REFRAMING REGIONAL ECONOMIC RESILIENCE FOR COOPERATIVE REGION (1117)

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Abstract. The impact of socio-natural disasters and the process of coping with them vary across regions, primarily due to disparities in their socio-economic structures. This study aims to develop a regional economic resilience model capable of capturing the impact of different socio-natural disasters and the adaptive capacity of regional economies. We analyse regional economic resilience through two complementary dimensions: local residents and local firms. We employ both indicator-based static frameworks and sequence-based dynamic frameworks. By examining the cases of the 2007 financial crisis and the 2018 heat wave, we find that metropolitan cities and provinces in Korea share common characteristics of low resistance to shocks but exhibit rapid rebound. However, the level of adaptive resilience in the short and long term varies across regions. This study contribute to the policy-making process by providing an easily applicable economic resilience model that incorporates considerations of local adaptive resilience.

Keywords: Regional Economic Resilience, Socio-natural Shock, Resilience Framework, Regional Planning.

1. Introduction

Shocks are increasing in frequency and impact. According to the World Economic Forum's report, natural disasters are becoming more intense and more frequent in the last five years due to unprecedented extreme weather events caused by climate change. In addition, downward pressure on the global economy from macroeconomic fragilities and financial inequality is growing, and the 2007 global financial crisis has led to growing uncertainty about the effectiveness of countercyclical policies (World Economic Forum, 2020). Outbreaks of infectious diseases such as COVID-19 and MERS affect not only human lives, but also local economies and the local businesses that make them up (Lee et al., 2022).

This diversity of shocks has led to a growing body of research noting that local impacts vary according to the social, economic, and cultural structures and characteristics of communities (Martin et al., 2016; Kim, 2021; Oliver-Smith, 2022). In this context, local resilience is gaining traction as a concept that encompasses not only the impact of shocks that vary across regions, but also resistance to shocks and subsequent recovery and adaptation processes (Simmie and Martin, 2010; Martin, 2012; Sánchez-Zamora et al., 2014). Resilience is differentiated from the concept of vulnerability, which focuses on the short-term effects of shocks, in that it takes a more long-term perspective and provides implications for the region's long-term policy direction (Wolman et al., 2017). It also has links to research in the area of regional disparities in that disparities between regional economies lead to disparities in regional responses to shocks (Martin et al., 2016; Le Gallo and Fingleton, 2021). Thus, in contrast to the past focus on identifying regional differences per se, recent trends have focused on the role that resilience plays in regional economies (Simmie and Martin, 2010; Sánchez-Zamora et al., 2014).

The purpose of this study is to construct a framework for measuring the economic resilience of regions to various shocks in a multifaceted way, and to use it to examine regional responses to shocks. Regional economic resilience, as discussed in this study, is the economic dimension of a region's ability to anticipate, prepare for, respond to, and recover from a disturbance (Foster, 2007). In order to consider the impact of various socio-natural disasters on the local economy, resilience is multifaceted through multiple variables, and it is differentiated in that it is analysed not only statically but also dynamically. By providing an easy-to-apply economic resilience model, we aim to solve the problem of applying engineering resilience and contribute to policy processes that consider regional adaptive resilience.

We proceed as follows. First, we review the literature on resilience. We then present the data and methods used to build our resilience framework. We consolidate the discussion in the literature by separating the economic resilience of a region into the dimensions of residents and regional firms. We then present a method to capture the economic resilience of a region in dynamic terms as well as static resilience based on an index.

2. Literature Review

2.1. Concepts and Definitions of Resilience

Resilience began to be discussed in earnest after Hurricane Katrina (2005) destroyed New Orleans and displaced survivors to other regions (Lang and Danielsen, 2006). The concept of resilience has been discussed in many different fields. One of the strengths of resilience research is its interdisciplinary nature, especially when it comes to observing the recovery process as well as the impact of a major problem or event. For example, Martin and Gardiner (2019) estimate the shocks and resilience of the UK subregional economy in 2016, when the UK was debating leaving the euro (Brexit). More recently, research has also focused on individual and community resilience in the wake of the COVID-19 pandemic and individual psychological resistance to the Russian invasion of Ukraine (Blanc et al., 2021; Angeler et al., 2022; Fransen et al., 2022; Riepenhausen et al., 2022).

Therefore, resilience is a concept that is gaining traction in many fields and is regarded as an ideal goal for systems. More specifically, resilience discussed in the context of local economies consists of both engineering and ecological dimensions. First, engineering resilience assumes that there is a single equilibrium in the local economic system and focuses on whether it can return to its previous equilibrium after a shock (Pendall et al., 2010). From this perspective, the main topic is the resistance of the system to withstand the shock and the speed of return to the previous state (Martin, 2012). It is understood in terms of the plucking model proposed by M. Friedman (Friedman, 1993): the intensity of the downturn leads to the intensity of the recovery, but the intensity of the recovery does not lead to the intensity of the downturn, and the shock is a temporary phenomenon that does not change the long-term growth path of the region, which returns to its previous state over time (Fingleton et al., 2012).

Ecological resilience is considered a traditional resilience alongside engineering resilience, but there is a clear distinction between the two. From an ecological perspective, a shocked local economy is viewed as one or more multi-equilibrium systems that can return to their previous state, but either get worse or get better (Pendall et al., 2010). The difference is that the recovery process of a system after a shock is considered as a return to a new equilibrium, rather than simply a return to the previous equilibrium. The measure of resilience is not the time or speed of recovery after a shock, but rather the magnitude of the shock that forces structural change in the system, and the greater the magnitude of the shock required for change, the more resilient the economic system (Simmie and Martin, 2010). Martin (2012) borrows the concept of hysteresis, often used in psychology, to suggest that the impact of a shock that causes structural transformation in a local economy affects the region's growth path over a long period of time, not just in the short term.

