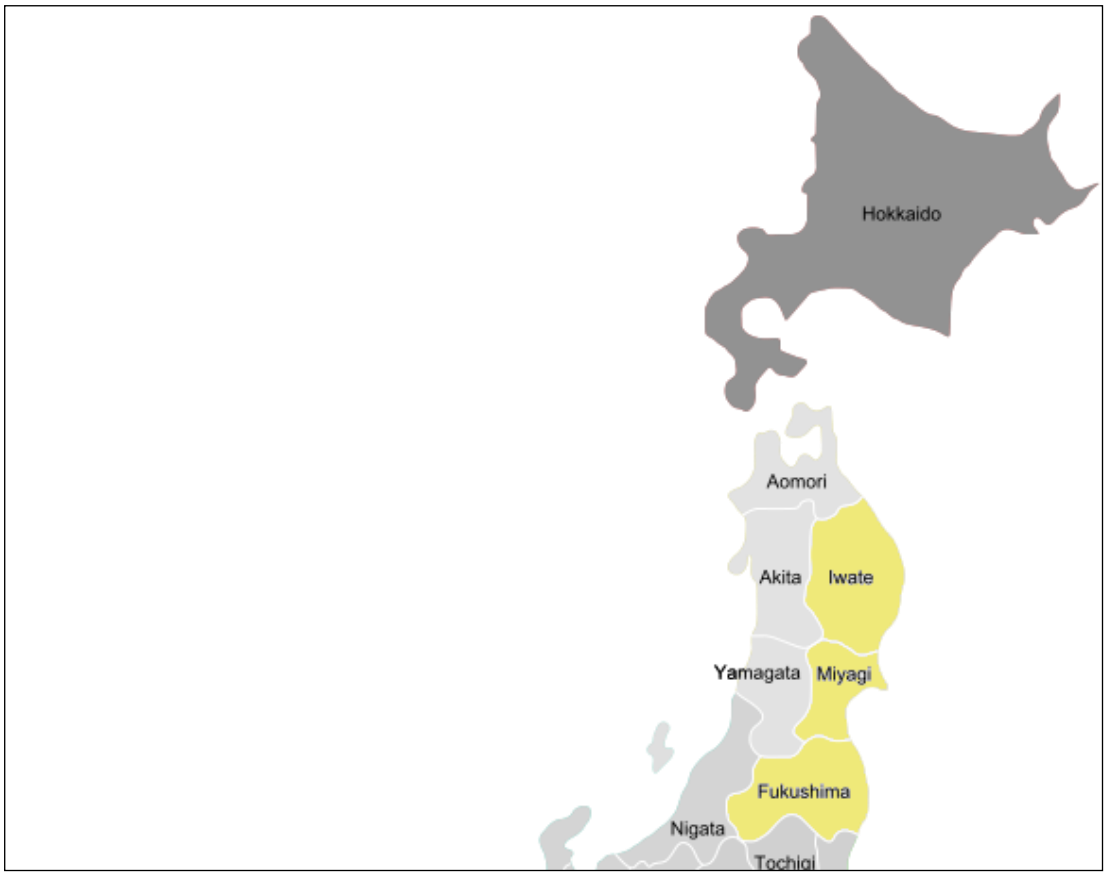
In the year of the Tokyo earthquake, a peak in the employment rate of the prefecture is recorded. After one year of stability, between 2008 and 2009, it is

possible to record a decrease in the observed variable. A trough is recorded in 2010 and a following increase is kept until 2012. The drop of employment rate is perceived more deeply in the economy of the city of Tokyo than in the national trend. The year of the earthquake is also the year of global economic and financial crisis.

### 4.5.6 The Great East Japan earthquake in 2011

In March 2011, in Miyagi, Fukushima and Iwate prefectures, in the Tohoku region, occurred one of the most destructive earthquakes ever recorded (Figure 4.17).

*Figure 4.17 Position of Iwate, Miyagi and Fukushima prefectures on the map of Japanese regions*




*Source: Author's elaboration from Wikipedia*

According to the data of the Global Significant Earthquake Database, the earthquake generated a tsunami that had a maximum height of 37 meters. This caused landslides and soil liquefaction. At least 15,550 dead, 5,344 missing, 5,314 injured, 130,927 missing people were recorded. About 332.395 buildings, 2,126 roads, 56 bridges and 26 railways were destroyed.

We could not consider the earthquake in the analysis of indices of resistance and recovery because employment data are available just for the period between 1997 and 2011. Consequently, it is not possible to evaluate employment recovery in the period post-earthquake. However, in relation to the significance of the earthquake, a brief discussion of the case of Tohoku earthquake can contribute to better understand the relationships between economic effects and natural shocks.

The earthquake originated in Pacific Ocean and had a magnitude of 9, shaking the ground for kilometres in the north coast of Japan. The shaking was experienced as far as the city of Tokyo, about 250 miles away from the earthquake's epicenter. Despite the large magnitude of the earthquake, the damage due to the seismic motion was relatively small and most of the damage was caused by the tsunami. The impact was enormous and some areas of the coast of Iwate, Miyagi and Fukushima prefecture were wholly destroyed. The evaluated damage was around 220,000 million US dollar causing a huge economic and social impact on the Tohoku region. It was recorded as the earthquake that involved the highest economic loss in history.

Moreover, the earthquake caused the shutdown of nuclear reactors at the power plants owned by Tokyo Electric Power Company (TEPCO) at Fukushima and a subsequent explosion damaging the reactor. Despite the accident having no fatalities, it had important economic and environment consequences (Aoki and Rothwell, 2013).

Although Japan is one of the best country in the world for warning systems of earthquakes and tsunami, the size and magnitude of the 2011 earthquake was underestimated.

The earthquake occurred in a period of economic recovery and produced an impact on productivity. Such impact is related to more than one reason (Bank of Japan, 2011). It was not just a single shock but it was possible to count three different disasters associated with the Great East Japan earthquake: the quake itself, the tsunami and the damage to the nuclear plant.

Furthermore, since disasters involved the destruction of firms engaged in the production of component for the automotive, the negative economic impact had an effect within the global supply chain and was spread in the international context.

Finally, the earthquake caused serious damages to coastal villages in which the major economic sectors were fishing and agriculture. In this area, the recovery was slow because of the impossibility to restart agricultural activities as a consequence of the salinization of the soil. The fishing sector, moreover, recorded a high economic damage and reconstruction slowed in relation to the fear for a future tsunami. The idea for economic recovery of coastal cities and villages was to differentiate the economic structure through the creation of new sectors. Reconstruction of cities and villages stricken by the earthquake in Tohoku region is still not complete.

## 4.6 **Conclusions**

The chapter focuses on the analysis of methods to measure resilience.

We build two indices based on resistance and recovery indices proposed by Martin (2012). After a critical analysis of the main measurement methods of resilience in relation to different types of shocks and in many fields of study, we discussed the construction of our indices. These were calculated through the OECD employment data of the Japanese prefectures, selecting those affected by significant earthquakes between 1997 and 2012.

Results for indices were discussed highlighting the prefectures that recorded the best and worst performance, in order to identify the most and the least resilient. Finally, a contextual analysis was proposed to highlight the major

changes in trends in the employment rate of the prefectures compare to national trend.

Building an index through the measure of change in employment in the regions hit by a shock can help to identify in relative terms the system that has better reacted to the shock. This kind of measurement is certainly useful to identify the impact of the shock and the consequent performance of the region in the recovery period. However, a different interpretation of the index can give rise to different evaluations of the resistance and the recovery from a shock.

In the case discussed, the resilience was associated to the capacity of the regions to both withstand the shock and recover in the following years. Different analysis could consider resilient those systems that have a stronger impact of the shock - a minor resistance to the shock - and a subsequent major recovery. Again, the problem reflects the need for a careful and precise definition of resilience.

Finally, the contextual analysis showed that impacts of economic and environmental shocks are often parallel and, sometimes, they overlap. The economic effects of natural disasters can exacerbate some regional dynamics and slow down the growth paths.

Proposing an analysis of long-term territorial dynamics caused by a natural disaster can help to understand the impact of the disaster but also the interaction between the economic and environmental aspects and to identify vulnerable aspects of regional economies.

Recognizing these vulnerabilities could foster joint actions able to face with increasingly unstable systems where boundaries between economic, social and environmental spheres are more and more blurred.

