

A review of the theory and practice of regional resilience



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ABSTRACT

The concept of resilience deeply affects regional planning, development, and post-disaster reconstruction. Recent research advances on the theories and practices of regional resilience are discussed in this article. First, the concepts of resilience and regional resilience are summarized, and the spatial characteristics of the resilient region are analyzed from the standpoints of property, process and capability. Second, the definition, research background, visual angle, basic research framework, guidelines, importance, and future development of regional resilience are evaluated from the following point of views: engineering, economy, ecology, and society. In addition, the predominant methods and technologies are reviewed to evaluate the regional resilience from the perspectives of property, process and capability factors. This is followed by a detailed discussion on the practice of regional resilience in planning and disaster management. Last, but not least, the worldwide main research results, their current deficiencies, and future research directions are presented.

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Under the background of climate change and resource depletion, how to maintain the adaptability of 'resilience' for regions facing a variety of natural and man-made disasters becomes a new subject of urban and regional planning. The concept of resilience has revealed the content and view of regional research, which reflects new requirements and transformation characteristics of regional development. Currently, this concept, which has surpassed the notion of 'Green', 'Sustainability' and 'Smart Growth', is affecting the planning, development, and restructure of the regional space.

Regional resilience emphasizes the behaviors, culture and policy contributions of the regional subject (Christopherson, Michie, & Tyler, 2010; Dawley, Pike, & Tomaney, 2010; Foster, 2007; Iordan, Chilian, & Grigorescu, 2015; Shaw and Maythorne, 2013), which embodies the dynamic role of the spatial feature during construction. Accordingly, regional resilience is of great importance, both practically and theoretically, and has become an important element in regional research. In recent years, with the deepening of the relevant research, the recognition of the concept, components, research field and assessment of regional resilience has gained much ground (Fig. 1).

1. The concept of resilience

1.1. The basic concept and multi-dimension connotation of resilience

The word 'resilience', which originates primarily from physics, refers to the variability of an object under the premise of keeping its essential characteristics. It is a reaction of a substance to its external forces. In the 1970s, this concept was applied in ecology by an American researcher named Holling (Holling, 1973). The primary meaning of resilience was interpreted as the system's capability to predict and resolve the external shocks (Cai, Guo, & Wang, 2012), to maintain its main functional operation when crises occur, and meanwhile to enhance itself utilizing available resources and opportunities. Resilience alliance puts forward three essential characteristics of resilience: (1) the controlling force with which the system can withstand a series of changes and maintain its function and structure, namely 'equilibrium', (2) the capacity of self-organizations, namely 'self-organization' and (3) the capacity to establish and promote adaptive learning, namely 'innovation' (Tongyue, Pinyi, & Chaolin, 2014).

Since then, many researchers and research institutions have analyzed the concept and connotation of resilience in different contexts (Capello, Caragliu, & Fratesi, 2015; Eraydin, 2015; Foster, 2007; Hill, Wial, & Wolman, 2008; ISDR, 2009; Lester and Nguyen, 2015; Pachauri and Reisinger, 2007; Pendall, Foster, & Cowell, 2009; Pike, Dawley, & Tomaney, 2010; Rose and Liao, 2005; Simmie and Martin, 2010; Swanstrom, 2008; Tongyue et al., 2014; Vale and Campanella, 2005; Williams, Vorley, & Ketikidis, 2013), including engineering resilience, economic resilience, ecological resilience, social resilience, etc. (Table 1).

1.2. The notion of regional resilience

The combination of the concept of 'resilience' regarding the city and the region reshapes the properties of space. As a pioneer in the field, the definition of the resilient city was first defined by

'Resilience Alliance' as the capacity to digest and absorb the external interference and maintain the main original features, structure and a key function for the cities and city systems (Alliance, 2007). Thanks to the in-depth research on 'resilient city' and the macroscopic expansion of the views, questions like, "How to handle various regional crises and challenges?", "How to digest regional adverse interference?", "How to adapt to a new environment?" and "How to recover the regional economy after a crisis?", have attracted broad attention and created a hot debate about 'regional resilience' and 'resilient region' (Hill et al., 2008; Klein, Nicholls, & Thomalla, 2003; Lester and Nguyen, 2015; Pendall et al., 2009; Swanstrom, 2008; Xiaohui, 2012).

The research on regional resilience has gradually developed for nearly five years (Boschma, 2015; Christopherson et al., 2010; Iordan et al., 2015; Qi and Wei, 2010; Yan, Wei, Jiuchang, & Zhixiang, 2012). 'Resilience' redefines the connotation of regional development and competitiveness (Bristow, 2010; Hudson, 2009) after being applied to regional ecology and social system (Berkes, Colding, & Folke, 2003; Walker et al., 2002). Based on the research of 'resilience' and the 'resilient city', 'regional resilience' can be defined based on three characteristics, namely 'stability', 'self-organization', and 'innovation', as shown in Table 2.

Accordingly, the author thinks that the basic meaning of resilience is that the system has the ability of: expectation, resolving external shocks, maintaining its main functions by itself in the presence of crisis operation and using the resources and the opportunity to further enhance its own abilities. Combining the concept of resilience with the spatial object, it is done as a measure of regional space development. Its core value is to predict the threat of regional space and its extent, and to take action to alleviate the impact of harmful precedent. On the other hand, when facing the sudden regional shock, it can give a timely response, alleviate the impact of regional space, become stable after the impact of the regional condition and promote regional space recovery with a new balance according to the review opinions.