Traditional resilience is also characterised by the following features. The disaster and psychology literature on traditional resilience shares a systematic approach to the internal and external factors that cause systems to change, a long-term perspective, and the assumption that equilibrium states are path-dependent, shaped over time by cumulative decision-making processes (Pendall et al., 2010). In addition, traditional resilience research tends to view human societies in terms of natural systems. For example, just as an ecosystem composed of a few dominant species is vulnerable to wind and water damage, the idea is that as market economies become more sophisticated, capital is concentrated in certain places and industries become monopolised, the diversity of the system is lost, competition is eliminated, resilience is reduced and the system becomes vulnerable to external shocks. When this happens, the system is unlikely to return to its previous state, according to the traditional explanation of resilience.

However, the study of local economies based on the traditional concept of resilience, especially engineering resilience, has several limitations. The first is the point about equilibrium. As noted above, engineering resilience studies assume a prior state of equilibrium in the real world and identify the time and speed at which it is reached after a shock. As Martin (2010) points out, local economies cannot be 'locked' into a stable, static equilibrium state; they are subject to gradual and continuous change, rendering the analysis of reaching a prior state meaningless. It has also been suggested that the failure to return to equilibrium is more frequent and common after deindustrialisation (Cowell, 2013). With this in mind, ecological resilience, with its potential for change, can be seen as a concept that reflects the reality of local economies, rather than engineering resilience, which is a static concept.

2.2. Learnings from previous research

The following are the findings from previous studies on resilience. First, at a conceptual level, the definition of resilience needs to be clarified. Resilience is an interdisciplinary concept and while its meaning varies across disciplines, the concept remains ambiguous (Martin, 2012). Therefore, a more sophisticated conceptualisation is needed. In particular, there is a need to focus on specific dimensions of resilience rather than considering all the broad conceptual dimensions it encompasses (Kaye-Blake et al., 2019), such as economic or social resilience.

Second, at a practical level, it is important to note that resilience is often a theoretical and clichéd phrase that is difficult to apply in practice. A study of the use of the concept of resilience found that while resilience in planning is widely discussed as a normative concept, including climate, terrorism, disaster, and economic and regional decline, it remains a vague concept for practitioners (White and O'Hare, 2014). This leads practitioners to focus on easily measurable engineering resilience, which limits their ability to address resilience in its true sense. They warn that the pursuit of engineering resilience, which focuses on overcoming short-term shocks, rather than ecological or evolutionary resilience, which focuses on overcoming existing systemic practices and new institutional changes, may contribute to the reproduction of existing neoliberal growth-oriented planning practices. Thus, the concept of resilience at the planning levels remains theoretical and lacks applicability and practicality (Collier et al., 2013).

Third, as social and natural disasters emerge and economic disparities between regions widen, so does the disparity in resilience. In the past, disasters were often considered as natural phenomena, but recent research suggests that disasters are the result of the interaction between a destructive agent (such as an earthquake, tsunami, hurricane, flood) and the socio-cultural and environmental context on which it impacts (Cannizzaro et al., 2020). More recently, as a disaster, the COVID-19 pandemic demonstrates that even the same disaster can have different impacts depending on the economic values, priorities, structures and practices of countries, societies and regions (Oliver-Smith, 2022). In particular, Korea has experienced a rapid increase in regional disparities since its rapid economic growth in the 1980s (Moon, 2003), and the different regional environments combined with the increase in socio-natural disasters have led to regional inequality (Jeong and Yoon, 2018; Kang and Skidmore, 2018; Kim and Yoon, 2020). Therefore, it is necessary to reflect the reality that while the scope of socio-natural disasters is expanding, regional inequality is emerging due to the expansion of regional disparities.

3. Data and Methods

The process of this study is illustrated in Figure 1. First, we construct the dimensions of resident and regional firm to conceptualise and operationalise regional economic resilience. The dimension of residents is divided into population and employment, which are measured by the variables total population and working-age population, and total employee and regular employee, respectively. The dimension of regional firm is identified through the profitability of the region, which is measured through gross operating surplus and productivity of capital.

The framework for analysing this consists of a static and dynamic resilience framework. Static resilience is determined through an index-based approach, with the result being whether the region is resilient for each year. Dynamic resilience is captured through a sequence-based approach. This involves assuming a specific shock and dividing the sequence into before, during, and after the shock. Dynamic resilience is then determined by looking at the growth direction and growth rate of the region in each sequence.

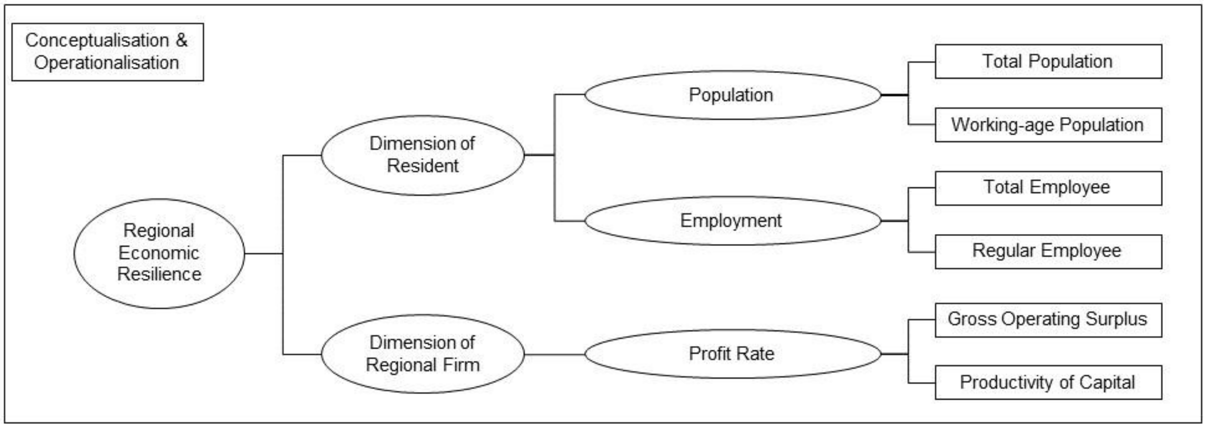

Figure 144. Framework of Study

3.1. Data

The spatial units and periods of analysis used in this study are as follows: metropolitan cities and provinces, 2000-2020. The reason for this choice of spatial and temporal units is to measure the multidimensional resilience of regions at a longer time span. In addition, using a smaller spatial scale would have resulted in many areas with zero values, such as heat wave mortality, making resilience sensitive, so we conducted our analysis at the regional level. Three sources were used to organise the data for the analysis. First, to analyse the resilience of the population at the regional level, we used the Population Statistics Based on Resident Registration (1992–2022) provided by the Ministry of the Interior and Safety. From this data, we collected the total population for each spatial unit and the working age population, i.e. the population aged 15–64.