# 5 Adaptation and adaptability: the case of Kobe and the Great Hanshin Earthquake in 1995

## 5.1 Introduction

In this Chapter the analysis of the case of Kobe and the Great Hanshin Earthquakes is proposed. Through the reconstruction of main steps in recovery following the earthquake, we would like discuss dimensions of reorientation and renewal in face of a natural shock. These can occur through the adjustment of the structural economic base of the system and involve a dynamic dimension in the resilient process.

According to the discussion of adaptive resilience (Simmie and Martin, 2010; Martin, 2012), approaches to analyse the ability of systems to adapt to shocks can be related to process of adaptation and adaptability. The first one proposes a reconfiguration of existing patterns while the second one evidences the possibility to create new firms and sectors as a consequence of the disturbance. According to Hu and Hassink (2015) a complementarity of processes of adaptation and adaptability can promote a sustainable resilience.

Based on this hypothesis the analysis of the case of Kobe will propose to understand if virtuous process of adaptation and adaptability can be generated after the occurrence of a natural shock. In order to achieve this aim, an analysis of main changes in the economic structure will be investigate to understand if the city has been able to promote new sectors or maintain the existing activities. Moreover, actors and resources involved in this process will be critically discussed in order to understand how behaviuors, resources and component of the system can positively affect resilience.

In the history of Japan, three major earthquakes will never be forgotten in relation to number of deaths, economic damage and affected people: Kanto earthquake in 1923 caused 143,000 of dead people; the Great Hanshin

earthquake in 1995 affected 541,639 people; the Tohoku earthquake in 2011 caused a damage of 210 million dollars (Table 5.1).

*Table 5.1 Details of three major earthquakes in Japan*

| Year | Location | Deaths | Affected | Damage* |
|---|---|---|---|---|
| 1923 | Tokyo | 143,000 | 203,733 | 600 |
| 1995 | Hyogo | 5,297 | 541,636 | 100,000 |
| 2011 | Iwate Miyagi Fukushima | 19,846 | 368,820 | 210,000 |

**Damage is evaluated in Million US $*

*Source: Author's elaboration on CRED, EM-DAT database*

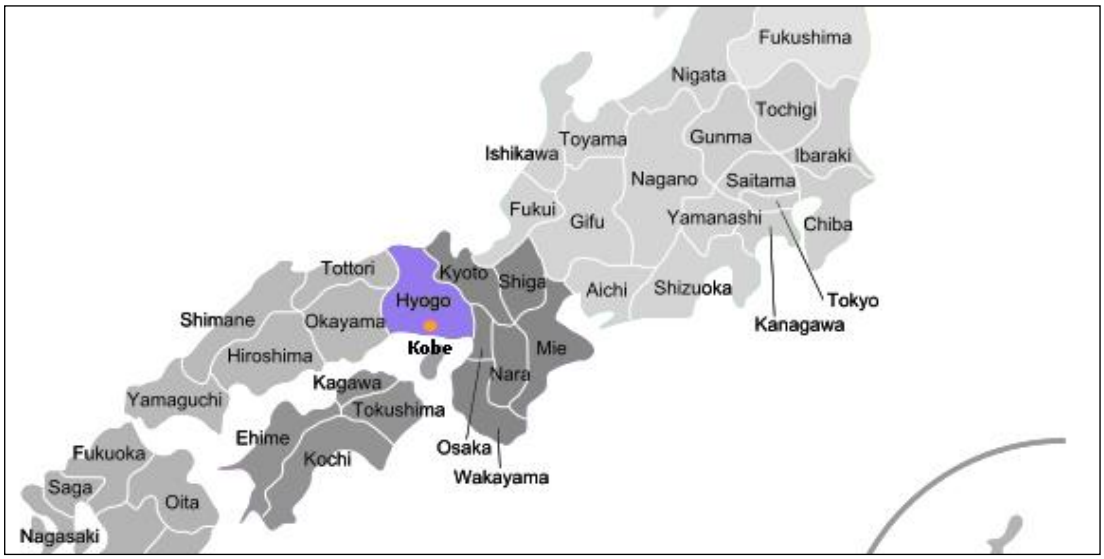
These events can be defined as a record in earthquakes: despite Japan being a country subjected to frequent natural disasters, events of this scale can be considered extraordinary even for the islands sited on the Ring of Fire.

Particularly, the case of the Great Hanshin Earthquake of 1995 marked history of Japan to be one of the most destructive seism occurred in the proximity of a modern and urbanized city. Although the intensity and the amount of damage, the recovery from the Kobe earthquake appears as a virtuous case in relation to the capacity to quickly reconstruct the city and the ability to transform and adapt its economic structure in the long-term. The response to the earthquake leads to consider Kobe a resilient city. Moreover, the case is relevant in respect to change and transformation occurred at institutional level and in the management of disasters of the whole of Japan.

## 5.2 **Main aspects and features of the city of Kobe**

The city of Kobe has a territory of 553 square kilometres and counts around 1.5 million of inhabitants. Territory has a hilly part around Rokko Mountains and is divided into nine wards: Higashinada, Nada, Chuo, Hyogo, Kita, Nagata, Suma, Tarumi, Nishi. It is one of the major cities of the Kansai region and it is the capital of the prefecture of Hyogo (Figure 5.1).

*Figure 5.1 Position of the city of Kobe on the map of Japan*




*Source: Author's elaboration from Wikipedia*

The construction of the port, in 1868, contributed to the fortune of the city and helped to create a vital and multi-cultural environment. Before the earthquake, Kobe was the second largest port in Asia for container transit and was ranked the sixth in the world in terms of cargo transit. Port activity accounted for about 39% of its gross industrial product (Chang, 2000). Moreover, urbanization increased concurrently with the economy of the port, making Kobe a densely-populated city.

In the inner town, the east coast was a residential area inhabited by high-income residents and white collar workers, along with universities and schools. A district to produce sake was in Nada ward. On the west coast, there was a low-income residential area hosting blue collar workers and the hybrid-rubber shoe industry in Nagata ward. Before the earthquake, the shoe industry counted 1,600 companies with 15,000 to 20,000 employees.

A unique characteristic of Kobe was its ancient tradition of community inclusion in the decision-making process for the economic development through *machizukuri kyogikai*, local associations for urban planning and local development. The city was the first in Japan to support such kind of associations

in order to create a bridge between institutions and local communities promoting a shared planning process (Edgington, 2010).

After the Second World War, a part of the city was completely rebuilt but modernization measures were partially absent in the coastal inner city. Buildings in those areas were mostly old traditional wooden Japanese houses and only a minor part of constructions were built under the modern anti-seismic requirements. Furthermore, in the past, the city recorded floods and storms as major natural disasters. As a result, countermeasures were limited to the prevention of this disturbances and there was poor attention paid to earthquakes.

## 5.3 **The Great Hanshin Earthquake**

In the early morning of the 17th January 1995, at 5:46 am, an earthquake of magnitude 7.2 on the Richter scale shook violently the ground in the district of Hanshin, an area located in southwestern Japan, in the Kansai region. The epicenter was about 200 km north of the Nankai Trough, along the Nojima fault a branch of the Japan Median Tectonic Line, a highly seismic area struck in the past by other severe earthquakes (Zhao *et al.*, 1996).

The area affected by the earthquake includes several towns and cities in the Hyogo prefecture, the north of the island of Awiji and some areas in the east of the prefecture of Osaka (UNCRD, 1995). The Great Hanshin Earthquake was one of the most destructive earthquakes recorded in the whole world in terms of economic damage, only surpassed by the Tohoku Earthquake of 2011 (Table 5.2).