1.3. The components of regional resilience

Based on regional resilience, namely the ability to anticipate, prepare for, respond to, and recover from external disturbance. Many researchers put forward different components for regional resilience, as well as their inner link (Dabson, M.Heflin, & Miller, 2012; Foster, 2007; Wilbanks, 2008), which can be summarized as follows: (1) the regional resilience properties (Cai et al., 2012; Tongyue et al., 2014), namely the maximum shocks bearable after forecasting harms and shocks comes; (2) the regional resilience progress (Cai et al., 2012), namely pre – shock, shock and after shock; (3) the regional resilience abilities (Cai et al., 2012). These elements could determine the difference between before and after.

1.3.1. Property components

Regional resilient property is the foundation of the whole system capacity, which is determined by system vulnerability and resource availability. System vulnerability includes physical damage (fundamental damage to infrastructures and facilities), economic damage (the major medium and long-term impact on the economy) and social damage (damage to the operation of government, social stability and normal life) (Dabson et al., 2012).

Table 1
Main points of current researches in the field of resilience.

Research fields	Main points	Concepts brought forward by Representative researchers or institute
Engineering resilience (can be found in physical sciences)	Efficiency, recovery and conservation (resistance to change and maintain the status quo), stability and balance.	<p>(1) Resilience is the capacity to respond to regional disasters and recover itself back to normal level, emphasizing on the toughness during the disaster and the adaptive ability aftermath (Wildavsky, 1988)</p> <p>2.Holling emphasizes the efficiency of the system, stability, and predictability, focusing on the stability of the system in equilibrium, the rate of recovery and the tolerance of the interference (Gunderson et al., 1995;Holling, 1973;Holling, 1996).</p> <p>3. Bruneau (Bruneau et al., 2003) argues that resilience includes strength, elastic system redundancy, fast recovery capacity, and the capacity to adapt itself to changing circumstances, and he has given a specific evaluation for the measurement of resilience.</p> <p>4.MCEER (Bruneau et al., 2007) proposes a resilience frame for infrastructure which reflects the main characteristics of resilience in the perspective the robustness and rapidity.</p> <p>5.resilience is a certain kind of capacity that enables a system, community, or society to resist, absorb, adapt itself to, and recover from the crises confronted when it is exposed to dangers, the recovery referred here includes the capacity to preserve and restore the necessary infrastructure and function (ISDR, 2009).</p>
Economic resilience	Structure stability, innovation, development, break the balance and restructuring (in the direction of the fine), sensitive degree, self-organizing capacity, the capacity to adapt.	<p>1. Rose (Rose and Lim, 2002) argues that economic resilience is the system's inherent capacity to respond and adapt itself to disasters confronted, and that of individual and communities to adopt appropriate strategies (behavioristics) to cope with negative effects during the occurrence of an external impact or aftermath to avoid potential losses.</p> <p>2. Polèse (Polèse, 2010) argues that economic resilience is the capacity for the region to preserve itself and keep development vitality in times of crises.</p>
Ecological resilience (can be found in ecological sciences)	Buffering capacity, ensure impact (interference) absorption, the unchanged function interference, restructuring and sustainable development and its balance	<p>1. Holling (Cai et al., 2012; OECD, 2013), as a founder, Holling holds that resilience refers to the system's capacity to realize rapid representation and maintain its structure and function.</p> <p>2.Gunderson (Gunderson and Holling, 2002) present a Panarchy model, an adaptive cycle, and a model of adaptive multi-scale nested loops for the dynamic mechanism of ecosystem evolution. a</p> <p>3.resilience is used to describe a system that can absorb interference while maintaining the basic structure and the capacity to function, and the capacity of self-organization, adaptation to changes in pressure and changes (Pachauri and Reisinger, 2007)</p>
Social resilience	Reform of public management behavior, productivity, power, learning, and capacity to adapt	<p>1. Adger (Adger, 2000) holds that the first researcher's research group who brought the concept of eco-resilience into human society argue that social resilience includes the community's capacity to resist the pressure from social, political, and environmental changes.</p> <p>2. Paton et al. (Paton and Hill, 2006;;Paton and Johnston, 2001) propose that resilience refers to the system's capacity to maintain its regular function, gather resource under the external interference, the system can maintain normal function, attract resources agglomeration, the challenge and the capacity to change</p> <p>3.Paton et al. (Paton and Hill, 2006;;Paton and Johnston, 2001) put forward that a system, community or society can, using resistance or changing itself, adapt to potential risks and disasters and maintain the default structure and function. A social system can enhance the capacity to learn through the self-organization, with which, it can gather experience from the past disasters, so as to provide the system with better protection and improved solution to disasters in the future.</p> <p>4. Paton and Hill (Paton and Hill, 2006) regards resilience as a process, involving continuous learning and improve the decision-making capacity, at any time to deal with all kinds of disasters, which is the crises management strategy.</p>

Source: based on published literature (Bruneau et al., 2003;Bruneau et al., 2007;Gunderson, Holling, & Light, 1995;Gunderson and Holling, 2002;;Holling, 1973;Holling, 1996;ISDR, 2009;OECD, 2013;Pachauri and Reisinger, 2007;;Paton and Hill, 2006;;Paton and Johnston, 2001;;Polèse, 2010;Rose and Lim, 2002;;Scheffer, Carpenter, Foley, Folke, & Walker, 2001;Wildavsky, 1988).