Next, we used the Census on Establishments (1993–2021) provided by Statistics Korea to analyse regional employment resilience . From this data, we calculated the total number of employees for each spatial unit and the number of regular employees, which refers to relatively high-quality employment with a labour contract of more than one year.

Third, we used the Regional Income (2000–2021) to analyse resilience at the level of regional firms. From this data, we collected gross operating surplus and compensation of employees for each spatial unit and summed them to derive national income at factor cost. We also collected gross fixed capital formation to measure the capital stock of the region.

Finally, the impact of heat waves by region derives from the Causes of Death Statistics (2000–2021). This data is collected for all deaths in the country and is highly reliable as it is based on accurate diagnoses from medical institutions. From this data, we applied the International Classification of Diseases, Tenth Revision (ICD-10) code for heat-related deaths from the US Centers for Disease Control and Prevention (CDC) to derive heat wave mortality, which corresponds to ICD-10 codes X30 (exposure to excessive natural heat) or T67 (effects of heat and light) (Vaidyanathan et al., 2020).

3.2. Measuring Resilience Index

The regional economic resilience framework used in this study consists of an index-based approach to derive resilience at each point in time, and a sequence-based approach that allows for dynamic analysis over multiple time periods. The index-based approach consists of two dimensions: residents and regional firms.

First, the resilience index at the resident level is derived from two variables: population and employment. Population consists of total population and working-age population, and employment consists of total employees and regular employees. Employment represents the performance of the regional labour market, and the impact of shocks is primary and more pronounced in the labour market compared to output (Martin, 2012). It is also characterised by its sensitivity to short-term fluctuations at large spatial units, such as states or NUTS 2 level (Dubé and PolèSe, 2016). Population is a proxy for defining the robustness of labour market conditions and is suitable for application in rural areas, where the number of employees is too small to overestimate changes in resilience (Fantechi and Modica, 2022).

For the four variables, the resilience indicator uses a method that measures the adaptive capacity of a region to socio-natural disasters, and the resilience derived from this means the capacity to adapt to different socio-economic events in an adaptive aspect (Fantechi and Modica, 2022). Resilience is determined by comparing the average annual population growth rate over a five-year period before and after time t. If the later growth rate is higher, the region is considered resilient.

As the economic agents of a region, regional firms are an important factor in the composition of a region's resilience. To reflect this, we use a methodology in which the resilience of regional firms is derived from the growth of the region's profit rate (Navinés et al., 2022). Navinés et al. (2022) suggest that a firm-oriented approach is complementary to traditional employment performance-based approaches, as the long-term survival of firms and profit maximisation are related. They also show that a region is resilient if the growth of its profit rate is higher than the national rate.

Looking at their method in more detail, first, profit rate (r) is the ratio of gross operating surplus gross operating surplus (GOS) to net capital stock (K), i.e. $\mathrm{r} \equiv \frac{GOS}{K}$. regional income ($\mathrm{Y}$) consists of the sum of GOS and compensation of employees (W), as shown in equation (1) below.

$$\mathrm{Y} = \mathrm{GOS} + \mathrm{W} \quad (1)$$

r can be decomposed into the surplus share ($\mathrm{q} = \frac{GOS}{Y}$) and the productivity of capital ($\pi_{\mathrm{k}} = \frac{Y}{K}$). q is defined as the contribution of regional firm's GOS to Y and is a variable that shows the dynamics of income distribution. The productivity of capital is defined as is defined as Y produced per unit of K in the region, and is a variable representing the degree of technological change and innovation in the region. Under this relationship, r is defined as follows:

$$\mathrm{r} \equiv \frac{GOS}{K} \equiv \frac{GOS}{Y} \times \frac{Y}{K} \equiv \mathrm{q} \times \pi_{\mathrm{k}} \quad (2)$$

At this point, Navinés et al. (2022) note that an increase in q and π_{k} has different implications for the growth of r in a region. While an increase in π_{k} implies technological progress and increased utilisation of productive capacity, an increase in q implies a decrease in the share of labour income in constant regional income. Since the 1970s, the stagnation of labour incomes has led to an increase in household debt, resulting in a debt-led growth regime. Therefore, even if a region is resilient with high r growth relative to the nation, a region with a high share of q is unlikely to be resilient in the long run. We classify regions as super-resilient if the growth rate of r is higher than the national rate and the growth rate of growth rate π_{k} is higher than q, and as moderately-resilient if the growth rate of π_{k} is lower than q, and as moderately-resilient if the growth rate of π_{k} is lower than q.

3.3. Resilience framework for Dynamic Analysis

In this part, we describe a framework for taking a multidimensional view of regional economic resilience by extending it to a dynamic dimension. Such a framework aims to evaluate resilience metrics from a dynamic perspective to assess the ability of systems to prepare for and resist unexpected hazards, absorb their impacts, maintain desired functionality, and recover rapidly (Cheng et al., 2022). Dubé and Polése (2016) used a dual decomposition approach to estimate the economic resilience of a region by dividing the whole period into sequences.

They assume a socio-economic shock within the analysis period and divide the analysis period into pre-shock, shock and post-shock sequences for each indicator. Since the resilience of a region can yield different results depending on which time frame is applied (Dubé and PolèSe, 2016), we set the pre-shock period to the entire period before the shock, and the post-shock period to the short (3 years) and long (10 years) periods to examine the impact of the shock in different aspects.

