Dominant Industry and *Lock-in* Ripple Effects on the Local Economy: Searching for a path renewal of the shipbuilding industry and local economy in Geoje, South Korea

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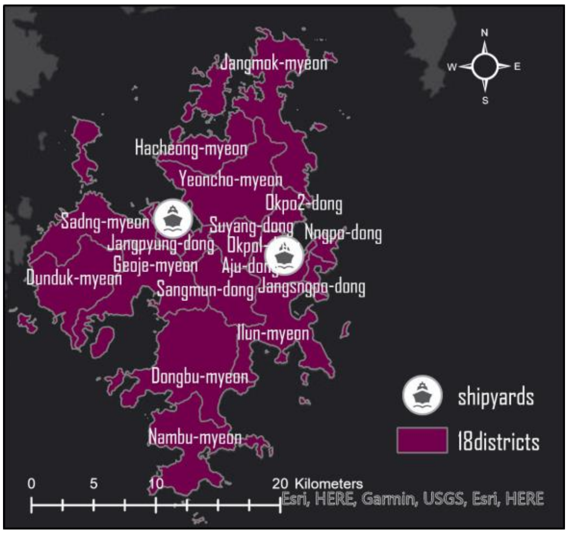
Abstract

This research investigates regional economic *lock-ins* in locations where their economy has been shaped with an old industry. Under regional *lock-ins* of path dependence theory in evolutionary economic geography, the ripple effects of shipbuilding industry in Geoje, South Korea are investigated to measure how strongly its local economy is tied into the dominant industry. This ripple investigation is to provide a novel sight of how the local economy could be renewed towards a more stable and resilient one. Using spatial analyses with GIS and econometrics, the statistically significant relationships are found between the shipbuilding industry, and regional economic indicators such as employment (total number of employees) and economic structure (industrial diversity) in each administrative division. These statistical models take spatial and time factors into account in order for the analyses to provide deeper insights of the *lock-in* effects in Geoje. As the research results indicate, the shipbuilding industry has statistically significant positive relationships with the both indicators, but low coefficients for the industrial diversity. However, even with the low coefficients between the shipbuilding industry and the industrial diversity, the spatial econometrics model (dynamic Spatial Durbin Model (SDM) with common factors) indicates the industrial diversity of one spatial unit impacts its neighbouring units. Therefore, diversifying the economic structure and employment in the shipbuilding industry can provide the ripple effects throughout Geoje. In order to maximize the ripple effect, the attention of the national, regional, and local governments should focus not only on the industry itself but also on intentional plans connecting regional firms to diversify regional economic structures and employments for a more resilient local economy.

Key words: path dependence, local economic lock-ins, local economic sustainability, diversifying economic structures and employment, statistical analyses, case study

1. Introduction



Map 1. The location of Geoje in South Korea (left)

Map 2. 18 administrative divisions in Geoje (above)

Geoje island in South Korea has a regional economy locked-in with the island's main industry, shipbuilding. South Korea adopted *Growth pole model*, a theory by Perroux (1955), as a regional development and decentralization in 1973; this strategy was followed by a successful national development plan of industrialization (Kim, 1976; Lo, F. C., & Salih, K., 2013). As part of the regional development strategy, a heavy industry of shipbuilding formed the clusters on the island. Samsung in 1979 and Daewoo in 1981 constructed their shipyards in the 383.4 m^2 island, with support from the central government. In general, the development strategy was seen as a success since the shipbuilding industry became a leader in the international market (Hassink & Shin, 2005), but the island has been experiencing economic and population downfalls due to recessions on shipyard business ignited by 2007 world economic crisis. Woo and Lee (2018) argue that this is due to economic dependency on the dominant industry and lock-in effects; the shipbuilding business has continued to be a major economic source for the island community as 39% of the regional employment is involved in the industry directly and indirectly (Geoje City, 2022). Although industrial lock-ins are not necessarily negative in a regional economy, the case of Geoje is seen as a low-endogenous industrial innovation and lack of industrial diversification due to the 'economic-structural factors': 'mono-structure, high entry and exit barriers, and oligopolistic market structure' (Hassink, 2010).