*Table 5.2 Top 10 of the most damaging earthquakes in the world, 2015*

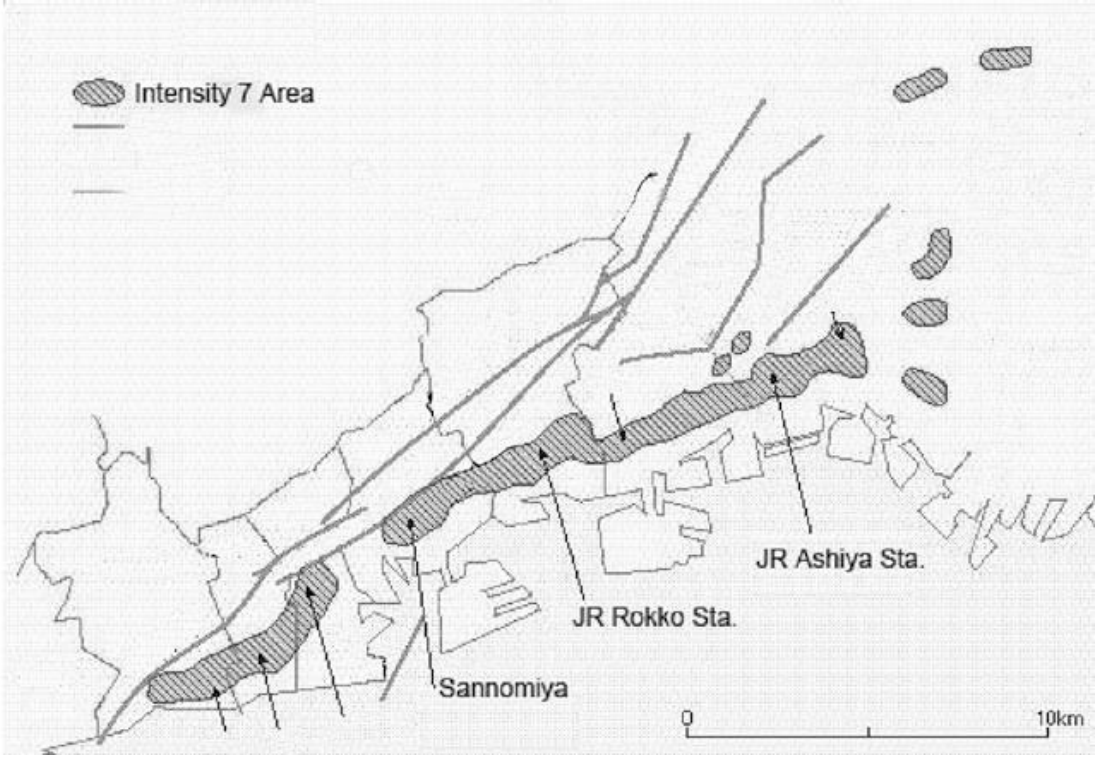
| Country | Date | Magnitude | Damage* |
|---|---|---|---|
| Japan | March 11, 2011 | 9 | 210,000 |
| Japan | January 17, 1995 | 6.9 | 100,000 |
| China | May 12, 2008 | 7.9 | 85,000 |
| Chile | February 27, 2010 | 6.7 | 30,000 |
| United States | January 17, 1994 | 8.8 | 30,000 |
| Japan | October 23, 2004 | 6.6 | 28,000 |
| Turkey | August 17, 1999 | 7.6 | 21,000 |
| Italy | November 23, 1980 | 6.9 | 20,000 |
| New Zealand | February 22, 2011 | 6.1 | 18,000 |
| Italy | May 20, 2012 | 5.9 | 15,800 |

**Damage is evaluated in Million US $*
*Source: CRED, EM-DAT database*

Although the city of Kobe was not the only city stricken by the earthquake, major damages were recorded in proximity of the inner coastal part of the city. This is mainly due to the proximity of the epicenter with the stricken city - the epicenter was only 32 km far from the city of Kobe - and to the features of the earthquake itself. Indeed, the Kobe earthquake was called "inland", a type of shock which may be destructive even at low magnitudes because it occurs near populated areas and has an epicenter near the land surface. The duration of ground shaking was ten seconds, but the time history had two or three pulse waves with a large amplitude. Such characteristic caused the collapse of several buildings, both modern structures and traditional wooden structures, also due to liquefaction of soil.

A large part of the damage in the city concentrated in the coastal wards of Higashinada, Nada, Hyogo, Nagata and Suma (Figure 5.2). In these areas about 70% of housing collapsed and 90% of the rest suffered minor damage. Share of collapsed buildings increased in relation to their urban deterioration having such buildings survived to World War II (City of Kobe, 2010).

*Figure 5.2 Kobe areas stricken by the earthquake*




*Source: City of Kobe, 2010, p. 25*

An overview of the damage caused by the earthquake can give an idea of the huge disruption in the city of Kobe: total death amounts to 4,571 and total injured is 14,678 people; 67,421 structures were fully destroyed and 55,145 structures were partially destroyed; the total amount of damage is estimated to 6,3 trillion of JPY (around 60 billion US dollar).

On 26th January, the mayor gave a statement on his vision for the future of the city. The recovery process needed to contribute to:

> "*build a disaster-safe model city where citizens can live and work in a safe and secure manner through the swift recovery of the urban infrastructure, civic life and urban development*" and to "*create a new Kobe that will became a civic-minded creative city interacting with the world*" (City of Kobe, 2010, p. 11).

Based on such declaration, the whole recovery process would be started under those principles to bring back the city to a normal state but also trying to change the image of the city, involving a structural adjustment of the economic basis and the creation of a liveable and stronger environment. The basic idea for reconstruction in Kobe was to use a long-term recovery to build a resilient city.

### 5.3.1 First steps of the reconstruction

Despite the extent of the disaster, local government could implement immediate steps to handle the emergency. Immediate countermeasures included the organization of research and rescue groups, the supply of hot meals and drinking water, the provision of shelters and the construction of temporary housing. In addition to short term recovery operations, an Earthquake Recovery Headquarters headed by the mayor was created to formulate a "10-year Kobe City Recovery Plan". Such Plan was based on three major recovery trajectories: a *physical* recovery by reconstructing infrastructures and planning operations of urban development; an *economic* one by a revitalization of the economy and a support to small businesses; a *social* recovery by construction of new houses and restoration of livelihoods.

In April 1995, Hyogo Prefecture and City of Kobe established "The Great Hanshin-Awaji Earthquake Public Reconstruction Fund" intended to favour recovery of the damaged areas, to provide financial support to the victims and to pursue long-term reconstruction purposes. The fund had 100 million yen (around 955,000 US dollar) for the basic assets and 1.67 billion yen (around 16 million US dollar) for assets management. Specific actions designated by the fund included reconstruction of the earthquake victims' houses, assistance to small and medium-sized enterprises to resume their economic activities, direct assistance to victims through health, welfare and culture to overcome the tragedy of the earthquake, reconstruction of private schools and actions related to promotion of disaster preparedness and public information.

Following the quake, the main problem in helping local community was to manage a high number of evacuees: 599 shelters were operating at the peak of operations and hosted about 236.899 people. However, housing evacuation established under plan of local disaster authority was not able to accommodate everyone. As a result, some of the shelters were assigned in different places from those planned in the emergency management plan in a first instance. Due to the lack of spare land, government decide to use spaces belonging to public schools or parks. The construction of temporary houses started three days after the quake and houses were available in mid-February: 32,346 temporary houses were constructed, about 29,178 in Kobe and 3,168 outside Kobe. All debris were removed in March 1998, three years after the quake.

In July 1995, local government established the "Kobe City Emergency Three-Years Plan for Housing Reconstruction" to promote housing recovery. In July 1996, a second plan, "Kobe Housing Restoration Plan", increased the number of public houses built by government according to a survey on age of residents in temporary houses which found 42% of residents over 60 years old and 69% with a low-income. Originally, public and private sectors had newly constructed 72,000 units, including private homes and public housing, but the number increased to 134,000 units built by January 1999.

A financial support system for rental of public housing was created. Cooperation between national government and the local government has allowed a reduction in rents. The central government guaranteed grants and subsidies for victims considering the impoverishment due to the earthquake. In addition, a special support was intended for the elderly reducing rent fee of 6,000 or 7,000 yen per month (around 60 US dollars per month).

In order to support the reconstruction of private houses stricken by the earthquake, financial measures were applied to support housing loans with interest reduced. A special financial support gave the elderly the chance to borrow money for living expenses on the security of their own properties. Moreover, several programs started to give assistance to restore housing

through consult of specialists from the Kobe Housing and Urbanization Personnel Centre. The "Kobe Earthquake Recovery Fund" was also created to give support service to victims for housing reconstruction and manage subsidies. *Machizukuri* Centre and Comprehensive Housing Consultation Centre gave both technical and engineering support for rebuilding and legal and economic advice.

In addition to the actions of the institutions, also local community was engaged in the reconstruction process. In some cases, local community promotes projects for restoring buildings and streets, demonstrating the power of social capital and the need of ties within communities. Generally, the absence or presence of a strong community has affected reconstruction speed. One example was the Mano neighbourhood in Nagata district which organized several projects dedicated to the reconstruction, activating public events and creating sixteen local organizations involved in reconstruction. Compared to other areas, Mano has known a faster recovery, reasonably due to power of social capital (Aldrich, 2012).