In this study, we apply their dual decomposition approach to the previous resilience variables, which are presented in Table 1 (Dubé and PolèSe, 2016). Although we apply the same methodology as in the previous study, we distinguish between the short term (3 years) and the long term (10 years) in order to examine the results that vary according to the time span. Firstly, Approach 1 was labelled as 8 scenarios reflecting the direction of increase or decrease (i.e. arrows pointing upwards or downwards) over the period of each sequence.

Approach 2 is the assessment of resilience to changes in sequences, categorised as resistance, rebound and recuperation. Resistance means that there is no negative change in the metric in the year before the shock, rebound means that there is no negative change in the year before the shock, and recuperation means that the overall change during and after the shock is globally better than that recorded in the period before the shock (Dubé and PolèSe, 2016).

Table 1. A Dual Decomposition Approach

Approach 1: Direction of the sequence				
Scenario label	Time sequence			
	pre-shock	Shock	Post-shock	
			short term (3 years)	long term (10 years)
Resistance	↗	↗	↗ or ↗	
Resistance and Lagged Shock	↗	↗	↘ or ↘	
Standard Resilience	↗	↘	↗ or ↗	
Hard Hit, No Recovery	↗	↘	↘ or ↘	
Positive Jolt	↘	↗	↗ or ↗	
Counter Cyclical	↘	↗	↘ or ↘	
Turnaround	↘	↘	↗ or ↗	
Systematic Decline	↘	↘	↘ or ↘	
Approach 2: Growth or change of the sequence				
Resistance	$g_{shock}(Y) \geq g_{\text{pre}}(Y)$		-	
Rebound	-	$g_{post\_short}(Y) \geq g_{shock}(Y)$		-
Recuperation_short term	$g_{\text{shock}}(Y) + g_{post\_short}(Y) \geq g_{pre}(Y)$			-
Recuperation_long term	$g_{\text{shock}}(Y) + g_{post\_long}(Y) \geq g_{pre}(Y)$			

4. Findings

4.1. Resilience index for residents

The resilience of the resident dimension is divided into two components: population and employment. First, resilience on the population side is derived from the average annual population growth rate of the total population and the working age population over a five-year period. The resilience results for both variables are presented in Table 2. Firstly, we find that different regions have different resilient periods. The longest resilience periods were found in Jeollanam-do (10 years), Jeju-do and Gyeongsangbuk-do provinces (9 years), while Daejeon metropolitan city (1 year) and Gyeonggi-do province (2 years) had shorter resilience periods than the nation. In contrast to most of the regions that included the nationwide resilient period, Gyeonggi-do and Chungcheongnam-do provinces were not resilient in 2005–2008. Second, the results for the working-age population were almost identical to those for the total population, with the only difference being 2011 for Busan metropolitan city. These results suggest that fluctuations in the total population and the working-age population are highly correlated.

The resilience of the employment side is derived from the average annual population growth rate of total and regular employees over a five-year period. Firstly, the results for total employees and population resilience are broadly similar. The longest resilience periods were found in Jeollanam-do (10 years), Jeju-do (10 years) and Gyeongsangbuk-do provinces (9 years), while Daejeon metropolitan city (1 year) and Gyeonggi-do province (2 years) had shorter resilience periods than the nation. Unlike most of the regions that included the resilient period of the nation, Gyeonggi-do and Chungcheongnam-do provinces were not resilient in 2005-2008. The resilience results for total population and working-age population in terms of population and total employees in terms of employment are similar, indicating a high correlation between changes in these variables.

On the other hand, the resilience results for regular employees, which refers to the quality of employment, are significantly different. The longest period of resiliet was in Jeju-do Province (12 years) and, contrary to the previous results, Gyeongsangbuk-do Province does not have a very high level of resilience for regular employees. In particular, the whole country and all metropolitan cities have not been resilient since 2008, the year of the global financial crisis. Seoul has not been resilient since 2007, meaning that the effects of the global financial crisis were experienced more rapidly than in other regions. In Daejeon metropolitan city, the resilience period for total employees was only one year, while it improved to three years for regular employees. Moreover, metropolitan cities did not regain resilience after the financial crisis. Some provinces, however, were resilient until 2009 and 2010 after the financial crisis, and Jeju-do province remained resilient until 2014. In Gyeonggi-do Province, which has the largest concentration of workers in Korea, there was no period of resilience for regular employees.

Table 2. Resilience at the Residents dimension

region		population		employment	
		total pop	working age pop	total employee	regular employee
National		2005–2008	2005–2008	2005–2008	2003–2008
Metro-politan city	Seoul	2000–2007	2000–2007	2000–2006	2002–2007
	Busan	2004–2011	2004–2010	2004–2011	2004–2008
	Daegu	2005–2010	2005–2010	2005–2010	2005–2008
	Incheon	2003–2010	2003–2010	2003–2010	2003–2008
	Gwangju	2005–2008	2005–2008	2005–2009	2004–2008
	Daejeon	2008	2008	2008	2006–2008
	Ulsan	2006–2010	2006–2010	2006–2010	2005–2008
province	Gyeonggi	2015–2016	2015–2016	2015–2016	–
	Gangwon	2003–2010	2003–2010	2004–2010	2003–2010
	Chungbuk	2003–2008	2003–2008	2003–2008	2003–2009
	Chungnam	2001–2006 2013–2014	2001–2006 2013–2014	2001–2006 2013–2014	2001–2006 2013
	Jeonbuk	2003–2010	2003–2010	2004–2010	2003–2010
	Jeonnam	2003–2012	2003–2012	2003–2012	2003–2011
	Gyeongbuk	2003–2011	2003–2011	2003–2011	2003–2009
	Gyeongnam	2000–2001 2003–2008	2000–2001 2003–2008	2000–2001 2003–2008	2000–2008
	Jeju	2006–2014	2006–2014	2005–2014	2003–2014

4.2. Resilience index for regional firms

Next, we examine resilience at the regional firm level. This resilience is considered to be high if the profit rate, which can be decomposed into gross surplus and capital productivity, is higher for the region than for the national level. As this analysis is based on annual growth rates and covers data for 2000-2021, growth rates for the year 2000 are not calculated. In addition, unlike resilience at the resident level, national values are used for comparison with individual local values.