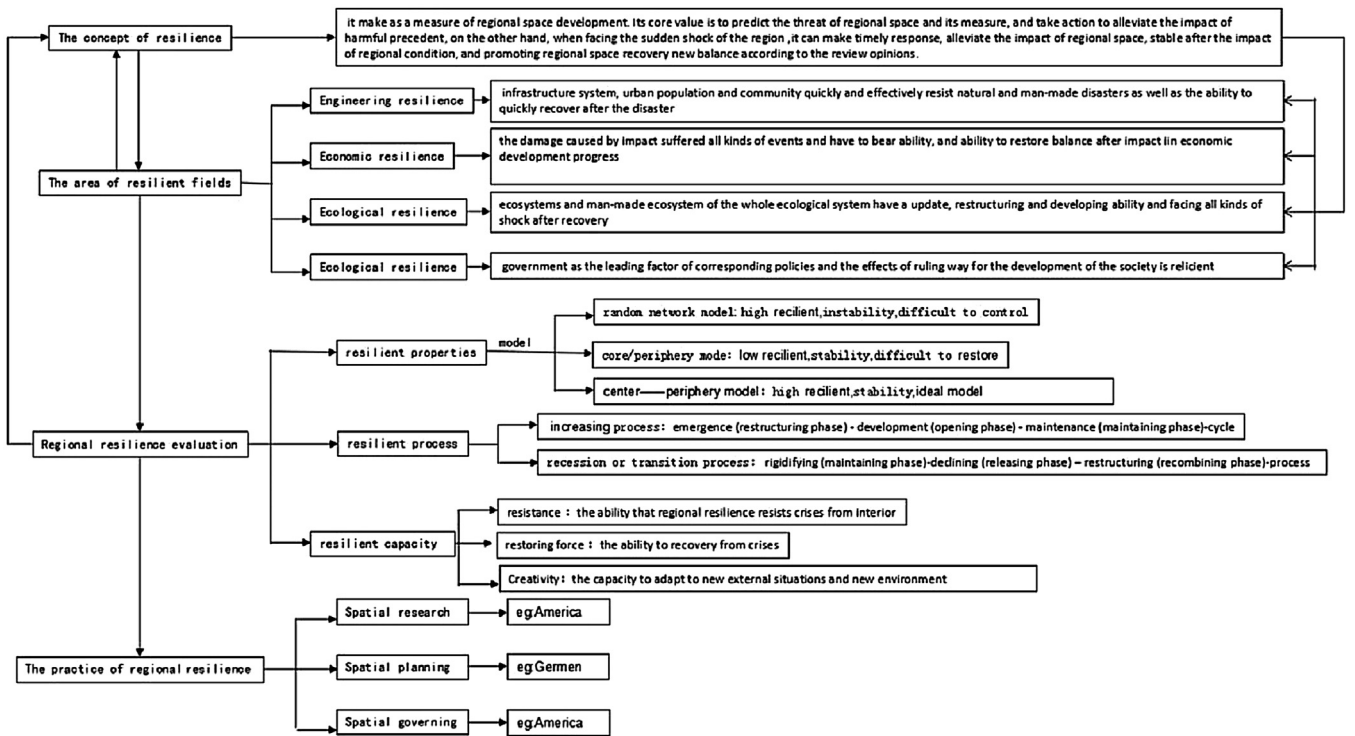


Fig. 1. Concept, components, research field, and assessment of regional resilience.

Table 2
Classification of regional resilience definitions based on resilient characteristics.

Characteristics	Definition
Stability	Stability refers to the ability to anticipate, prepare for, respond to and recovery when a region is confronted with external interference or impact (Dabson et al., 2012; Foster, 2007; Wilbanks, 2008; Xiaohui, 2012). Regional resilience reflects the regional crisis response capacity, which is the measurement of the stability of regional development (Qi and Wei, 2010).
Self-recovery ability	The ability to deliver a timely, effective, fair and reasonable response to emergencies, so as to ensure a faster, better, safer and fairer recovery (Wilbanks, 2008). Based on its "resilience", a region can reduce its vulnerability when its energy value is of 1; then we have: regional resilience = 1 - vulnerability (Qi and Wei, 2010).
Innovation	It refers to a feature that a region restores its original status without changing its system structure and function or changes the characteristics of the original trajectory and enters a new state (Hill et al., 2008).

Source collected from the literature (Dabson et al., 2012; Foster, 2007; Hill et al., 2008; Qi and Wei, 2010; Wilbanks, 2008; Xiaohui, 2012).

Resource availability refers to resource redundancy (Dabson et al., 2012) and availability of resources when a region experiences shock during the development progress.

So, the strengthening of regional resilience requires the reduction of system vulnerability and the increase of available resources. It would also be beneficial to improve the cooperation between the government departments for the enhancement of resilient policy.

1.3.2. Process components

Different processes exist depending on the objective and emphasis. Most researchers focused on the final result of the

process, which is to enhance resilient regional capacity. The process itself could be simplified as Resistance-Renewal-Recovery-Reorientation (Martin, 2012). Additionally, this resilience building process is also presented as a 'Shock-Capacity-Impact-Trajectory-Outcome-New Capacity' framework (Dabson et al., 2012) (Fig. 2).

The trajectory of recovery can be categorized as static resilience and dynamic resilience. The former refers to the ability that a region has to resist functional damage and restore itself to the pre-shock status (Dabson et al., 2012), whereas the latter refers to achieving a new balance different from that of pre-shock (may be better or worse). Regardless of the final status, the resilient building process is a dynamic process (Adger, 2010; Boschma, 2015; Christopherson et al., 2010; Dawley et al., 2010; Eraydin, 2015; Simmie and Martin, 2010).