To overcome the strong regional economic dependency and to form a more sustainable economic path in Geoje, the importance of diversifying economic structures has been suggested (Woo, 2004; Hassink, 2010; Woo & Lee, 2018). To be clear, the economic sustainability in this paper rather refers to economic stability and resilience from external shocks than natural environmental sustainability. Nonetheless, this suggestion has barely been addressed and implicated at the policy level. Even the recently-announced shipbuilding industrial transformation by the South Korean president Moon Jae-In (09.09.2021; now former president) failed to address what it means for the wider regional economy and to how this transition can help to restructure the broader local economy besides simply increasing labour forces (See strategy reports and news article: Relevant ministries, The, 09.09.2021;

Ministry of Trade, Industry and Energy & Ministry of Oceans and Fisheries, 2021; Lee, 09.09.2021). This 'K-shipbuilding' strategy detailed by Moon is for revitalizing the shipbuilding industry and regional economy through smart and green shipbuilding.

These policy gaps are due to the long-standing top-down regional development strategies since the shipbuilding industry is an important part of the national economy, as such the local economy has been approached by the shipbuilding industrial development rather than the place-specific capabilities of the local economy. In addition, previous studies mostly highlighted the historical perspective stating overall regional economic lock-ins relating with Gross Regional Domestic Product (GRDP), population expansion/contraction, and related firms to the industry (see studies on Hassink, 2010; Woo & Lee, 2018; Woo, 2004; Park, 2008). As such, current literature on the topic lacks more detailed local economic capabilities, which can in turn direct the path renewal process. Investigating the *lock-in* ripple effects with new methodological approaches in Geoje is critical to identify the local specific ripple patterns and economic capabilities, especially in time of newly implemented industrial transformation process. Therefore, this paper investigates the lock-in ripple effects with spatial analyses, and discusses how to enable the linkage between transforming the industry and renewing the regional economic path as an opportunity.

On that account, this research aims to scrutinize to what extent the Geoje economy is locked-in to the shipbuilding industry using three steps of quantitative analyses. These statistical analyses investigate not only the general overview of the lock-in effects, but also deeper insights of the ripple effect patterns incorporating smaller spatial units—the eighteen administrative divisions in Geoje. These insights will answer the extent to which the shipbuilding industry has statistical relationships with regional employment and economic structure. The following economic indicators are included in statistical models for the analyses: GRDP, total number of employees regional and division level as employment, and industrial diversity as economic structure. Furthermore, renewing local economic path as a regional development strategy will be discussed based on the analytical results.

2. Theoretical framework

An ***Evolutionary perspective*** in economic geography has been taking shape since the economist Schumpeter adopted an evolutionary paradigm in economics with his theories of creative destruction and endogeneity of innovation and knowledge (Metcalfe et al., 2006; Fine, 2000). Schumpeter (1939) built the foundation based on the work of Soviet economist Kondratieff (1925) about the major economic cycles. Followed by this foothold, the eminent theory of *Creative Destruction* in his book *Capitalism, Socialism and Democracy* (Schumpeter, 1942) was published elaborating the work of Karl Marx, and has been influential in Evolutionary Economics. The evolutionary perspective in the field is distinctive from the Neoclassical economics, which approaches economic processes with static and equilibrium status. Although economists like Paul Krugman and Michael Porter in 1990s took *institutional* and *cultural* aspects into account in economics differentiating from the Neoclassicals, the historic aspects were still missing in their ideas (Boschma & Martin, 2010). Evolutionary thinking considers complex and diverse economic behaviours taking history into account; economic innovation is created by endogenous factors for its transformation (Ghazinoory et al., 2017). Therefore, evolutionary approach is rather *dynamic, irreversible,* and *self-transformational* with generation and novelty (Witt, 2003; 2006).

Understanding evolutionary economics as a starting point and taking these foundational ideas in geography, **three main theories** became a backbone of the discipline. Boschma and Martin (2010) marshalled the evolutionary view on economic geography with these three main theories: *Generalised Darwinism*, *Complexity Theory*, and *Path Dependence Theory* (Table 1). *Generalised Darwinism,* incorporating biological metaphors in economics and economic geography, was challenged by scholars like Penrose (1952), Fincher (1983) and Witt (2016) because of the viability of economic interpretations. Nonetheless, this cross-disciplinary approach benefits “the major sources of theoretical and empirical innovation, not only providing new perspectives but also in the process stimulating conceptual advance and creating new intellectual contact points and avenues” (Boschma & Martin, 2010, p6). *Complexity Theory* in economic geography has been highlighting the *dynamics* of the economic system and the role of geographical space in complex economic landscapes. The multi-agents in economic systems create their unique economic landscapes through multi-level interactions, as such the system self-organizes, emerges, and adopts in geographical restrictions (Martin & Sunley, 2007). *Path Dependence Theory* in economy geography focuses on the unique historical economic paths in geographical spaces, but differentiated by any sorts of equilibrium thinking (Martin & Sunley, 2010; Boschma & Martin, 2010). The extensive work of economists David (1985; 1994; 1997; 2000; 2007) and Arthur (1988; 1989; 1994) provided the groundwork of the path dependence notion in economics. Economic geographers like Walker (2000) and Scott (2006) opened the implication of the path dependence in the field. At the same time, the empirical works of the path dependence in economic geography including the locked-in local industry, and economic renewal studied under path dependence framework (Grabher, 1993; Fuchs & Shapira, 2005; Hassink, 2005a).