The results for resilience at the regional firm level are shown in Table 3. A cell marked with hyphen (-) indicates that the region was not resilient in that time period. Resilient regions are further categorised as super-resilient and moderately resilient, where the former is defined as having an absolute value of capital productivity growth greater than the absolute value of gross surplus share growth, and the latter is the opposite. Super-resilient regions are coloured darker green to distinguish them from moderately resilient regions.

For all 20 regions, annualised growth in the profit rate was higher than the national rate in about half of the time periods. Among metropolitan cities, the longest resilient periods were in Incheon and Gwangju, while Busan and Ulsan had the shortest periods of 9 years. Among the provinces, the longest period was 12 years in Gyeongsangbuk-do.

However, a closer look at the duration of the resilient periods reveals different findings. Incheon and Gwangju have the longest resilient periods, but their super-resilient periods are shorter than those of Seoul and Daejeon. These regions are more vulnerable to a decline in local purchasing power and aggregate consumption in a future downturn when the nationwide rate of profit declines, which could trigger an increase in local household debt and negatively affect the region's economic resilience in the future (Navinés et al., 2022). On the other hand, regions with a high proportion of super-resilient periods are those with high capital productivity, which implies technological progress and higher utilisation of productive capacity, and thus a greater capacity to withstand and recover from future downturns.

Table 3. Resilience at the Regional Firm dimension

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Seoul	M	-	S	S	-	S	S	S	-	S	S	-	-	-	-	-	S	-	M	-
Busan	-	-	-	-	M	S	-	M	S	-	M	-	S	M	-	-	-	-	M	S
Daegu	M	-	-	S	-	M	-	S	S	-	S	-	-	M	-	S	S	S	-	-

Incheon	S	-	-	-	M	M	M	S	-	S	M	S	M	M	-	-	S	-	M	-
Gwangju	S	-	-	-	M	-	S	-	S	S	M	M	-	M	S	S	S	-	M	-
Daejeon	S	-	-	S	-	S	-	S	-	-	S	S	-	S	-	-	S	M	M	-
Ulsan	-	-	-	-	S	M	-	M	S	M	-	-	-	-	M	M	-	-	S	S
Gyeonggi	-	S	-	S	-	-	-	-	-	M	-	M	S	-	M	-	M	M	-	M
Gangwon	S	-	-	-	S	M	-	S	-	-	M	-	-	M	M	-	S	S	-	-
Chungbuk	-	-	S	-	S	-	-	S	-	-	S	M	S	-	M	-	-	-	S	S
Chungnam	S	-	-	M	-	-	-	-	M	-	-	S	M	-	M	M	-	S	S	-
Jeonbuk	S	-	-	-	M	-	-	-	M	-	-	M	-	M	S	S	-	-	M	M
Jeonnam	S	-	-	-	M	M	-	-	S	-	-	-	S	S	M	S	-	-	-	M
Gyeongbuk	-	-	S	M	S	-	S	M	-	-	S	-	-	S	S	S	-	S	M	S
Gyeongnam	M	-	-	-	S	-	M	-	S	-	M	-	-	M	-	S	-	-	S	S
Jeju	-	-	-	-	S	S	-	S	-	-	M	-	M	S	-	-	S	S	S	S

Note: S: Super-resilient, M: Moderately-resilient

4.3. Dynamic Resilience – The Global Financial Crisis

While the previous index-based resilience results were for a single point in time, this chapter is about resilience over a period of time. Here we extend the dynamic dimension to look at the aftermath of a specific shock in a dynamic way. In this study, we choose the shocks of the 2007 global financial crisis. The dynamic resilience analysis methodology used in this study provides insights into the resilience of a region before, during and after a shock, regardless of the nature of the shock (Dubé and PolèSe, 2016).

First, we present the results of the dynamic resilience analysis for socio-economic disasters. The shock period is set from 2007, the beginning of the financial crisis, to 2009, taking into account the different end points for different regions. Tables 4, 5 and 6 show the results of applying the two approaches of Dubé and PolèSe (2016) to the resilience variables: total population, regular employees and profit rate (presented in Table 1). For approach 2, red means that each category of resilience corresponds to a positive growth rate, while blue means a negative growth rate. The darker the value, the closer it is to the minimum or maximum value.

Before looking at the results at regional level, we can see that the national trends show resilience for all four variables before, during and after the shock: total population and regular employees show an increasing trend in the three sequences, while the profit rate decreases before and after the shock and increases during the shock.

At the regional level, the results are as follows: In terms of population, 8 out of the 17 regions were resistant to the economic crisis (see Table 4). In terms of total population, Seoul showed a countercyclical response to the shock, while Busan and Jeollanam-do showed a systematic decline in population in all three periods. There are also differences between the short and long term, with Daegu, Jeollabuk-do and Gyeongsangbuk-do showing a turnaround in population growth in the three years after the shock, but a decline in the long term. In contrast, Chungcheongnam-do experienced a short-term decline in population but a long-term increase. More importantly, there is no standard recovery in terms of population. These results, combined with the different results for different lengths of the post-shock period, suggest that the mechanisms of population movement are not significantly affected by short-term shocks.

We can also see the results of the second approach to dynamic analysis. This allows us to examine the magnitude of change over time. This complements the first approach, which only looks at the direction of change. First, in terms of total population, all but two regions showed a recovery. This means that the population decline caused by the shock recovered quickly after the shock. In Incheon, Gwangju, Ulsan and Gyeonggi-do, resistance was found in Approach 1 but not in Approach 2. Among them, Incheon showed rebound and short- and long-term recuperation, but Ulsan and Gyeonggi-do did not correspond to any resilience category except rebound. Chuncheongnam-do was vulnerable to recession in the short term, but showed remarkable resilience in the long term.