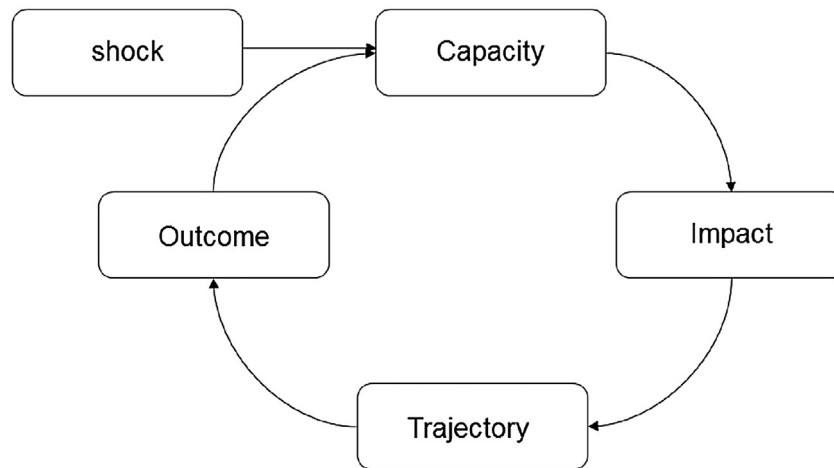
1.3.3. Capability components

Resilient capability refers to the maximum pressure that the regional system can withstand, which mainly includes resistance, recovery, and creativity. All high-resilience systems manifest three resilient abilities, specifically resistance, recovery and creativity, as shown in Fig. 3 (Frommer, 2011; Maguire and Hagan, 2007; Weick and Sutcliffe, 2011).

Resistance: refers to the ability that a system bears interference, similar to buffer capacity, regarded as the level of maximum damage that a system could bear without changing its function and structure, as shown in Fig. 3B (Frommer, 2011).

Recovery: is a kind of 'coping ability' which describes the function whereby a system can bounce back to the pre - disruption state after a certain amount of time (Frommer, 2011; Yan, 2009). This property is an important indicator of system resilience. The faster the system returns to its original state, the more resilient it is, as shown in Fig. 3A (Frommer, 2011; Maguire and Hagan, 2007)

Creativity: is the ability of a system to adapt itself to the new situation, whereby the system not only restores itself to the original level but achieves a higher level. This is the "adaptive capacity" of resilience (Frommer, 2011; Maguire and Hagan, 2007). High-



Shock—the possible range and level of the impact of an event

Capacity—a property to indicate the regional vulnerability and adaptive resources when the region is confronted with shocks.

Impact—all kinds of outcome dysfunction caused by shocks.

Trajectory—the resistance, recovery, resilience, or everlasting function breakdown.

Outcome—3 cases as indicated in Fig. 2: 1. achieving the critical value that a region could bear; 2. achieving a new balance and 3.

adapting the regional capacity to the next shock

Fig. 2. Resilience cycle(Dabson et al., 2012).

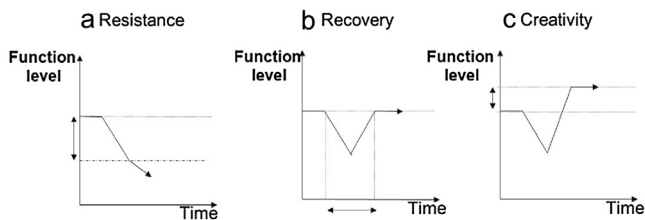


Fig. 3. Three Forms of Resilience (Maguire and Hagan, 2007).

resilience systems possess a self-learning ability to improve itself from the experience and new circumstances, as shown in Fig. 3C.

Based on the analysis of the concept and the literature, we can roughly categorize regional resilience into three stages: evaluation, resilience, and recovery. Through improving regional resilience, following the right resilience process, and promoting resilience in recovery, we could build a more resilient regional system.

2. The area of resilient fields

Corresponding with regional vulnerability, regional resilience is the comprehensive measurement of human society (Bohle, Downing, & Watts, 1994; Maguire and Hagan, 2007; Qi and Wei, 2010). Recently, researchers have made great progress in multi-fields of regional resilience, which is exemplified in the following four branches: engineering resilience, economic resilience, ecological resilience and social resilience.

2.1. Engineering resilience

According to Holling, engineering resilience, which is a potential growth path for 'bouncing back', reflects the physical property of impact resistance and the speed of recovery to the original state (Crespo, Suire, & Vicente, 2013), similar to the so-called 'swing mode' (Kim and Nelson, 1999), which focuses on an assumed steady-state and emphasizes the ability of recovering from exter-

nal impact (Berkes and Folke, 1998; Folke, 2006; Pimm, 1984; Qi and Wei, 2010; Walker and Salt, 2012; Yan et al., 2012).

Engineering resilience, in the perspective of disaster prevention and post-disaster recovery, emphasizes the fast recovery of urban infrastructure, urban population and community from natural and artificial disasters, as well as the adjustability of engineering construction and urban land utilization (Cai et al., 2012; Juan, 2013; Xiaohui, 2012). This includes topics like evaluating the resilience of urban infrastructure (Allenby and Fink, 2005; Cai et al., 2012; McDaniels, Chang, Cole, Mikawoz, & Longstaff, 2008), utilizing disaster prevention and reduction technologies to enhance urban infrastructure so as to ensure its normal operation in the global economy (Allenby and Fink, 2005; Cai et al., 2012; McDaniels et al., 2008).

Earthquake engineering research has put forward the framework of resilience with the focus on urban infrastructure, which emphasizes sturdiness (Under a certain level of pressure, the system keeps oneself's circumstance, not degradation and loss of function in the presence of vibration) and speed (the abilities of a system to reduce losses and avoid future disorders in the shortest possible time) in resilience(Alberti et al., 2007; Cai et al., 2012; McDaniels et al., 2008). Based on this framework, Bruneau et al. introduced the concepts of redundancy and the adjustability (Bruneau et al., 2003).