	Generalized Darwinism	***Path dependence theory***	***Complexity theory***
concepts	Modern evolutionary biology	Role of the historic path and capability	Complex adaptive system
characteristics	Variety, novelty, selection, fitness, retention, mutation, adaptation	‘lock-in’, network externality effects, branching, path creation	Emergence, self-organisation, adaption, fitness landscapes, hysteresis
focus area	Within population and between interaction: “how emergent properties of economic agents and places co-evolve and lead to different trajectories of economic development over space” (p8)	a path dependent trajectory of regional economies encompassing firms, industries and the regional economy as a whole. Existence of multiple paths, the interactions, and the transition.	Open system and connectivity: Study focusses on “uneven development and transformation of the economic landscape” and *computational architecture* with time series data.
More details in reference	Esletzbichler & Rigby (2010)	Martin & Sunley (2006)	Foster (2005)

Table 1. The three main theories in Evolutionary Economic Geography (Boschma & Martin, 2010, p4-11)

The previous studies on the **Geoje shipbuilding industry** have been studied mostly with the ***lock-ins*** under Path Dependence in the evolutionary theoretical frameworks. Woo (2004) provide insights of how the shipbuilding industry induced the industrial specialization in the region and created industrial clusters in Geoje. This study suggests selective spatial relationships between the shipyards and the (un)related firms inside and outside of Geoje to strengthen the industry. This emergence of industrial clusters is also mentioned by a comparison study by Hassink (2010). The study indicates that the emergence of innovative clusters in Geoje managed for the industry to survive from the 1998 national financial crisis. However, Hassink (2010) warns about a possible industrial decline due to potential external shocks, and rise of Chinses shipbuilding industry because the industrial lock-ins induces a lack of ability to adjust the economy during crisis. Similarly, Hassink and Shin (2005) warned the negative externality of lock-in effects in Geoje previously, that the economic structure is more prone to lose economic stability and resilience. Nonetheless, the regional economy has been shaped tightly with the shipbuilding industry, and experienced the economic downfalls, as the scholars warned, during the periods of external economic shocks such as 2007-8 global financial crisis and competitions with Chinese shipyards. Woo & Lee (2018) explicitly studied about the industrial decline and the regional *lock-ins* in Geoje. Their study not only provides historical aspects of the *lock-ins* but also the three drivers of the lock-in phenomena, that explains the industrial declines: functional, political, and cognitive lock-ins. Functionally, the regional economy has been developed as a mono-industry economic structure, despite the importance of economic structural diversification was suggested. As a consequence, the sub-contractors of the shipbuilding industry lost self-sustaining function. Politically, the endogeneity of innovation and industrial restructuring were lost due to the continuous public investment to maintain the industry. These functional and political lock-ins reduced cognitive lock-ins that the regional economy continues to shape around the industry. As such, endogenous innovations and further restructuring the local economy could not sprout in Geoje.

The **other studies of *lock-ins*** in old industry and regional economy suggest several insights of path renewal solutions. Grabher (1993) studied the Ruhr region with old industries such as coal, iron, and steel, and emphasizes loosely connected relationships between the old industries and regional economy. The weak lock-in is better for providing opportunities of endogenous innovation and self-sustaining. One step forward from the loose connection, Fuchs and Wassermann (2005) suggest 'on-course' path renewal which connects old and new structures for sustainable economic growth based on the case study of the Baden-Württemberg region in Germany. Similarly, Hassink (2010) indicates the weak connection with endogenous innovations in regions, where successfully renewed their paths in his comparison study. The study compares and investigates old industries and regional economy in Germany and South Korea including the Geoje shipbuilding industry. This study delves into why some regions with old industries have successfully transformed and economically diversified, but why some have not. In addition, this study, aligning with Martin and Sunley's (2006), suggests the renewal process of the economic path as a 'place-dependence' restructuring because the lock-ins gradually occur not only with the industry but also under institutional, and social levels.