Table 4. Dynamic resilience of the Total Population to the global financial crisis (2007–2009)

region	approach 1		approach 2			
	short-term (3 years)	long-term (10 years)	resistance	rebound	recuperation	
					short term	long term

National		Resistance	Resistance	-2.20%	1.11%	-0.06%	1.98%
Region	Seoul	Counter Cyclical	Counter Cyclical	1.30%	-0.28%	1.18%	-3.39%
	Busan	Systematic Decline	Systematic Decline	4.27%	1.11%	4.14%	0.62%
	Daegu	Turnarround	Systematic Decline	1.09%	0.78%	1.73%	-0.99%
	Incheon	Resistance	Resistance	-2.94%	3.20%	1.98%	6.15%
	Gwangju	Resistance	Resistance	-1.60%	1.05%	0.88%	-0.01%
	Daejeon	Resistance	Resistance and Lagged Shock	-5.92%	2.14%	-3.20%	-6.55%
	Ulsan	Resistance	Resistance	-4.39%	1.55%	-1.49%	-1.42%
	Gyeonggi	Resistance	Resistance	-17.28%	2.33%	- 11.75%	-1.75%
	Gangwon	Positive Jolt	Positive Jolt	3.88%	1.10%	5.58%	5.77%
	Chungbuk	Resistance	Resistance	0.78%	1.11%	3.28%	5.53%
	Chungnam	Resistance and Lagged Shock	Resistance	-1.74%	-2.54%	-2.17%	19.20%
	Jeonbuk	Turnarround	Systematic Decline	6.43%	1.43%	7.45%	4.52%
	Jeonnam	Systematic Decline	Systematic Decline	8.55%	0.70%	8.37%	6.24%
	Gyeongbuk	Turnarround	Systematic Decline	3.71%	1.50%	4.78%	3.56%
	Gyeongnam	Resistance	Resistance	-1.65%	0.46%	0.48%	1.81%
	Jeju	Resistance	Resistance	-2.51%	3.13%	1.24%	16.75%

In terms of employment, the crisis seems to have little impact on the resilience of the regions (see Table 5). In 16 of the 17 regions, the number of regular employees increased regardless of the shock, indicating resistance. Ulsan shows an immediate response to short-term shocks in terms of regular employees. In contrast, in approach 2, only two regions were found to be resistant: Daegu and Jeollabuk-do. This means that the regions were vulnerable to the global financial crisis in terms of employment stability. In terms of recovery, all regions rebounded and continued to grow in the long run by adapting to the shock.

Table 5. Dynamic resilience of the Regular Employee to the global financial crisis (2007–2009)

region		approach 1		approach 2			
		short-term (3 years)	long-term (10 years)	resistance	rebound	recuperation short term	recuperation long term
National		Resistance	Resistance	-10.76%	9.02%	2.23%	32.53%
Region	Seoul	Resistance	Resistance	-6.20%	2.56%	1.43%	22.51%
	Busan	Resistance	Resistance	-0.68%	10.31%	11.23%	34.28%
	Daegu	Resistance	Resistance	1.93%	9.97%	15.48%	36.36%
	Incheon	Resistance	Resistance	-8.93%	9.59%	2.96%	35.41%
	Gwangju	Resistance	Resistance	-14.82%	8.33%	-1.56%	24.94%
	Daejeon	Resistance	Resistance	-7.55%	3.57%	3.91%	34.80%
	Ulsan	Resistance	Resistance	-20.44%	12.99%	-8.62%	8.64%
	Gyeonggi	Resistance	Resistance	-25.16%	16.57%	-5.75%	41.75%
	Gangwon	Resistance	Resistance	-8.93%	5.12%	-0.03%	38.21%
	Chungbuk	Resistance	Resistance	-12.44%	10.43%	2.17%	44.94%
	Chungnam	Resistance	Resistance	-24.73%	8.54%	-10.18%	50.05%
	Jeonbuk	Resistance	Resistance	0.98%	4.93%	13.46%	39.02%
	Jeonnam	Positive	Positive	-0.95%	6.45%	10.51%	47.06%

		Jolt	Jolt				
	Gyeongbuk	Resistance	Resistance	-1.84%	12.41%	12.92%	35.04%
	Gyeongnam	Resistance	Resistance	-18.00%	8.40%	-5.17%	9.43%
	Jeju	Resistance	Resistance	-8.47%	2.48%	0.78%	48.10%

The most frequent scenarios of resilience at regional firm level were counter-cyclical (see Table 6). For all time periods, only one region, Gwangju, shows an increase in the short term and a decrease in the long term. Jeollanam-do, on the other hand, shows a decline in both the short and long term for all sequences. The variation in results over the length of the post-shock period is consistent, with the exception of Incheon and Gwangju, both of which show an increase in profit rates in the short term and a decrease in the long term. In the case of Gyeongsangnam-do, there is no resilience for the profit rate. At the level of regional firms, with the exception of Incheon, the rest of the regions recovered from the impact of the shock within three years and achieved growth as high as before. In particular, Seoul and Incheon, with the exception of Gyeonggi-do, did not return to growth in the long run of 10 years.

Table 6. Dynamic resilience of the Profit Rate to the global financial crisis (2007–2009)

region		approach 1		approach 2			
		short-term (3 years)	long-term (10 years)	resistance	rebound	recuperation	
						short term	long term
National		Counter Cyclical	Counter Cyclical	9.57%	-8.51%	5.58%	-9.37%
Region	Seoul	Resistance and Lagged Shock	Resistance and Lagged Shock	29.35%	-38.18%	23.69%	-36.35%
	Busan	Counter Cyclical	Counter Cyclical	35.16%	-28.57%	22.76%	6.22%
	Daegu	Counter Cyclical	Counter Cyclical	53.13%	-26.27%	48.70%	34.49%
	Incheon	Turnarround	Systematic Decline	-7.92%	11.33%	-5.50%	-12.61%
	Gwangju	Resistance	Resistance and Lagged Shock	0.68%	2.54%	4.80%	-3.51%
	Daejeon	Positive Jolt	Positive Jolt	10.26%	11.62%	22.39%	10.39%