Several countries have acknowledged that enhancing the infrastructure is an important measure to strengthen the regional engineering resilience. Furthermore, they have proposed coping styles in the perspective of academic research, engineering practice and policy practice. In the suburban areas of America, the National Organization Committee of Regional Development has declared that infrastructure construction can be helpful to solve the problems of resource allocation and overcome the weaknesses. It is thought of as a smart move for the state to invest in regulating and protecting regional structure (Dabson et al., 2012). China, for instance, has proposed 'resilient' planning model to implement the idea of urban-rural integration of green infrastructure network, which is suitable for the transformation of the land property. By assessing the factors, the model determines the classification and

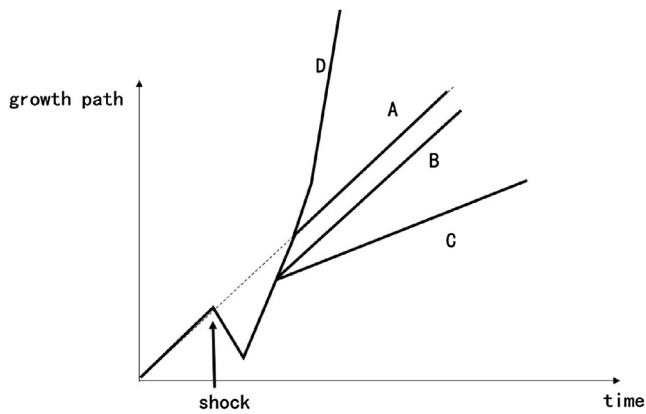


Fig. 4. Different reactions by regional economy after-shock.

sort the regional land, where high level means high resilience. When the lands for construction are adequate, the highly resilient land can be used as a buffer, and when the demand for land is intense, it can be converted to other purposes.

The characteristics of engineering, such as diversity of engineering systems, multi-scale networks, versatility, modularity, and adaptive design (Ahern, 2011; Juan, 2013) determine that the planning and design approach should be 'resilient' to adapt to different needs of development. That is to break the traditional idea of 'toughness' projects with resilient tools and strategies to promote the resilient development of the whole region.

2.2. Economic resilience

In the new economy era, with all kinds of external shocks, such as the 2008 financial crisis, researchers are driven to pay more attention to the issue of regional economic resilience (Boschma, 2015; Carpenter, Walker, Anderies, & Abel, 2001; Christopherson et al., 2010; Hudson, 2009; Martin, Sunley, & Tyler, 2015; Salvati, Carlucci, Venanzoni, & Chelleri, 2015; Simmie and Martin, 2010; Yan, Chuanglin, & Qiang, 2013).

Regional economic resilience originated in the post-crisis era, which is a new issue under discussion proposed by Western researchers to address issues of regional economic recovery and sustainable development. It is a coupled system that contains self-organization and artificial organization processes. This system is usually connected to regional policies, management, planning, etc. (Xiaohui, 2012). From the perspective of policy management, some researchers have stated that the degree of regional economic resilience depends on the development strategies, socioeconomic characteristics and the diversity of economic structures (Dabson et al., 2012), whose resilience can be impacted by human interference, such as pre-planning, policy guidance and strategic management.

According to its development path in the recovery process, a regional economy could be divided into four categories: a. Resuming the original (pre-shock) development path at the original growth rate (as shown in Fig. 4a); b. Restoring the original growth rate, but with a lower level of development at the regional level (as shown in Fig. 4b); c. Failing to return to the original path and remaining in a downswing due to severe impact (as shown in Fig. 4c); d. Not only returning to the original status but achieving a higher level of development (as shown in Fig. 6d).

After the explosion of external shocks, due to the change in time and space, local or regional economy usually could not be fully restored to its original state and development trajectory (Martin, 2010, 2012; Martin and Sunley, 2006; Simmie and Martin, 2010), which means that the first development path (Fig. 6(a)) is not a

common pattern. Numerous scholars have dedicated themselves to research on 'lock-out' processes, as shown in Fig. 6(d) (Crespo et al., 2013; David, 2007; Xiaohui, 2012) and 'lock-in' processes, as shown in Fig. 6(c) (Crespo et al., 2013; David, 2007; Xiaohui, 2012). In the former (lock-out), the economy can withstand and digest external shocks, and consequently, resume the road to adaptive development. On the other hand, the latter (lock-in) indicates a failure for the economy to adapt to new changes and gradually head towards recession. There are several approaches to break the 'lock-in' state (Harrison, 2015; Hassink, 2010; Martin, 2010; Pike et al., 2010). A considerable number of studies and examples (Martin, 2010; Xiaohui, 2012) have proved that maintaining path independence, path creation, policy support and economic diversity may be the most important factors to shape the regional economic disparities, of which the diversity can be divided into several categories whose most effective one is to break regional economic locking-in.

- (1) Economic structural diversity: structural diversity could help to prevent regional locking-in caused by a single industrial structure, reduce the destructive power of regional economy crisis and facilitate the rapid recovery of the regional economy (Martin, 2010).
- (2) Economic typological diversity: areas characterized by diversity show more resilience than specialized areas. A diversified area can enable the transfer and dispersion of external shocks into different directions and contribute to regional economic recovery and adaptation (Dawley et al., 2010; Xiaohui, 2012).
- (3) The economics of implementing diversity: Even at the 'lock-out' stage, economic growth alone does not bring full optimization to the regional resilience. The rapid transformation of economic implementation is more important. Implementations such as adjusting the economic structure, strengthening scientific and technological innovation, rational development of ecological resources and environmental protection can effectively improve regional resilience.

The resilient process was first proposed by Holling and applied to many fields, including economy resilience (Holling, 1973; Qi and Wei, 2010; Xiaohui, 2012). The process has two adaptive cycles (Fig. 6). One represents the process that the regional economy will experience: an emergence phase (restructuring) – development phase (opening) – maintenance phase (maintaining)-cycle, crescendo. The other shows a rigidifying phase (maintaining)-declining phase (releasing) – restructuring phase (recombining)-process, namely the recession or transition process (Simmie and Martin, 2010).

Some researchers pointed out that resistance is the ability that regional resilience resists crises from the interior, while the restoring force is the ability to recover from crisis and creativity is the capacity to adapt to new external situations and a new environment (Adger, 2000; Qi and Wei, 2010).