In similar manner, the previous studies of Geoje, as aforementioned, suggest **lock-in solutions** such as economic restructuring and endogenous innovation through economic diversity. Economic diversity is a key element not only for economic growth but also for regional economic stability and resilience (Koster et al, 2020). Xu et al. (2002) incorporate ecology point of views from Darwin (1895) to Tilman et al. (1996) and define economic diversity as "the number and equitability of energy flow paths within an economic system. It can be measured by how many different types of economic activities exist within the system and how equitably energy is distributed between them." (p 370). In addition, Tran (2011) uses spatial analysis to find the relationship between industrial diversity and economic growth using employment and industrial diversity indicators in the US context. The "findings suggest that efforts to diversify state economies will generate long-term benefits but maintenance of steady overall growth in employment and capital should be focused on, at least in the short run.". Therefore, "local economies should focus on policies that focus on growth of employment in the short-run while long-run economic policy should be focused on diversifying the local economy."

Therefore, this research tests the research hypothesis *the shipbuilding industry in Geoje induces ripple effects on local economies in term of the local employment and industrial diversity* mainly with the two indicators: employment and industrial diversity. The total employees in each division are incorporated as one of the indicators since the (in)direct shipyards employments are a big part of the local economy. The industrial diversity is chosen to measure the relationship because the relevant studies like Martin and Sunley (2006), Tran (2011), Koster et al. (2020) refer to industrial diversity as a key element for the local economy. With these two indicators, the research outcomes provide discussions on the local economic path renewal adopting the Martin and Sunley (2006)'s de-locking mechanisms; they present five mechanisms with indigenous creation, heterogeneity and diversity, transplantation from elsewhere, diversification into (technologically) related industries, and upgrading of existing industries. This investigation is critical foundation to search how the newly adopted industrial transformation can be linked to the regional economic sustainability.

3. Data, methodology, and methods

3.1. Data

Data is collected from four different sources: Korean Statistical Information Service (KOSIS), Korea Offshore and Shipbuilding Association (KOSHIPA), Geoje City Hall, and Statistical Geographic Information Service (SGIS) plus. KOSIS as the main national statistical bureau provides wide range of datasets. National Business Survey data from KOSIS contains information about local establishments such as industrial types and total number of employees. Establishment[1] as the unit of analysis, the industrial diversity, size of shipbuilding establishments, shipbuilding employees in each division are calculated from the survey. Also, variables such as population are collected from KOSIS. Goeje City Hall provides customized data only regarding to Geoje such as total employees of two main shipyards over the years and GRDP of Geoje. However, the shipyards employee dataset only provides data from 2012, as such KOSHIPA data from 2000 to 2009 is combined to the dataset. Spatial data of Geoje with eighteen divisions is incorporated in GIS using shape file data from SGIS plus (Table 2).

Variables in the research	Source	Purpose of the survey	Survey cycle	Subject of the survey	Main Contents	Survey Methods	File Type
Total number of establishments and **total number of employees**: establishment and employees by Industrial groups & divisions	National Business Survey from Korean Statistical Information Service (KOSIS; Geoje City)	KOSIS Business Survey data aggregated number of establishments and employees in each division under industrial classification[2].	1 year	All establishments with one or more employees performing industrial activities within the jurisdiction as of the survey base date	Aggregated number of establishments and employees in each division.	Not indicated	Web/ PDF/ xls
GRDP: Gross Reginal Product (GRDP)[3]	Korean Statistical Information Service (KOSIS)	Basic data for policy establishment and academic research by identifying the value-added amount by city, county and industry	1 year	Geoje City	Economic size by city, county and industry, economic growth rate, GRDP per capita, etc.	Collect and process the results of statistical investigations, administrative agencies (National Tax Service, etc.) and business expenditure settlement data, etc.	xls
Two shpipyard employees[4]:	Geoje City Hall,	not indicated	1 year	Two shipyards	Geoje City Hall data: total number	Not indicated	Web/ PDF

[1] An establishment is a legal production activity location where sells goods or/and services. A firm can consist of one establishment and more (U.S. BUREAU OF LABOR STATISTICS, np).