Another neighbourhood directly involved in reconstruction was Noda Kita, in Nagata ward, one of first neighbourhoods to react and return to normal life after the earthquake. Because of damages recorded after the earthquake, the community set rules for common life to prevent future disasters. In addition to damage of buildings, one of the biggest problems related to the earthquake was the spread of fires. Streets in Noda Kita were filled with plants and litter bins, while the area near the station was occupied by a number of bikes that made cars transit difficult. Such behaviour favoured the fast spread of fires and made impossible the access for firefighters. Consequently, local community established strict rules for the maintaining of urban roads, the waste collection and the management of bicycles parking. Today, these established rules are still operative. Local volunteers are responsible for the management of the neighbourhood. This change has involved not only the efforts of the entire community but it has also required the introduction of a common vision.

Social capital is something old in Kobe. The city was the first in Japan to promote *machizukuri kyogikai* (local planning associations) with the desire to involve local communities in their planning activities (Edgington, 2010).

Another unique feature in Kobe recovery was the big attraction of volunteer movements in order to rebuild the city and support victims. Earthquake recovery process involved several NPOs organizations around the country: 1.3 million of volunteers participated in the reconstruction of the city of Kobe after the 1995 Great Hanshin earthquake (Kingston, 2012).

Despite pro-activeness of government in allocating resources for an immediate disaster recovery, actions implemented were not exempt from problems and mistakes. First, a series of problems derived from the allocation of temporary houses of evacuees and by the following transfer into permanent homes. Lack of adequate spaces for construction of temporary accommodations and the resulting decision to use public spaces, such as schools and parks, to host displaced people created situations of discomfort for weaker citizens. As a result, elderly and children lived in precarious conditions, above all considering that the staying period in temporary accommodation was in some cases until August 1995, about six months after the earthquake occurrence. In order to solve such problems local government, once completed the construction of permanent homes, decided to prioritize the moving of older citizens into new houses. Although this decision came from the desire to help a vulnerable social group, it had the negative effect to isolate elderly community, separating older and younger and producing a lack of integration between different generations. It also produced a double break in the local community: the earthquake produced a first break, splitting the community from their original locality and assigned people from different communities to temporary shelters; a second break occurred as a result of the government decision to separate the community placed in temporary housing, moving the elderly in permanent homes. Consequently, the community was victim of a double shock and elderly were subject to social exclusion. Experience of agonizing decision

of municipal government led to a rethinking of the building process of permanent houses: while following the Kobe earthquake, law allowed to build permanent houses only on public land, as a result of the earthquake and tsunami the region of Tohoku in 2011, a reviewing of law created the possibility of using private land and private flats not damaged by the disaster for temporary houses. Moreover, through the terrible experience of 2011 tsunami damage, some local governments started to assign private office buildings as evacuation places.

Even system of aid for the reconstruction of private homes had some gaps. First, a major problem was the double loan for a part of those who lost their houses during the earthquake. The first loan was designated to buy the houses and owners should continue to pay for damaged houses. The second loan was designated to reconstruct the property after the earthquake's damage (Banba and Shaw, 2016). It was because of a law of 1961 which prohibited the government to bestow individual aid to rebuild personal property in case of disasters. Owners could receive only a monetary help from public funding or subsidies subject to an interest rate (Oguma, 2013).

Further problems stemmed from a lack of clarity on property rights for houses and land, the complexity of the set of rules imposed by the "Building Standards Law" and the lack of technical knowledge for the houses' reconstruction (City of Kobe, 2010).

However, according to the agreements of the time, the government would compensate who demolished the damaged houses to rebuild them. Such compensation only occurred for demolition and not for restoration. This led many citizens to choose the first way. An absurd paradox took place: the earthquake destroyed many houses but more had been destroyed by human action through demolitions. It seems to have about 100,000 demolished homes.

In addition, private housing reconstruction was difficult due to urban structure of Kobe and legislation constrictions in construction. Narrow streets and density in urbanization were a limit for possibilities of massive reconstruction.

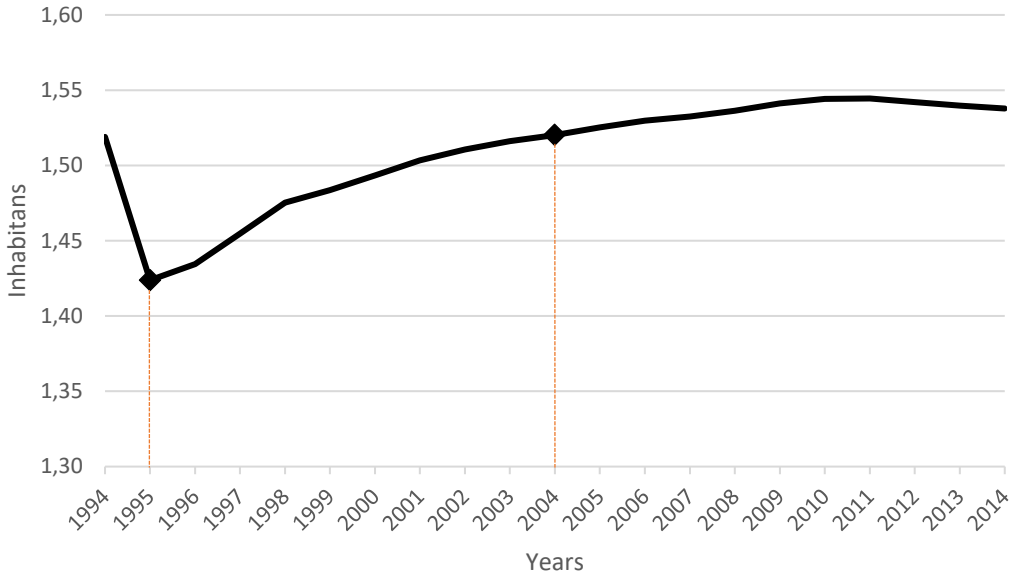
In revising the recovery process, City of Kobe (2010) recognized those bureaucratic and physical limitations and proposed to improve support measures in private reconstruction field, adding data and information services to the existing fiscal and monetary system. Importance of creating cooperation between construction companies and consultant services and the revision of legislation to promote deregulation in reconstruction law are also emphasized. This led to one of the major changes related to the earthquake: new standards for the building reconstruction and a new approach in disasters management.

Despite difficulties in planning reconstruction, the recovery plan of Kobe and the actions taken by the local government have assumed an important role both in city recovery and in emergency management process for the whole of Japan. In fact, before the Great Hanshin earthquake, there were no national plans for long-term recovery. In this context, local government has played a key role in promoting long-term development, both proposing a project approved by national government and creating a starting point for improving systems Japanese emergency management from the Kobe case. The turning point was the recognition of the long-term effects of natural disasters.

### 5.3.2 Social effects of the earthquake

A long-term analysis of the effects of earthquakes starts from effects on population. Although deaths and injuries caused by the earthquake, it can have important indirect effects on the people that move in or out the stricken areas. As a result of the disaster the population has decreased by approximately 95,000 people. Faced with 4,571 people dead, the remaining decreasing in population is due to a moving out of the area. In 2004, the population returned to 1994 levels (Figure 5.3).

*Figure 5.3 Evolution of population in Kobe in millions of people (1994-2014)*




*Source: Author's elaboration on City of Kobe, 2015*

Moreover, analysing the movement of people within the area of the city of Kobe is possible to identify interesting features of the change in population as an effect of the quake (Table 5.3).

*Table 5.3 Rate of change of the population in Kobe areas in 1994-1996, 1996-2014 and 1994-2014*

| Areas | 1994 – 1996 | 1996 – 2014 | 1994 - 2014 |
|---|---|---|---|
| Higashinada | -15.4 | 31.7 | 11.4 |
| Nada | -19.8 | 35.7 | 8.8 |
| Chuo | -6.9 | 25.4 | 16.7 |
| Hyogo | -15.9 | 7.3 | -9.7 |
| Kita | 7.2 | -3.8 | 3.1 |
| Nagata | -24 | -0.7 | -24.6 |
| Suma | -7.8 | -5.7 | -13.1 |
| Tarumi | -0.9 | -6.9 | -7.7 |
| Nishi | 14.5 | 8.0 | 23.7 |
| Total | -5.6 | 7.2 | 1.2 |

*Source: Author's elaboration on City of Kobe, 2015*

In the years immediately after the earthquake, the coastal wards (Higashinda, Nada, Chuo, Hyogo, and Nagata), extremely damaged by the quake, was

affected more by migration effects than unaffected wards (Suma, Tarumi Nishi and Kita). In a part of unaffected areas, population increased confirming an internal moving of people as an effect of earthquake. People decided not to move out from the city after the quake but they just moved within the urban borders. This confirms the Japanese attitude to the establishment of ties with the community and the low inclination to move away from the native area.