	Ulsan	Counter Cyclical	Counter Cyclical	19.46%	-31.12%	1.79%	-10.63%
	Gyeonggi	Turnarround	Systematic Decline	9.03%	16.35%	24.25%	6.19%
	Gangwon	Counter Cyclical	Counter Cyclical	5.74%	-6.07%	1.11%	-5.28%
	Chungbuk	Counter Cyclical	Counter Cyclical	16.52%	-3.36%	16.32%	4.37%
	Chungnam	Counter Cyclical	Counter Cyclical	9.23%	-7.63%	3.71%	5.92%
	Jeonbuk	Counter Cyclical	Counter Cyclical	18.07%	-8.26%	12.72%	10.16%
	Jeonnam	Systematic Decline	Systematic Decline	5.77%	-9.79%	-5.81%	-1.46%
	Gyeongbuk	Resistance and Lagged Shock	Resistance and Lagged Shock	-14.67%	-19.15%	-30.39%	-32.62%
	Gyeongnam	Counter Cyclical	Counter Cyclical	19.82%	-27.07%	4.77%	2.35%
	Jeju	Counter Cyclical	Counter Cyclical	39.89%	-18.48%	33.80%	27.46%

4.4. Dynamic Resilience – The Heat Wave

To analyse the dynamic resilience to heat waves, we make several additional assumptions. First, in the case of the heat wave, the arrows pointing upwards represent a decrease in heat wave mortality in order to produce consistent results on past regional resilience. Second, in 2000, the earliest year in the period analysed, there were only six heat wave deaths in the whole country, leaving many regions with no deaths. To prevent this from biasing the results, we start in 2004, when heat wave deaths began to appear in earnest across the country. The three sequences are accordingly pre-shock (2004–2017), shock (2017–2018) and post-shock (2018–2020). Third, the growth rate cannot be calculated in the absence of deaths, so the growth rate was assumed to be 0.1 instead of 0. Fourth, resilience was analysed using mortality by heat wave instead of population, as the population losses due to the heat wave represent a very small proportion of the region's population. Finally, as the impact of the heat wave occurred recently, the recuperation can only be considered from a short-term perspective (2018–2020).

Table 7 shows the dynamic resilience results for the number of deaths caused by the 2018 heat wave. According to approach 1, the majority of regions, including the national level, showed standard resilience or turnaround. That is, the number of mortalities increased and then decreased due to the impact of the heat wave in the shock and post-shock periods, although the pre-shock trends were different. In the case of Daejeon, the number of heat wave mortalities remained unchanged at zero in all three sequences. Incheon and Gyeongsangnam-do had a constant number of deaths in the pre-shock period and Jeju-do had a constant number of deaths in the post-shock period.

Due to the small number of deaths, approach 2, which unlike approach 1 is based on growth rates, showed large fluctuations. Most regions, including the whole country, showed patterns of resistance and recuperation, but not rebound. Jeju-do, on the other hand, was the only region to show a rebound, as it showed a reverse reaction to the impact of the heat wave. The impact of the heat wave on other regular employees and profit rates is presented in the appendix (see Table A1-A2).

Table 3. Dynamic resilience of the Mortality Rate by Heat Wave (2018)

region		approach 1	approach 2		
		short-term (3 years)	resistance	rebound	recuperation
					short term
National		Standard Resilience	0.0003%	-0.0005%	0.0000%
Region	Seoul	Standard Resilience	0.0002%	-0.0004%	0.0000%
	Busan	Turnarround	0.0002%	-0.0006%	0.0000%
	Daegu	Standard Resilience	0.0004%	-0.0009%	0.0000%
	Incheon	Standard Resilience	0.0001%	-0.0003%	0.0000%
	Gwangju	Standard Resilience	0.0002%	-0.0003%	0.0001%
	Daejeon	No Changes	0.0000%	0.0000%	0.0000%
	Ulsan	Standard Resilience	0.0003%	-0.0003%	0.0001%
	Gyeonggi	Turnarround	0.0001%	-0.0003%	-0.0001%

	Gangwon	Standard Resilience	0.0008%	-0.0009%	0.0004%
	Chungbuk	Turnarround	0.0001%	-0.0006%	-0.0002%
	Chungnam	Turnarround	0.0004%	-0.0010%	-0.0001%
	Jeonbuk	Standard Resilience	0.0003%	-0.0007%	-0.0001%
	Jeonnam	Standard Resilience	0.0005%	-0.0011%	-0.0001%
	Gyeongbuk	Standard Resilience	0.0008%	-0.0010%	0.0004%
	Gyeongnam	Standard Resilience	0.0002%	-0.0003%	0.0000%
	Jeju	Positive Jolt	-0.0005%	0.0002%	-0.0005%

5. Discussions

The significance of this study is that it considers shocks of different nature simultaneously and measures the changes that occur in a region under the same conditions. The implication of this is that it provides information on how regions should manage their resilience characteristics by observing common characteristics that appear at a relatively large regional scale. This study proposes a coordinating strategy for a collaborative resilience region.

A collaborative resilience region is an intra- and inter-regionally coordinated cooperative networking system that uses optimised economies of scale and scope to form an inter-local economic system (Nakamura, 2022). In the sub-locals of the region (e.g., Seoul, Busan, Ulsan) that show poor resilience to profit rate, which is the result of this study, which refers to the resilience of local firms, a pattern of consumer exclusion may emerge that reduces local consumption by locals and perpetuates the decline in the region's attractiveness under the love of variety principle, which states that consumers prefer a variety of goods and services (Dixit and Stiglitz, 1977; Nakamura, 2010), creating a vicious circle for the region's economic development and growth. The resilience region's strategy is to promote co-operative production between the region and the locals, and there are three levels of options.