[2] 19 industrial classification, 73 or 74 medium sub-classifications, and 229 small sub-classification. See the classification table in Appendix. One category, 34. Industrial machinery and equipment repair, has been added in the sub-classifications since 2017 as the industrial categorization 10th edition. Therefore, for the spatial econometrics' dataset, 73 sub-classifications are used for the calculation in the year up to 2016. From year 2017, the establishments are divided by 74. For the OLS analysis with GIS uses 74 for the calculation since the analysis uses the 2019 dataset.

[3]There are some value differences in certain years in different year datasets. For example, the GRDP value on 2015 in the 2015 dataset and 2016 datasets are different. This is due to data reorganization which aims for enhancing the degree and comparability of GRDP and strengthening the link between economic statistics. The values of GRDP over the years are improved by reflecting changes in the economic structure, administrative district classification, and standard industry classification (KOSIS, 2019). Therefore, the values in this research dataset are added from the most recent GRDP datasets of KOSIS.

[4] These two datasets are combined due to different years of data which the sources are providing. Geoje City Hall provides year 2012- 2020, while KOSHIPA provides year 1978-2009. Therefore, 2010 and 2011 values are missing.

Number of (in)direct employees	Shipbuilding Industry Jobs Division & Korea Offshore and Shipbuilding Association (KOSHIPA)				of employees by both shipyards, total number of employees by each shipyard, direct employees, indirect employees (partners' firms) KOSHIPA data: number of employees in each shipbuilding company in Korea.		
Population and working population variables: Resident registration demographics in each administrative division (eup, myeon, dong)/	Korean Statistical Information Service (KOSIS)[5]	"Identify changes in population by region and age structure and use them as basic data for administrative matters of each local administrative agency" (KOSIS)	2000-2011: 1 year, 2011-2021: half year	Population in each division by ages	Total number of populations, population by sex, population by ages 5-year interval.	Reporting statistics	xls
Statistical Area Boundaries	Statistical Geographic Information Service (SGIS) plus	Not relevant	1 year	Administrative district boundaries in eup, myeon, dong	Administrative district boundaries for the 2021 census (eup, myeon, dong)	Geospatial coordinate system: UTM-K (GRS80 ellipsoid) (EPSG5179)	SHP

Table 2. Datasets and properties for the research analyses

3.2. Methodology

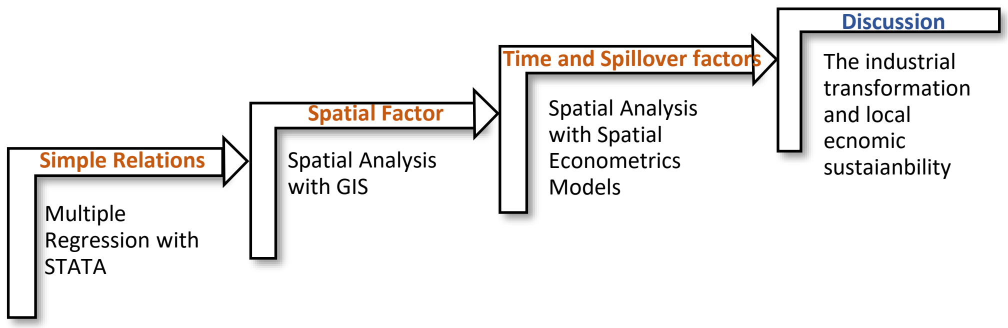


Figure 1. The research methodology using three quantitative analyses for complementing the weakness of each analysis, and the discussion based on the research findings

To provide deeper insights of the economic lock-ins in Geoje, three different statistical analyses are performed: Multiple Regression, Spatial Analysis with Geographical Information System (GIS), and Spatial Analysis with Spatial Econometrics Models (Figure 1). Each analysis contains similar, but also different properties; as such, this triangulation approach aims to complement factors that one analysis does not provide. First, multiple regression aims to investigate the relationship between the shipyards and the island economy in general and to examine the statistically significant relationships.