Accordingly, the regional economic development is not only influenced by industrial structure, economic types and implementations, but also it is the outcome of policy management and allocation.

2.3. Ecological resilience

Confronted with global climate change, resource depletion, and environmental quality recession, the ecosystem is no longer able to cope with various challenges through self-recovery. Thus, ecological resilience is particularly important and urgent, which can further be classified into two categories: (1) The single equilibrium or static equilibrium that holds the ecosystem, absolutely and stably resilient (Xiuqi and Peihong, 2008). It absorbs interference before reaching dynamic equilibrium and emphasizes on the

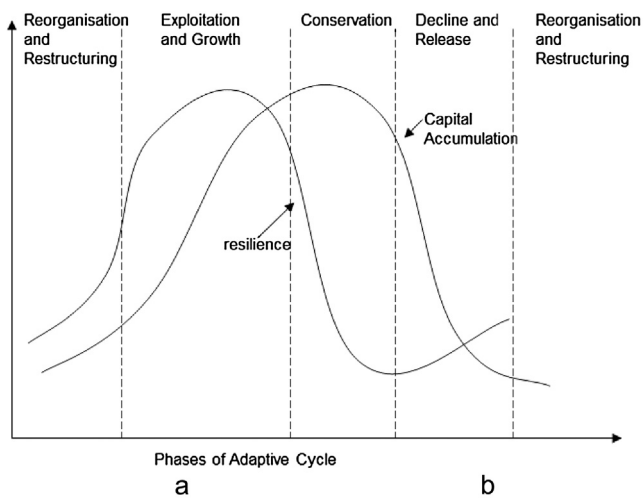


Fig. 5. Resilience as a process: variations in resilience across the adaptive cycle. Source: (Simmie and Martin, 2010)

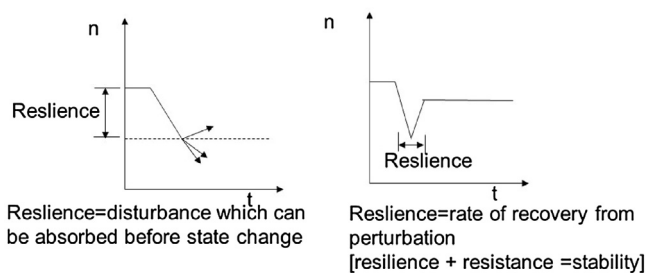


Fig. 6. Ecological Resilience.

Source: (Adger, 2000). There is no precise definition of resilience. Two alternatives appear to be: (a) the disturbance which can be absorbed before the dynamic equilibrium is change completely (according to Holling) and (b) the rate of recovery from a disturbance.

process of returning to normalcy (Berkes and Folke, 1998; Folke, 2006) without changing its original functions (Adger, 2000; Xiuqi and Peihong, 2008), as shown in Fig. 5(a). (2) The steady-state or multi-domain of attraction stresses that ecological resilience is the ability of ecosystems to consistently update, restructure and continuously develop with acceptable speed of recovery (Adger, 2000; Folke, 2006; Qiu, Tong, & Jiang, 2011; Shijun, Yongchao, & Zhangxian, 2010; Xiuqi and Peihong, 2008; Yan et al., 2012), as shown in Fig. 5(b).

Through the use of adaptation circulation, ecological researchers identified factors influencing regional evolution: (1) the potential value, (2) correlation and (3) resilience. These factors soundly explain the resilient ecological system resulting both from internal and external forces. Each stage of the cycle requires a comprehensive judgment on the degree of resilience and the vulnerability of a system (Pendall et al., 2009) towards surprise attacks, system pressure and shocks.

Ecosystems vulnerability is affected by multi-factors. Due to the complexity, the process of *single-equilibrium* and *multi-equilibrium* should be taken into consideration (Berkes and Folke, 1998; Folke, 2006; Gunderson and Holling, 2002). Any shock will affect the ecosystem to go beyond the 'rebound threshold' and into another trajectory. In this situation, the system can hardly be restored to its original state, thus resulting in a lower level of development for a long time (Holling, 1973; Xiaohui, 2012). On the other hand, the system can go beyond its original level by reorganizing the system structure into a better state of development (Simmie and Martin, 2010).

2.4. Social resilience

Social resilience mainly emphasizes the ability of government-centered institutions and agencies to respond to and offset crises in economic, political, ecological and social aspects (Cho, Willis, & Stewart-Weeks, 2011). Social resilience includes the ability to (1) bounce back: to recover from the destruction caused by the last shock, emergencies and catastrophes and restore the original state; (2) bounce forward: to anticipate, prevent and prepare for the bad effect brought by the next shock (Cho et al., 2011). The social resilient shocks are mostly invisible or intangible shocks, such as policy changes in developing countries, economic changes affected by financial crises, demographic changes characterized by an aging population and unbalanced population mobility, environmental changes under a wide range of population pressure, agriculture and water resources depletion, as well as the technological transformation that is gradually changing the traditional way of life (Mazur, 2013).

Social resilience can be considered as the guarantee of regional resilience, while the governmental institutions can maintain and develop the resilience in other aspects by resilience management and policy making. Government actions and decision-making are the main factors affecting social resilience. The government and relevant departments should strive to enhance social productivity (doing things better) and creativity (doing better things) to ensure sufficient resilience (Cho et al., 2011), as shown in Table 3.

Researchers have put forward the social resilience-center-periphery model (Crespo et al., 2013), in which official institutions and government organizations play the role of 'center' and common citizens, as well as other distributed organizations, act as the 'periphery'. The concept of resilience thereof will be implied to build a new transition model of center-periphery, whereby a new dialogue between the central area and the periphery area is established (Cho et al., 2011).