Nakamura (2022) suggests three strategies to achieve this. First, increase economic efficiency by sharing resources between regions, such as intra- and inter-regional infrastructure, resources and technology. Second, sharing innovative ideas and technologies through intra- and inter-regional technology exchange to promote sustainable economic development. Third, it strengthens the resilience of regional economies by making intra- and inter-regional competition cooperative. This allows firms to benefit from economies of scale and scope, enabling the additional production of more goods and services at lower cost, and a sustainable virtuous circle can emerge in which local consumption increases as the utility of local people increases. This study combines index-based static methods with sequence-based dynamic methods to provide a model for analysing regional economic resilience from multiple perspectives. We are motivated by the idea that in regional economic development, business and non-government residents work collectively to create economic growth and job creation (Swinburn et al., 2006). On this basis, this study structures the economic resilience of a region into two dimensions: the resident dimension, where resilience consists of population and employment, and the regional firm dimension, where resilience consists of the rate of profit, decomposed into gross surplus and capital productivity. The importance of considering both dimensions of resilience simultaneously is that it reflects the complementarity between them and builds a resilience model that can cover any shock affecting the regional economy.

Limitations of this paper include, on the methodological side, that the dynamic resilience framework we use does not capture the net effect of the shocks under analysis. We have previously analysed dynamic resilience by assuming the duration of the shock in advance and analysing the direction or growth rate of the sequence. It is therefore not an analysis that reflects the content or nature of the socio-natural shocks. A limitation of this resilience framework is therefore that it should be applied to phenomena that occur simultaneously globally or nationally, rather than locally. For example, COVID-19 is an appropriate shock because it occurred simultaneously within a country or region, whereas localised windstorms, accidents are not appropriate for this framework.

Another limitation in terms of content is the lack of consideration of the role of the public in local resilience. Previous research has highlighted the importance of institutional and policy arrangements shaped by local and national governments in the resilience of local economies (White and O'Hare, 2014). While it is important to consider the different socio-political environments of different regions, the purpose of this study was to construct and apply a resilience framework, so it was difficult to identify variables that might reflect this in common across regions. This limitation will be taken into account in the specific application of the collaborative resilience region in future research. The formation of resilience regions requires the establishment of networks for inter-regional exchange and policy and financial support to facilitate collaborative projects (Nakamura, 2022), and a more specific public role could be promoted in the application process in different settings.

Despite these limitations, this paper is significant in that it presents a resilience framework that can reflect different socio-natural shocks. The advantage of the framework is that it can be easily applied to identify the factors of socio-natural hazards that threaten cities in order to minimise damage, recover quickly and enhance the ability to adapt to the new normal. In particular, the concept of smart cities using digital technologies is in line with the goals of resilience and sustainability, and the adaptation, efficiency and knowledge creation of urban systems as a means to enhance innovation capacity is similar to resilience (Tzioutziou and Xenidis, 2021). In addition, big data based on smart city technologies can augment limited human cognitive capacities and enable proactive responses in the era of climate change to enhance regional or urban resilience (Apostu et al., 2022). Therefore, the introduction and implementation of smart cities should be accompanied by considerations of resilience, and it is significant that we have provided a policy basis for static and dynamic analysis of resilience.

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Appendix

Table A1. Dynamic resilience of the Regular Employee to the Heat Wave (2018)

region		approach 1	approach 2		
		short-term (3 years)	resistance	rebound	recuperation short term
National		Resistance	-59.22%	-3.04%	-59.22%
Region	Seoul	Resistance and Lagged Shock	-43.09%	-4.04%	-44.65%
	Busan	Resistance and Lagged Shock	-35.41%	-3.03%	-37.56%
	Daegu	Resistance and Lagged Shock	-34.91%	-2.68%	-35.90%
	Incheon	Resistance and Lagged Shock	-52.66%	-6.18%	-54.92%
	Gwangju	Resistance and Lagged Shock	-63.93%	-4.80%	-66.27%
	Daejeon	Resistance	-68.19%	0.83%	-65.83%
	Ulsan	Resistance and Lagged Shock	-49.30%	-5.77%	-53.83%
	Gyeonggi	Resistance	-99.25%	-3.11%	-97.71%
	Gangwon	Resistance	-55.54%	-0.69%	-52.42%
	Chungbuk	Resistance	-67.86%	-1.26%	-63.62%
	Chungnam	Resistance	-113.82%	-0.92%	-109.43%
	Jeonbuk	Resistance	-47.35%	-1.67%	-46.20%
	Jeonnam	Resistance	-48.62%	0.95%	-44.10%
	Gyeongbuk	Resistance and Lagged Shock	-39.68%	-2.57%	-40.88%
	Gyeongnam	Resistance and Lagged Shock	-59.60%	-1.77%	-61.07%
	Jeju	Resistance and Lagged Shock	-70.42%	-11.46%	-73.55%

Note: The darker the value, the closer it is to the minimum or maximum value

Table A2. Dynamic resilience of the Profit Rate to the Heat Wave (2018)

region		approach 1	approach 2		
		short-term (3 years)	resistance	rebound	recuperation short term
National		Systematic Decline	7.12%	-12.42%	-7.54%
Region	Seoul	Hard Hit, No recovery	-19.43%	-19.04%	-55.23%
	Busan	Systematic Decline	6.46%	1.68%	-1.65%
	Daegu	Systematic Decline	13.86%	-26.46%	-14.77%
	Incheon	Systematic Decline	-1.54%	-9.54%	-17.69%
	Gwangju	Hard Hit, No recovery	-25.93%	-4.64%	-42.92%
	Daejeon	Systematic Decline	2.43%	-19.72%	-18.01%
	Ulsan	Turnarround	15.18%	7.36%	17.28%
	Gyeonggi	Counter Cyclical	3.92%	-24.29%	-16.86%
	Gangwon	Systematic Decline	9.16%	-13.72%	-4.79%
	Chungbuk	Turnarround	16.27%	5.03%	18.18%
	Chungnam	Counter Cyclical	11.50%	-6.03%	6.83%
	Jeonbuk	Systematic Decline	9.13%	-1.61%	4.22%
	Jeonnam	Hard Hit, No recovery	-15.59%	8.78%	-18.44%
	Gyeongbuk	Resistance and Lagged Shock	-4.92%	-12.05%	-15.11%
	Gyeongnam	Systematic Decline	6.28%	1.35%	4.15%
	Jeju	Counter Cyclical	29.04%	-6.00%	24.64%

Note: The darker the value, the closer it is to the minimum or maximum value