[5] Dataset ID: DT_217F2010F0052
https://kosis.kr/statHtml/statHtml.do?orgId=217&tblId=DT_217F2010F0052&conn_path=I3

However, the multiple regression analysis does not contain spatial properties, which makes it not possible to analyse spatial patterns. In this account, the spatial analysis with GIS, using the most recent dataset of 2019, is adopted secondly to enable an investigation of the relationship with *spatial* factors. Spatial analysis takes "spatial effects" into account using spatial data (Anselin and Getis, 1992), differentiating from the multiple regression above. The spatial factor in analysis takes notions of Tobler's First Law of Geography, and "the nature of the spatial units" which contains unique spatial sizes and configurations (p23). This analysis incorporates eighteen administrative divisions in Geoje to take into account the individual spatial units in the models. Third, spatial analysis with spatial econometric models complements two previous models with time and spatial spillover factors. The spatial econometric models using panel data facilitate investigating the relationships over the years and spatial spillover effect (neighbouring effect). Analysis with panel data indicates more reliable causal analysis than cross-section data because panel data takes time-invariant variables (ex. individuals and firms) into account in an analysis (Mehmetoglu & Jakobsen, 2017). Additionally, spatial econometrics takes *spatial dependence* and *spatial heterogeneity* into consideration, that differs from traditional econometrics (LeSage, 1999). Also, Anselin (1988), an influential figure in spatial econometrics, distinguishes the discipline from spatial statistics; spatial econometrics focuses on model approach rather than data approach. Therefore, spatial econometrics emphases model specifications with other properties such as spatial weight, dynamic, and common factors. As such, deciding the *best* model among eight spatial econometrics models[6] is critical for the right outcomes and interpretations (Table 3); Elhorst (2014) states the best model as the model "that best describes the data" (p34).

	Model Name	**Model Specification**
General	GNS	$Y=\rho WY+\alpha\iota_N+X\beta+WX\theta+u,\ u=\lambda Wu+\varepsilon$
↑	SAC	$Y=\rho WY+\alpha\iota_N+X\beta+u,\ u=\lambda Wu+\varepsilon$
	SDM	$Y=\rho WY+\alpha\iota_N+X\beta+WX\theta+u$
	SDEM	$Y=\alpha\iota_N+X\beta+WX\theta+u,\ u=\lambda Wu+\varepsilon$
	SAR	$Y=\rho WY+\alpha\iota_N+X\beta+u$
	SLX	$Y=\alpha\iota_N+X\beta+WX\theta+u$
↓	SEM	$Y=\alpha\iota_N+X\beta+u,\ u=\lambda Wu+\varepsilon$
Specific	OLS	$Y=\alpha\iota_N+X\beta+u$

Table 3. Spatial econometrics models and their specifications. *Red: the spatial interaction effects

3.3. Methods

Multiple regression

To investigate statistical relationships between the shipbuilding industry and the local economy, and their magnitudes, multiple regression is performed with STATA. The following models are incorporated for the multiple regression (Model 1 and 2) with the five variables: TSE, GRDP, NTE, Population, and NTEm (Table 4). GRDP is an important "indicator of macro-economic performance in the local economy" (Feriyanto, 2014, p131). Employment is often used as a key economic indicator in studies like rural development; Bryden (2002, November) lists employment as one of economic structure and performance indicators. On that note, the dataset contains of missing two values of 2010 and 2011 in the variable TSE (total shipyards employees). During the analysis, the list-wise deletion was used as a STATA default.

$$\mathbf{GRDP} = \alpha + \mathbf{TSE}\cdot\beta_1 + \mathbf{Population}\cdot\beta_2 \qquad \text{(Model 1)}$$
$$\mathbf{NTE} = \alpha + \mathbf{TSE}\cdot\beta_1 + \mathbf{Population}\cdot\beta_2 \qquad \text{(Model 2)}$$

[6] GNS: general nesting spatial model, SAC: spatial autoregressive combined model (SARAR), SDM: spatial Durbin model, SDEM: spatial Durbin error model, SAR: spatial autoregressive model (spatial lag model), SLX: spatial lag of X model, SEM: spatial error model, OLS: ordinary least squares model.

α: the constant term

β_i: coefficients β_i of the independent (exogenous explanatory) variable i; TSE, Population

Variables	Description
TSE	Total number of ship and boat building employees
GRDP (100won)	Gross Regional Product
NTE	Total number of employees
Population	Total population
NTEm	Total number of establishments

Table 4. Variables in the multiple regression analyses.