Within the regional scale, the concept of "network connection" is used to construct a regional resilience space structure to illustrate the relationship between nodes and ties. Three typical topological structures could be constructed, namely the random network model, the core/periphery model and the center—periphery model (Table 4).

Given regional development, the region with high resilience could merge the affluent suburbs around it to relieve the unbalance between central urban areas and suburban areas (Mazur, 2013). To establish an overall 'regional network' defined with nodes and ties, and build an utmost efficient resilient region network, with minimum nodes and the most effective connections (Crespo et al., 2013).

3. The practice of regional resilience




The regional resilience has become an important issue of national and regional development. For instance, the 2013 APEC Informal APEC Economic Leaders' Meetings and the 2013 Winter Davos Forum have conducted heated debates revolving around the topic of resilience and regional resilience. Currently, academic circles of international urban and regional planning, in the United States (US), Britain (UK), Germany, France and other countries have already established research institutions and groups relevant to regional resilience, which have carried out extensive research on regional resilience, including economic, social, environmental, traffic and all other related aspects. In China, regional resilience, resilient city, and resilient planning have attracted increasing attention from the urban and regional planning workers and researchers. For example, both the 2013 IACP and 2012 forum of the college of architecture and landscape architecture at

Table 3
Basic behavior of social resilience through making strategies.

Behavior	Goal	Outcome
Policy makers re-comprehend the definition of resilience and focus on the resilient growth of administrative institutions in a new way. Set up corresponding resilience organizations and institutions	Building resilience consciousness by decision-making. Urging people to consider what communities, cities, and regions they need	Promoting the basic resilient characteristics of policies Building safe, guaranteed communities, enhancing multi-public participation and strengthening the elderly welfare, young people's work, and health protection.
Public policy-making departments and institutions have become more resilient	Those public departments and institutions undertaking their responsibilities centered on social and economic productivity in different ways and gradually developing into better innovation model to strengthen the sense of reform	The public welfare and security will depend on the ability of public sectors to conduct response, adjustment, and development. That is, increasing assets, improving infrastructure and innovating working procedures, with minimal waste and cost, to push forward the reform.
The behavior of public policy-making department and institutions	Urging public sectors to realize the importance of citizens' benefits and rights fundamentally.	Promote the perfect combination of society, citizens, and government, to achieve a perspective equilibrium (Folke, 2006)

Source: Base on Cho et al. and Mazur (Cho et al., 2011; Mazur, 2013).

Table 4
Resilient property model and their advantages and disadvantages.

Name of Model	Pattern of Model	Advantage	Disadvantage
Random network		High resilience with uncontrollable resilience process and unpredictable resilience.	Causing instability of regional space; difficult to regulate the development tendency of space in the absence of the core, namely the situation of nodes and ties will be altered randomly, which will lead to an impossibility to forecast the spatial development trend.
Core/periphery network		Aiming at promoting integration cohesion, the network has a center of strong clustering with intensive resilience.	The centered framework weakens the expanding ability and resilience of the network. Moreover, the rupture of network after-shock is irreparable, poorly resilient.
Core-periphery network		With Strong resilience, and diverse and stability resilient process, this network is an ideal resilient model.	The establishment of the network is difficult since it is hard to achieve an equilibrium between the degree and the level.

Source: (Crespo et al., 2013).

Peking University set resilience as the theme of the seminars. As we always search for the spatial problems, we classified the practice of regional resilience into 3 parts, namely spatial research, spatial planning and spatial governing.

3.1. Spatial research on regional resilience

In the past five years, under the guidance of the regional resilience concept, represented by the US and the UK, many countries have conducted case studies (Foster, 2010; Swanstrom, 2008; Pendall et al., 2009; Hill et al., 2008). In the US, led by the University of California, Berkeley, many universities and research institutes jointly set up the Building Resilient Regions Research Network,

which aims at conducting a qualitative and quantitative policy analysis of regional resilience in the metropolis. Different researchers, such as Foster, Swanstrom, Pendall, Hill, Reckhow, Weir, etc., conducted research at different scales and comparisons (Foster, 2010) involving metropolitan areas, as summarized in Table 5.

Regarding the practice of regional resilience planning, the central part of the Minnesota regional planning model is the typical representative. The model aims creating the regional resilience, covering 11 themes, including economic, social, cultural, infrastructure, ecological and other aspects, and begins the public participation in planning. Case studies in the UK are mainly conducted by university researchers, who target the urban areas, such as Cambridge, Swansea and North-East England (Capello et al.,

Table 5
Case Studies on Different Problems Abroad.

Person	Content	Object
Swanstrom	Housing foreclosures	Six metro-case studies Atlanta, Chicago, Cleveland, St. Louis, Oakland, Riverside
Mollenkopf and Pastor	Immigration influx	Six metro-case studies Charlotte, Chicago, Los Angeles, New York, Phoenix, San Jose
Pedal et al.	Fast growth	Four metro case studies Boston, Cleveland, Denver, Miami
Hell et al.	Economic downturn	361 metro aggregate analysis plus Six metro-case studies Charlotte, Cleveland, Detroit, Grand Forks, Hartford, Seattle
Reckhow and Weir	Suburbanization of Poverty	Four metro-case studies Atlanta, Chicago, Denver, Detroit
Foster	Problems overall	Case studies on 100 large metro regions

Source: (Foster, 2010).

2015; Dawley et al., 2010; Martin, 2012; Simmie and Martin, 2010; Williams et al., 2013). Recent studies have started to move to the quantitative analysis of the data. In addition, a small number of studies are found in Eurasia, such as in Germany, Italy and Hong Kong, etc. (Frommer, 2011; Raco and Street, 2012; Wilbanks, 2008).