Data on population in 2014 shows a high increasing of inhabitants in a part of the stricken wards more than in some of the internal parts of the city. The areas of Higashinada, Nada, Chuo have better coped with the earthquake showing an increase of the population more than the pre-disaster level. However, the area of Hyogo has not fully restored the pre-disaster level and in the wars of Suma and Nagata, the population is continuing to decrease.

### 5.3.3 Economic effects of the earthquake

A second analysis concerns the impact of the quake on the job market in Kobe and in respect of the number of establishments to highlight economic effects of the shock. With regards to employment, in the period between 1996 and 1999 data point out a considerable decrease in employment and establishments. In contrast, the period between 1999 and 2001 shows a growth in number of employers and establishments (Table 5.4)

*Table 5.4 Rate of change in Establishments and Employers in Kobe, Hyogo and Japan from 1996, 1999 and 2001 census*

| Country | Period | Establishments (%) | Employers (%) |
|---|---|---|---|
| Kobe | 1996 – 1999 | -1.4 | -8.2 |
| | 1999 – 2001 | 2.7 | 10.2 |
| Hyogo | 1996 – 1999 | -4.1 | -7.3 |
| | 1999 – 2001 | 2.05 | 9.8 |
| Japan | 1996 – 1999 | -4.9 | -6.6 |
| | 1999 – 2001 | 2.37 | 11.8 |

*Source: Statistics Bureau of Japan, 2001*

To fully understand the economic recovery of the city of Kobe, in Table 3.4 data for Hyogo prefecture and the whole of Japan are shown. It is possible to see that changes in employment and establishments are similar for the city level, the prefecture and the national level. Thus, effects on employment related to earthquake can be considered partial and it could be linked to fluctuation in the national and global trend. In the first decade of 1990, a long period of economic stagnation affected the Japanese economy. This negative trend ended around the early years of 2000. As a consequence, the positive trend recorded in Kobe can be associated to the economic recovery of national accounts more that to recovery actions implemented after the earthquake.

### 5.3.4 Institutional effects of the earthquake

The Great Hanshin earthquake led to important institutional changes that involved not just the city of Kobe but the whole of Japan. These effects refer to institutional innovations in different fields. We will discuss the most important.

The first institutional innovation is due to the increase of voluntary actions and projects supported by local communities. Local and national governments started to recognize the importance of communities in the process of reconstruction after the earthquake. A consequence was the establishment of a law, passed by Government of Japan in 1998, to recognize legal personality to Non-profit Organizations (NPOs). Before the establishment of a specific law, voluntary associations and local communities had no legal power to negotiate with government. Initiatives were taken over by single leaders of associations acting as a private person. Following the earthquake of 1995, law of non-profit organizations recognizes the power of volunteers and social action (Oguma, 2013).

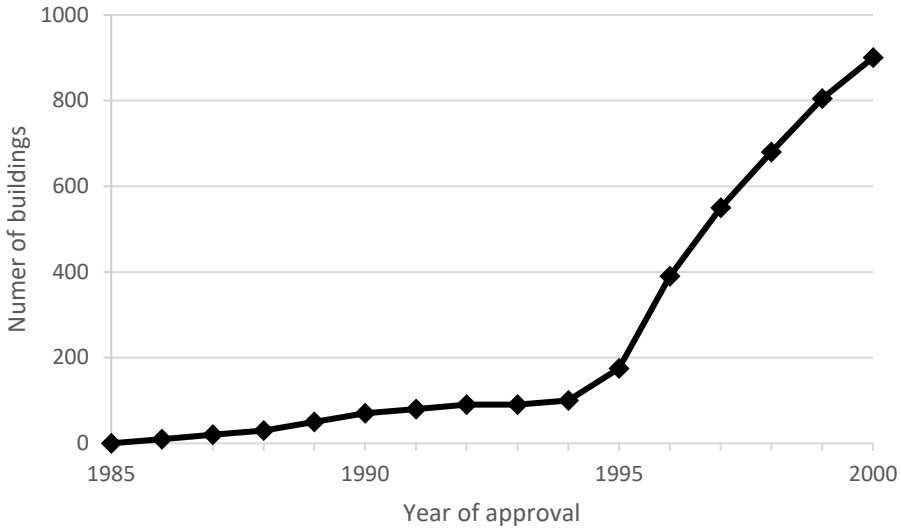
The second change involved the standard level for aseismic technology in the construction sector. A focus on technology in seismic mitigation and construction field is related to a reflection of the damage caused by the earthquake: Kobe as well as many Japanese cities is a densely populated area and consequently the greater amount of damage during the earthquake was caused by the collapse of buildings. Such reflection stresses the connection between the loss of life in earthquake and earthquake-resistant technology. About 70% of deaths in Great Hanshin Earthquake have lost their lives due to the collapse of buildings. It is clear, therefore, that innovation in seismic technology related to earthquakes is crucial to reduce loss in life.

Physical reconstruction of buildings is an essential phase of reconstruction process because of safety in houses and workplaces is a useful way to regain psychological stability after the quake. Moreover, buildings represent vital places in the city and as such should be rebuilt and reinforced. A process of successful recovery requires a rethinking of urban spaces, in order to improve the liveability of the city and create new areas that can be safe from disasters (City of Kobe, 2010). The Great Hanshin Earthquake was the opportunity to push toward a large application of technology in constructive sector and to revise standards for anti-seismic (Figure 3.9).

Following the Kobe earthquake, the national government started a campaign to promote the improvement of the old tradition Japanese houses, resulted inefficient to cope with the earthquake. In October 1995 was approved the "Seismic Rehabilitation Promotion Act for Existing Buildings" and several municipal governments established systems to financially support those who wish to strengthen their houses.

From a technological standpoint, Kobe has been the testing ground for anti-seismic technologies and has initiated a large-scale application of innovative technologies of "based isolation", an earthquake-proof technique which decouple a superstructure from its substructure resting on a shaking ground, driving Japan towards a leadership position in such industry.

*Figure 5.4 Cumulative number of seismically isolated buildings approved until 2000*




*Source: Author's elaboration from Nakashima and Chusilp, 2003, p. 9*

Finally, Kobe was the first case of promotion of long-term strategy to recover the city after the earthquake. It was a new approach to the recovery planning: Kobe Reconstruction Plan associate physical recovery to a revitalization of the local economy (Edgington, 2010).

### 5.3.5 Kobe as a new creative and high-tech city

The Great Hanshin Earthquake and the following plan for the reconstruction of the city involved a structural change in the economic base of the city.

Before the earthquake, Kobe was a port city and the main economic activities were related to the port traffics, the district of the hybrid-rubber used in the production of shoes and the district of sake. These major industries recorded a serious damage due to the earthquake. Approximately 80% of the establishments in the plastics industries and 50% of sake factories were destroyed. The port area was devastated with considerable damage to ships and fishing boats and the ways to access to port were cut off.

The district of hybrid-rubber was not able to be completely restored to pre-disaster level and also the port. Expeditions were routed to the nearest ports and transit of raw materials between Japanese companies was stopped, causing damage to the entire Japanese industry. The city of Kobe lost its position in the ranking of the major port cities.

In years after the earthquake, the city started to change its image from a port and manufacturing city to a new innovative and creative city. This transition, however, finds its root in the decade before the occurrence of the disaster. Already in the 80s, the local government favoured a policy of economic restructuring, promoting the transformation of the industrial port of Kobe into a new "urban resort" through increased tourism and a change in consumer and service oriented companies (Edgington, 2010). The idea was to dismiss the existing heavy industry to convert the economy of the city toward the services' sector. This conversion towards a service-oriented economy, involved the whole of Japan and can be considered as a consequence of the globalization that interested the global economic scenario in the 1990 (Chang, 2010).