*The models that include the variable NTEm cause autocorrelation issues with larger VIF scores, as such it is eliminated in the best performing models: model 1 and 2. All observations of the variables are from 2000 to 2019, except the TSE. TSE variable is missing the year of 2010 and 2011 due to the merged dataset from two different sources; year 2000-2009 values are collected from KOSHIPA and year 2012 – 2019 values are collected from KOSIS. As the STATA default function, the listwise deletion was performed during multiple regression process.

Spatial analysis with GIS

This analysis uses the Ordinary Least Squared (OLS) regression with spatial data containing various information. The variables such as number of employees, number of establishments, population, distance from the major shipyards, and industrial diversity in each division, is constructed based mainly on the KOSIS data (Table 5). The models analyse the relationship with two indicators mentioned in the *Theoretical and conceptual frameworks*: employment (the total number of employees in each division) and industrial diversity (diversity ratio in each division). These indicators are incorporated as dependent variables in the spatial analysis with GIS and the spatial econometrics, adopting the concept of Tran (2011) and Xu et al. (2002) studies. Tran (2011) uses these two indicators not only for statistical relationships but also for spatial spillover effects of economic growth using employment and industrial diversity indicators in the US context. Industrial diversity as economic diversity indicator is measure with ratio for the simplicity; Xu et al. (2002) states that the industrial diversity can be measured simply percentage of economic structures to complex analysis. The base model for the analysis is as it follows.

$$\mathbf{Y} = \alpha + \beta_i \mathbf{X}_i + \varepsilon$$

Y: dependent variable; Total_Employees, Industrial diversity_main categories, Industiral diversity_sub categories

α: the constant term

$\beta_i X_i$: independent (exogenous explanatory) variable i with parameter β_i; the variables besides the dependent variables in Table 5

ε: disturbance term

Variables	Description
Total_Employees	Total number of employees in each administrative division
Establishments	Total number of establishments in each administrative division
ship/boat building establishments	Total number of ship and boat building establishments in each administrative division
ship/boat building employees	Total number of ship and boat building employees in each administrative division
Average size of the shipbuilding	Ratio of *total number of ship and boat building employees* by *ship and boat building establishments*
Population	Total population in each administrative division
Working_age15-64	Total number of population age 15 -64 in each administrative division

Industrial diversity_main categories	Ratio of total number of industrial types by 19 (the number of the main categories) in each administrative division
Industrial diversity_sub categories	Ratio of total number of industrial types by 73 or 74 (the number of the sub categories) in each administrative division
Distance	The distance from the two major shipyards to each administrative division

Table 5. Variables in the spatial analysis with GIS

Spatial econometrics

All eight models in the analyses incorporate fixed effects. Using models with random (more efficient) or fixed effects (more consistent, but only controlling time-invariant variables) generate a model explaining data less biased and less erroneous with panel data, as such crucial determinant in model construction (Elhorst, 2005). Unlike pooled models, which is under the assumptions of each observation treated independently (same specification in same parameter values), models with random or fixed effects take the *within unit variation* into account. This prevents autocorrelation and heteroscedasticity issues which the Pooled models often confronts; Pooled models can miss unobserved variables affecting the error term which leads unreliable and biased coefficients of explanatory variables (Mehmetoglu & Jakobsen, 2017).

Binary contiguity weight matrix (BC) is incorporated in all models. Distance and connectivity in spatial analyses are crucial under the Tobler's law of geography, therefore finding the most suitable spatial weight matrix is a critical process. The simplest W matrix is the BC, which only considers the bordering spatial units. Row normalization in the matrix is a common practice because of the ability to compare 'different weighting schemes'; the mathematical transformation produces each row sum equals one (Dubin et al., 2009, p125). Incorporating BC in this investigation is due to the result of the Cross-Sectional Dependence Exponent Estimation and Pesaran Test (CD test), which indicates the significant p-value (< 0.05) with $\alpha=0.524$. These results suggest moderate cross-sectional dependence in the dataset, as such a model with a sparse spatial weight matrix using ML/IV/GMM will be propriate (Elhorst, et al., 2021). Another suggestion from the CD test is incorporating common factors. Adding common factors, *cyclical sensitivity*, in models is critical because it "filters out the common time trends in the data.", unlike the time-period fixed effects (Elhorst, 2021) and observe different impacts on individual spatial units (Shi & Lee, 2017). Using cross-sectional averages (CSAs) as common factors enables the estimation of the relationships between the local and individual scales. Therefore, this investigation incorporates fixed effects, BC, and common factors in models. Additionally, dynamic models are explored to see the model performance and habit persistence. The basic model is presented below.