3.2. Spatial planning on regional resilience

Nowadays, there is a blockbuster increase in the contents of the practical method of regional resilience planning, which can be divided into two aspects:

- Using stereoplasm, namely engineering measures, policy means and economic means to strengthen the basic properties of regional resilience. Researchers in Germany have put forward the 'hard location factors' according to their national conditions, including service centers, educational and research institutions, transportation, municipal infrastructure and other elements whose configuration shall be settled by traditional space planning under the guidance of the general idea of balanced development (Xiao, 2014). In general, the above-mentioned means will gradually reach a new balance with the development of the economy and the stabilization and nature of the society. Summing up, it is not the long-term means of enhancing regional resilience.
- By soft means, namely ecological means, some economic means, social service and other ways to strengthen the resilient capacity of the region. Soft location factors include high-quality living environment, outdoor sports and leisure opportunities, green ecological environment, multi-cultural atmosphere, high quality artificial and natural resources, etc. (Xiao, 2014). To some extent, soft location factors would promote the beneficial cycle and are the key to the improvement of regional resilience.

Saxenian established the basic characteristic information of regional resilience through the study of the Silicon Valley Industrial Area. On one hand, the formation of resilience needs central urban areas, which are of historical basis, and has a strong hierarchy and business scale, namely the so-called hard foundation (Crespo et al., 2013; Xiao, 2014). On the other hand, the region needs to maintain the capacity of contacting with the outside world and developing the external rental (Crespo et al., 2013). At the same time, it should avoid the herd behavior mechanism and enhance the peripheral contact, namely, forming the regional resilience through a soft contact or force. Currently, the soft power among agglomerations and regions is believed to be maintained by the ecological media. Based upon such idea, the concept of 'Regional Park' arises, a special park area, different from a traditional landscape place. It covers

a single administrative boundaries within (such as a province, city or county) or across administrative boundaries (Xiao, 2014; Yan, 2009), which is a kind of soft location factors to enhance the competitiveness of an urban area. The park is also a kind of regional government tool aimed at the landscape and open space.

3.3. Spatial governing on regional resilience

On the traditional study and practice of resilience planning, strategies for the region proposal under specific conditions are developed. In recent years, the American Economic Institutions of Shoreline Committee has proposed resilient planning and has started the discussion about the planning of coastal areas of San Francisco (Crespo et al., 2013). Taking all factors into consideration, they proposed the comprehensive planning for regional resilience (shown in Table 6). Research and practice of regional resilience are on the rise globally. Practice cases are transitioning from strengthening the hard foundation to the means of increasing the soft ways to promote the regional resilience.

4. The prospect

Despite the progress, more research is needed in the field of regional resilience, particularly from the following three aspects. First, the definition and the content need to be clarified to give the multidimensional nature of the concept. Second, a general approach and framework to evaluate resilience need to be developed. Third, innovative means need to be explored to support the practice of resilience further.

4.1. Clear the definition and content of regional resilience

(1) The concept of regional resilience has not yet achieved a unified understanding. As an idea, the intension and extension of the regional resilience are not clear. Clearing and defining the basic theoretical concept provide the premises of regional resilience research. First of all, we should define the basic concepts and characteristics of regional resilience and clarify the requirements and objectives. Second, for the internal study the boundary, elements, and content of engineering, economic, social and ecological resilience need to be defined and the complex interdisciplinary relationships need to be further analyzed. Regarding the resilience period, it needs to strengthen the process of resilience and the study of mechanism.

Table 6
regional resilience planning thinking steps.

Process	Action	Institution
The first phase	Clarifying regional geoFigy, culture, and ecological background, and conduct researches mainly on rising sea levels and related regional problems existing and are going to face	The government and the public management
The second phase	Collecting the information of the population, infrastructure construction, ecological system, agricultural and economic data mainly under the background of rising sea levels.	University researchers, experts, and institutions of public affairs
The third phase	Based on the research and information collection, focusing on two aspects of mitigation and adaptation, and paying attention to special circumstances and details	The government and non-governmental groups and the public
The fourth phase	Implementing the process of planning, including the participation of governmental and non-governmental groups to formulate the planning, the implementation strategy, and the discussion thereof.	The government and non-governmental groups and the public

Source: Base on Crespo (Crespo et al., 2013).

4.2. Explore the method of regional evaluation

The assessment of regional resilience is still in the stage of exploration. The recognition of regional resilience, namely the evaluation resilience remains one of the most important components to guide regional development, which is the foundation to further determine regional resilient objects and optimizing resilient development. When viewed from three different angles, specifically properties, procedure and abilities, for different fields, such as engineering, economy, ecology, society, etc., regional resilience will consequently lead to the establishment of diversified methods. The existing research mainly includes the qualitative method, economic, geographic model, economic cycle model, analysis of multi-level index weighted, etc. Deepening of the study on the quantitative method of regional resilience is necessary and should be combined with the existing qualitative analysis approaches. In particular, quantitative research should be developed in the following aspects: multi-application to the assessment of regional resilience, and analyzing and evaluating the capacity and efficiency of these methods themselves. Not only evaluating the current situation but also investigating spatiotemporal differences and resilience conditions under future conditions.

4.3. Strengthen the theory and practice of regional resilience

The application of the theory to practice still lacks an effective way to transformation. The concept of regional resilience is of great significance for the study of all aspects of space research, planning and management. However, how to put this idea into practice remains still unknown. Currently, research and practice are equally important and should be developed simultaneously. Different countries and regions have different requirements for their target, the core problem of resilience. One of the main purposes of regional resilience is to lead regional development through identification of goals and development of effective instructions. Performing the classification of theory and practice is of positive significance in this process. For instance, we can combine the regional situation, selectively analyze the problems, such as population, resources, environmental pollution and a fragile economy in the course of developing and carrying out the research on regional resilience classification and practical application.

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