Despite such reflections, the case of Kobe was a cutting-edge example of local economic revitalization through the creative and the high-tech sectors. The earthquake caused an acceleration of processes already activated on national and global level, such as the transformation towards a service-oriented economy. However, the strategy to promote a creative and innovative city was a direct consequence of the shock and a unique feature of the long-term economic recovery.

Boosting of the local economic development involved the establishment of two new pathways: (1) revitalizing the handicraft and (2) creating new businesses in high-tech and bio-medical in order to diversify the city's industrial structure.

Starting from the earthquake, a new urban strategy was promoted to improve attractiveness and vitalization of the city through the creative sector, particularly in design activities. The main idea was to favour tourism, wellbeing and sustainable development through three design perspectives: town design, life

design and *monozukuri* (manufacturing) design. The idea to use creativity to promote the city was aimed both to revitalize the economy and to create a comfortable place for living. Three main projects were activated to achieve the goals:

1) A school for young designers opened: *Kobe Monozukuri Shokunin Daigaku* (College for Craftsmen) inaugurated in 2000 to promote the transfer of skills and knowledge between old generation of craftsmen to the next generations.

2) In October 2008, Kobe was certified UNESCO City of Design, as was Nagoya for the first time among Asian cities, and became member of the UNESCO's Creative Cities Network.

3) In 2012 the "Design and Creative Centre Kobe" opened as a hub for attracting creative talents and as a place for dissemination of design culture. The Centre was built in a historical complex belonging to the former "Kobe Row Silk Testing Centre" and it was an important case of urban regeneration and enhancement of a historical building symbol of industrial culture in Kobe (Stocker, 2013).

The second strategy acted through the sector of the high-tech and involved the creation of two cluster, the first in the bio-medical and the second in the robot technology.

The medical industry was a completely new sector in Kobe. The aim of such project was to promote the research for advanced medical technology and to create a cluster of companies in the medical industry. Furthermore, such project was strictly linked to the idea of revitalizing the port area and as a result many industries were located in that area. The Kobe Medical Industry Development Project was launched in 1998 to create an R&D hub in the research of advance medical technology. It was the first Biomedical cluster in Japan and it was an example of successful collaboration between business, academia and

government. In 2015 the cluster counted around 7,100 employers and 316 firms[37] (OECD, 2016).

The Kobe RT (Robot Technology) Project came from existing resources in high tech industries in Kobe, such as machinery, metals and electrical equipment. The accumulation of knowledge and skills for industrial robots, mainly in large companies, as well as researchers in the field of robotics at universities and technical colleges were already established in Kobe. The goal for the industry was to develop and apply robotic technology to several fields and to combine technologies between different areas, such as control and communication, to foster innovation. The main idea was to re-vitalize the existing industry through the development and application of robotic technology. A part of the research was involved in project to create rescue robots to use in case of future earthquakes.

The Kobe Bio-medical and the Kobe RT clusters activated a number of shared project in the development of new drugs.

## 5.4 **Conclusions**

The chapter analysed the recovery of the city of Kobe destroyed by one of the major earthquake recorded in the history of Japan. The discussion of the case study was aimed to understand the effects of the earthquake and the major changes in the city perceived after the quake.

The earthquake affected population and firms but the city could recover from the shock: population gained the pre-disaster level in 2004, almost ten year later, and in the period between 1999 and 2001 establishments and employers regained a positive trend, despite this increase cannot be directly linked to the earthquake.

[37] According to the data of the city of Kobe, within the 316 firms, it is possible to count 53 in the field of biomedicine, 31 in the health care, 105 in the medical equipment, 14 in the regeneration medicine, 23 in the information technology, 9 universities and 7 medical institutions and support and related firms.

A direct consequence of the earthquake, however, was a number of institutional innovations. Main changes involved a law of the No Profit organizations, an upgrading of technological standards of aseismic constructions and the creation of an integrated strategy for the disasters management.

Finally, the local government promoted a transition of the economic structure of the city towards the high tech and creative sector.

Recovery process can be divided in two different steps: the first involved preliminary stages of reconstruction and actions of short-term recovery and the second concerned long-term changes in the economic structures and innovation created as a consequence of the earthquake (Figure 5.5).

*Figure 5.5 Short-term and long-term results of recovery process*

**PRE-DISASTER KOBE (Before 1995)**

Economic transition from industrial city to service-oriented city
Local communities' inclusion in planning through *machizukuri*
Wooden house and old technology in aseismic

**POST-DISASTER KOBE (After 1995)**

**Short-term recovery:**

Removing of debris
Construction of temporary houses
The Great Hanshin-Awaji Earthquake Public Reconstruction Fund
Volunteer's movement

**Long-term recovery:**

Reorganization of urban structure through change in people and firms
Promotion of high tech and biomedical clusters
Economic transition to creative city
Largest application of base isolation
Legal identity to NPOs
Revision of Rebuilding laws

*Source: Author's elaboration*

We propose to discuss the case of Kobe to investigate resilience in cities after natural disasters and to demonstrate if the city could resiliently respond to shock through a change in its economic structure.

The definition of resilience adopted in the theoretical chapter was that of adaptive resilience and involved the capacity of the system to evolve in respect of an external shock. Adaptive resilience was defined as:

> "*the capacity of a regional economy to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time*" (Martin, 2012, p. 10).

The city of Kobe can be, thus, considered as a resilient city because it successfully developed a long-term recovery that contributed to change the structure of the system and restore a growing path confirmed by the positive change in employment and establishments. The process of recovery in Kobe and the adaptive resilience of the city can be analysed through the lens of adaptation and adaptability.

We briefly recall the definition of adaptation and adaptability as theorized by Hu and Hassink (2015).

> *"Adaptation is an on-going and never-ending process, by which a regional economic system responses to a succession of challenges and disturbances, in order to become fitted to its varying environment. It refers to both the current function/performance of being maintained and to the potentials for regional dynamics.*
>
> *Adaptability is the ability to create new and/or change old actors, institutions and resources in a regional economy, which involves an action of innovation. It is a result of adaptation in which some actors intentionally or unintentionally adapt to environments. In a long-term perspective, adaptability should aim to strive for*

*alternative modes of doing things, rather than maintaining the existing functions and structures"* (p. 13-14).

The strategy of the 10- Year Kobe City Recovery Plan promoted long-term goals leading to the creation of new sectors through both adaptation and adaptability.

The adaptation in Kobe relates to the mobilization of existing resources such as the manufacturing sector, the robotic sector and the sake industry. Restoration of existing industries involved a bottom up and synergistic action between local government and local firms but it was favoured by a monetary aid from national, prefectural and local governments. Adaptability was due to the long-term strategy proposed by local government that involved the creation of completely new sectors, such as tourist sector, through the entrance in the network of the UNESCO creative cities, and the biomedical industry.

In our view, the processes of adaptation and adaptability have been complementary. Adaptation has been a source for adaptability: the rejuvenation of the existing sectors was the base for creating new sectors and promoting adaptability. On the contrary, adaptability in the long-term influenced process of adaptation reinforcing the old trajectories.

Table 5.5 summarizes the main paths generated in city after the earthquake.

The case of Kobe can suggest some reflections in the discussed issue of the economic effects of natural disasters. Studying the recovery process helps to understand both the direct and indirect economic effects of natural disasters and the countermeasures implemented. Even though macro fluctuations cannot be considered directly related to environmental disasters, a focus on economic effects of natural disasters is important because it can highlight indirect losses that have a long-term effect on the development of the region causing economic stagnation. Such damage can involve losses in productivity in the sectors directly impacted by the shock, losses in investments or decreasing in population and employment (Noy and duPont, 2016).

*Table 5.5 Changes in the economic structure of the city of Kobe*

| Pre-quake | Adaptation | Adaptability | Post-quake |
|---|---|---|---|
| Port Activities | Rejuvenation of manufacturing sector through design | Creation of an innovative bio-medical cluster | Creative industries of design |
| Manufacturing industry of hybrid rubber shoe industry | Reconversion of the existing robotic industry | Transition towards an UNESCO Creative city to foster liveability and tourism | UNESCO Design City |
| Sake brewery industry | Modernization of sake industry | | Robotic cluster |
| | | | Bio-medical cluster |
| | | | Sake industries |
| | | | Hybrid rubber shoe industry |

*Source: Author's elaboration*

Long-terms effects of natural disasters can also involve damage in the image of the region (Vale and Campanella, 2005) and have negative influence on economic trends, such as tourism. An evaluation of the economic effects of natural disasters can help to address the long-term policy and to strengthen regional resilience. Such evaluation is more important when national economies also suffer from long periods of economic recession, as Japan did. Japanese economy knew a continued recession from the early 1990s to 2005. Negative effects caused by environmental disasters can tighten up negative trends due to economic crisis.

Moreover, the case of Kobe can contribute to enlarge the debate of the creation of new paths helping to finds actors involved in the resilient process and the key elements in fostering resilience. Indeed, an analysis of long-term

recovery can help to go beyond the shock and investigate the origins of the resilience. Shocks are rare events. Thus, not only by external pressures can push change and transformations (Simmie, 2012).

The case of Kobe shows that the economic recovery has been possible thanks to a synergistic collaboration between local and external actors. Individual industrial associations collaborated with local networks to speed reconstruction through the aid given by the local government, the prefecture and the central government.

Strict cooperation between formal and informal institutions is an old tradition in Kobe. Such cooperation strengthens social capital and contributes to demonstrate that resilient communities can build resilient regions. The role of human agency is crucial in building the resilience: pro-activity of local government and a shared decision-making policy can make territories more stable, promoting processes of adaptation and adaptability.

Moreover, a mix of internal and external knowledge may foster regional resilience. In Kobe, after the earthquake, the city confronted with declining population and employment and a huge damage in the port area, the old economic heart of the city. Exploiting the creative industries such as the design sector was a way to react and reinvent the city promoting a new image of a creative city. Additionally, policy makers decided to expand and diversify the economic base through the existing robotic industry and the new bio-medical clusters. The case of Kobe shows that innovative and creative industries can be both sources for a transformation in the economic structure of the city and a way to increase the resilience.

# Conclusions

The thesis proposed to contribute to the still undeveloped debate about the relationship between adaptive resilience and the creation of new trajectories, with a focus on the impact of natural disasters and the possibility to develop opportunity for growth in relation to the occurrence of these shocks. The analysis focused on major earthquakes occurred in Japan investigating different dimensions of the resilient process related to resistance, recovery, reorientation and renewal (Martin, 2012). The framework proposed by Evolutionary Economic Geography (EEG) to study regional economic resilience is applied to the analysis of the response of Japanese economies to earthquakes. The empirical application involved the measurement of indices of resistance and recovery for Japanese prefectures evaluating changes in levels of employment before and after the occurrence of the shock. Moreover, a case study analysis has been proposed to test dimensions of reorientation and renewal analysing resilience through process of adaptation and adaptability.

To introduce the notion of resilience and to address the plurality of the questions, a literature review of the concept of resilience has been proposed in Chapter 1. In the first part of the chapter, resilience has be analysed as a multidisciplinary concept in order to understand limits and difficulties in formalizing a unique definition of it. Definitions of engineering and ecological resilience have been critically analysed focusing on main limits in applying such definitions to the study of the evolution of systems.

In Chapter 2, resilience as studied in the framework of EEG has been discussed. The definition of adaptive resilience theorized in EEG has emerged and the importance to link this concept to notions of adaptation and adaptability in order to identify the role of the past in explaining future trajectories. In Chapter 3, the research design has been discussed highlighting the main research questions and hypotheses of the research.

A description and a measurement of two indices to evaluate resilience have been proposed in Chapter 4 to test resistance and recovery dimensions in

response to earthquakes. The indices are based on existing indices to evaluate resistance and recovery after economic crisis. Despite difficulties in translating the indices into the field of environmental shocks, those measures have been applied to the case of earthquakes. The measures have been elaborated for the Japanese prefectures stricken by major earthquakes with data of employment from OECD in the period between the 1997 and the 2012.

In Chapter 4, a measurement of resilience in relation to earthquakes is proposed. In identifying measurements of resilience in face of natural shocks, the two main problems are the difficulty in searching a single measure of resilience and the complexity in finding a variable able to estimate the impact of natural disasters.

Using employment to measure the impact of the earthquakes is first due to maintain a coherence with the studies of resilience in EEG, in which employment was frequently used as a proxy to evaluate recovery of systems. Moreover, decreasing in employment is an indirect consequence of the earthquake related to the physical losses caused by the disasters. This indirect damage can be relevant when it involves a decrease in productivity in the economic scenario. Furthermore, it can overlap the negative effects of other shocks in the system, such as economic crisis. Despite the importance in measuring indirect economic impacts of natural disasters, a large part of studies limits the analysis to direct losses in evaluating the economic damage of environmental shocks.

The indices of resistance and recovery measured for Japanese prefectures give an idea of the ability of prefectures to cope with the shock. Furthermore, these indices provide a comparison between the different performances of prefectures for a single typology of shock.

The second part of Chapter 4 focused on an analysis of change in the employment rate in relation to earthquakes. This analysis confirms the difficulty to ascribe to earthquakes changes in employment and highlights a possible overlapping between effects of natural disasters and economic shocks. In some

cases, the occurrence of the earthquake reinforced negative effects of crisis can slow down the economic recovery.

The case of Kobe has been debated in Chapter 5. In 1995 a massive earthquake destroyed the city but local actors coped with the shock proposing a long-term strategy aimed to revitalize the local economy. Process of adaptation involved the rejuvenation of existing industries, while process of adaptability acted introducing new industries. These two processes assumed complementarity because revitalising of existing industries constituted a starting point to create a part of the new industries and, on the opposite, new industries collaborated and sustained existing industries favouring adaptation. The city of Kobe may constitute a virtuous case of adaptive resilience responding to the shock through both processes of adaptation and adaptability at the local level. Moreover, the shock was an opportunity to improve disasters management system and introduce revised standards of anti-seismic technology in the whole Japan. An important consequence of the disasters, moreover, was an institutional innovation that recognized legal identity to NPOs.

Natural disasters involve direct damage to physical elements of the city – such as houses and establishments - that translate in indirect damage to productivity, employment or growth. This scenario can create opportunities for both the physical reconstruction and the economic revitalization of the urban system. Both strategies are based on the identification of vulnerabilities of the system in relation to its physical attributes and in the elements of its economic and social structure.

The process of recovery after natural shocks can lead to the creation of new trajectories and structural adjustments in the economic base of a city. The case of Kobe shows that processes of adaption and adaptability activated in response to the shock can contribute to the adaptive resilience of the city.

It needs to be clarified that not all the disasters create opportunities for a change. In the long history of natural hazards, several cases described abandoned cities or unsuccessful recovery of economies as consequence of

disasters. Examples are the town of Beichuan in province of Sichuan in China destroyed by an 8-magnitude earthquake in 2008 or the town of Poggioreale in Italy stricken by the Belice earthquake in 1968. Both the areas were abandoned in the days after the earthquake, relocating survivors and turning cities in desert areas. Moreover, several areas stricken by the Tohoku Earthquake in the north of Japan cannot recovery from the disaster because it deeply impacted within the local economy.

Development of new trajectories cannot just depend on the occurrence of a shock but requires the interevent of other elements to de-lock the system from a previous path. In accordance to the vision proposed by the theory of new path creation, this involves the need to investigate the role of human actors in favouring the creation of new trajectories. Human actions can play a central role not just in relation to origins of new paths but also in response to external shocks

In Kobe, different levels of actors influenced process of reconstruction. An individual level refers to the actions implemented by volunteers and single communities, such as the case of Mano and Nagata wards. A local level involved local government and local institutions such as *Machizukuri* associations. An aggregate level involved actions of the government of the prefecture of Hyogo and the national level. These three main levels interacted demonstrating that a combined action can contribute to the territorial development. The case of Kobe can be emblematic in explaining resilience and can contribute to give a holistic vision of the issue.

The case suggests that a synergic and coordinated action of system's actors can positively affect resilience. Proactivness of local government and the inclusion of a plurality of subjects in planning the recovery after a natural disaster can be key elements in contributing to the emergence of an adaptive response to shocks.

In studying the role of actors involved in the recovery process and their degree of influence in resilience, the experience of Kobe can enlarge the

knowledge of factors fostering resilience. A combined action between local institutions, firms and communities with a support of national and prefectural governments can increase the resilience of the system and propose a successful strategy in response to shocks. On the one hand, volunteers and NPOs associations represented key actors in the process of physical reconstruction of the city. On the other hand, *Machizukuri* associations were fundamental in planning both reconstruction and economic revitalization. Finally, a central role was played by the local government: Kobe administration was the first one to propose an integrated strategy to promote reconstruction in Japan. Actions of local actors were combined to the aid of prefecture and national government that provided monetary help to sustain the recovery of the city.

Concerning the theoretical aspect emerged in the thesis, it is possible to argue that the notion of adaptive resilience seems to be the most appropriate to study the evolution of trajectories of local development in regional and urban dimensions. In relation to this point, the thesis tried to highlight the importance of a long-term perspective in studying the response of regional and urban systems in consequence of a shock. Despite shocks are sudden and unexpected events, processes of change need time to emerge. A short-term investigation can be appropriated to study simple process of coming back to previous conditions but it lacks an evolutionary perspective.

Moreover, through the analysis of the adaptive resilience emerges that concepts of adaptation and adaptability can be considered as filters to analyse the patterns popped-up in urban and regional systems after the occurrence of a shock. These concepts could represent a synthesis in the debate between path dependence and path creation. Adaptation involves the possibility of a reconfiguration of the historically accumulated assets of the system; on the contrary, adaptability suggests the emergence of new trajectories as a result of shocks. Possibilities for a complementarity of both processes proposed in literature imply that the de-lock of underperforming circumstances not necessary involve a deviation from existing paths. In relation to the combination

of adaptation and adaptability, path dependence could lose its negative connotation referred to the idea that resilience emerges when the system breaks with the past. New paths require the co-existence between the legacy of the system and injection of new resources to reorganize and renew in response to shocks.

Such theoretical framework can successfully be applied to the field of environmental disasters. Not only economic shocks, such as economic crisis or process of deindustrialization, can favour structural adjustments and the creation of new industries. Moreover, it is observed that negative impacts of economic and environmental shocks are frequently interrelated. A comprehensive theory of resilience cannot ignore environmental shocks as the starting point for new development paths.

The thesis would try to be an innovative contribution in the field of EEG because it proposed a combination of the framework of regional economic resilience and the field of natural shocks. This framework is applied to the case of Japanese earthquakes. However, it has several limitations that can be summarized in the following points.

First, the case of Kobe constitutes an important case both for the innovations produced in the national context of Japan and for the pioneering application of an integrated strategy based on creative and innovative resources to revitalize the local economy. Despite this, the analysis of the case of Kobe is almost completely qualitative. The qualitative nature refers to the nature of research questions. However, the case study methodology, analysing contextual embedded elements, can weak the general conclusions of the research.

Second, indices of resistance and recovery were not measured for the case of Kobe. The availability of data of OECD for employment of Japanese prefectures is limited to the period between 1997 and 2012. To evaluate resistance and recovery indices for Kobe, data for the prefecture of Hyogo was required starting from 1994.

Third, the case study has mainly been reconstructed from data provide from public administrations of Kobe city and Hyogo prefecture. Moreover, interviews involved institutional subjects such academics and public administration. A comprehensive analysis of the case study could be provided consulting non-official sources. To address this criticism, many scientific articles and books have been revised and compared to official data in order to have a more objective reconstruction of the case study.

These limitations can be overcome with a future most exhaustive research on the issue proposed in thesis. For this reason, ideas for future researches are presented to address limitations highlighted and to evidence important topics related to the issue of resilience.

In order to improve the research of resilience in face of earthquakes through the analysis of the recovery of the city of Kobe, future researches can include interviews to non-official subjects and a larger research of sources to describe the case study. Furthermore, the research could go ahead analysing specific aspects or elements of the recovery process. An idea is to analyse the different clusters of the city in order to understand how the different features of each cluster are related to a more or less adaptive response to the shock.

Indices of resistance and recovery can be further developed introducing a more complex analysis. This could involve specific aspects related to the earthquake, such as an evaluation of the dimension of the shock based on the magnitude or the economic damage.

To enlarge the general topic of resilience in response to natural shock and to generalize the theoretical framework built in Chapter 3, a comparative analysis can be proposed. An interesting idea is to compare the case of Japanese prefecture to Italian case studies. In the past few years, several Italian provinces have been stricken by serious earthquakes that in many cases caused damage to people but also to cultural heritage or to industrial areas, seriously affecting the economic resources of those regions. Responses to these events have been different and, frequently, have led through a slow economic recovery. A

comparative analysis to the Japanese cases can be interesting in order to highlight mechanisms that can favour resilience and make regions more or less vulnerable to shocks.

Moreover, regarding to researches of resilience in regional and urban economies, more attention needs to be paid to firms and local institutions and their contribution in improving the territorial resilience. New tools are required in order to achieve this aim and these tools should capture the efforts of firms and institutions to positive contribute to a sustainable local development. In this regard, social report and social accountability can constitute an important way to catch the measure of social and territorial resilience.

Finally, the thesis evidenced that communities and social relationships can be fundamental in constructing the resilience of systems. A future research on the role of social capital in positively affecting the response of territories to adverse events can constitute an important analysis in studying aspects that affect resilience. A bottom-up strategy is important to free the notion of resilience from its conservatism. Resilient communities can contribute to generate more equal and inclusive trajectories in response to shocks.

In this new scenario, the idea of resilience can constitute a valid theoretical support to study problems related to major shocks but also to study the continue uncertain as a feature of the economic system. Thus, the role of economists regains importance but require a new revised vision to propose solutions for managing uncertainty. Prediction models have resulted unable to anticipate both economic and environmental shocks. It follows that the priority of economic science should be to provide new tools to enhance the capacity of individuals, firms and institutions to be less sensitive to shocks. Resilience could be a fundamental one.

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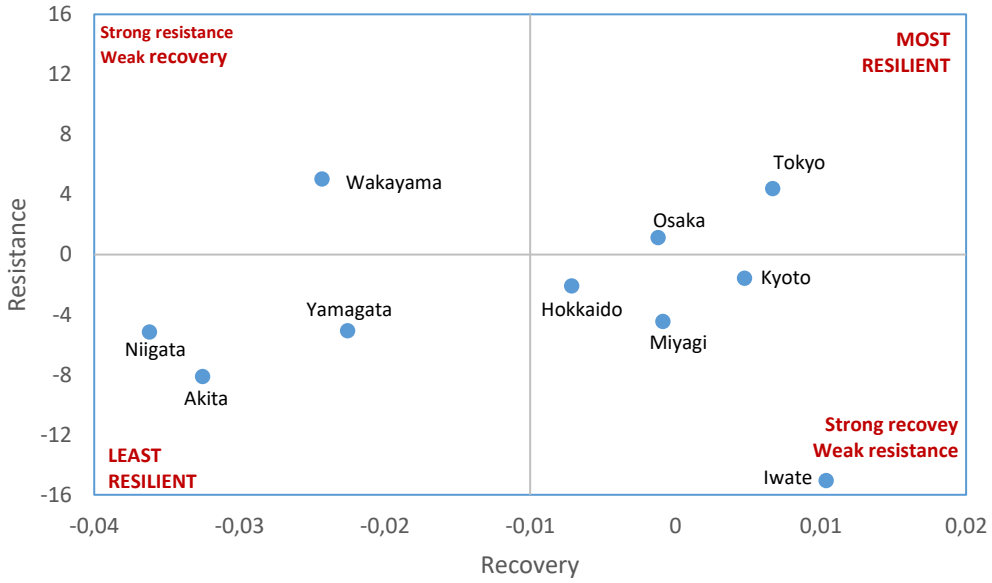
# Appendix 1

*Table A.1 Resistance Indices calculated following Lagravinese (2015)*

| Region | Recovery | Resistance |
|---|---|---|
| Hokkaido | -0,00715 | -2,0982 |
| Iwate | 0,010355 | -15,0512 |
| Miyagi | -0,00087 | -4,4692 |
| Akita | -0,03255 | -8,1354 |
| Yamagata | -0,02258 | -5,0844 |
| Kyoto | 0,004754 | -1,5788 |
| Osaka | -0,0012 | 1,1219 |
| Wakayama | -0,02434 | 5,0346 |
| Niigata | -0,03621 | -5,1675 |
| Tokyo | 0,006692 | 4,3918 |

*Source: Author's elaboration*

*Figure A.1 Resistance and recovery indices of Japanese prefectures calculated for the major earthquakes occurred between 2003 and 2008*




*Source: Author's elaboration*