$$\mathbf{Y}=\rho W\mathbf{Y}+\alpha\iota_N+\mathbf{X}\beta+W\mathbf{X}\theta+u,\ u=\lambda Wu+\varepsilon$$

Y: an N×1 vector, dependent variable

$X\beta$: an N×K matrix, independent (exogenous explanatory) variable with parameter β

ρWY: endogenous effects/ global spatial interactions with parameter ρ

$WX\theta$: exogeneous effects/ local spatial interactions with parameter θ

u: disturbance term

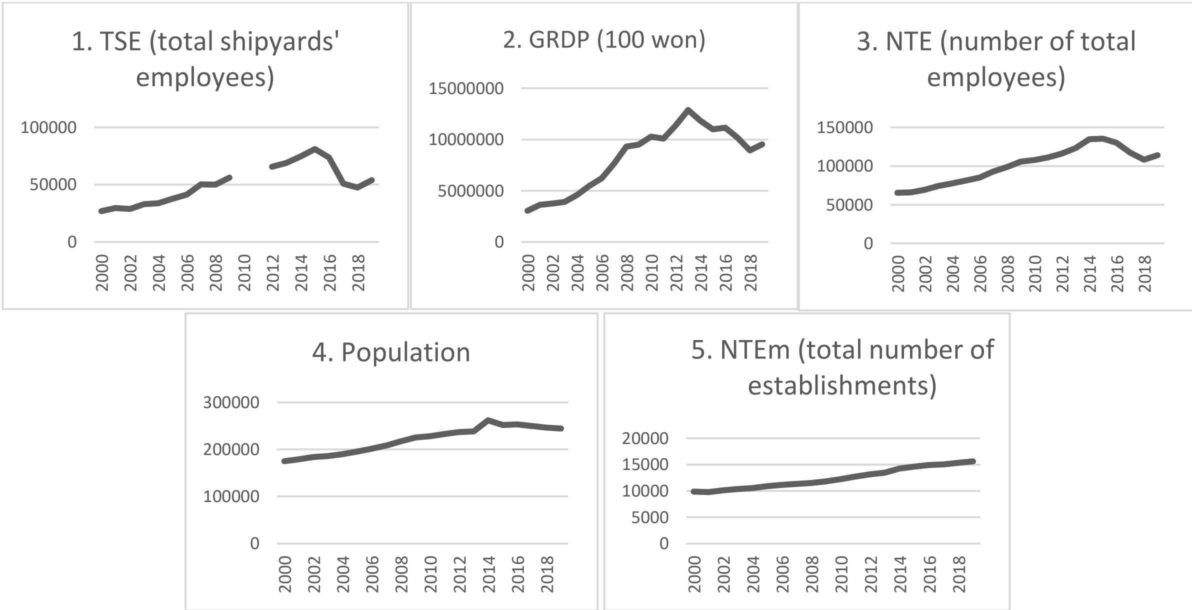
λWu: spatial interactions in disturbance term

$\alpha\iota_N$: an N×1 vector with the constant term parameter α

*W is binary contiguity weight matrix

4. Result

*4.1. **Multiple regression with STATA:** general overview*



Graphs 1-5. Descriptive graphs

The descriptive graphs (Graph 1 – 5) suggest possible relationships between the shipbuilding industry and local economy by the GRDP and employment. The graphs indicate similar visual patterns among some variables (Table 4) such as the total shipbuilding industry employees (TSE), GRDP, the number of total employees (NTE), and population in Geoje. These graphs show continuous increase up to 2007, then stagnation and upwards until 2015, followed by decreasing trends up to 2017 before another increasing trend. The last increase might be related the public investment (around 8.1 million euros[7]) to the one of the main shipyards between 2015 and 2017. These patterns align with the historical point of view from the previous literature that describes external shocks such as 2007 global financial crisis and growth of Chinese shipbuilding industry (see Woo & Lee, 2018).

Model (1)		**Model (2)**	
GRDP = β_0 + TSE·β_1 + Population·β_2		NTE = β_0 + TSE·β_1 + Population·β_2	
TSE 94.004 (3.21)	VIF 4.87	TSE 0.64 (12.69)	VIF 4.87
Population 54.647 (3.23)	VIF 4.87	Population 0.46 (15.92)	VIF 4.87
	Adj R^2: 0.918		Adj R^2: 0.996

Table 6. Multiple regression models

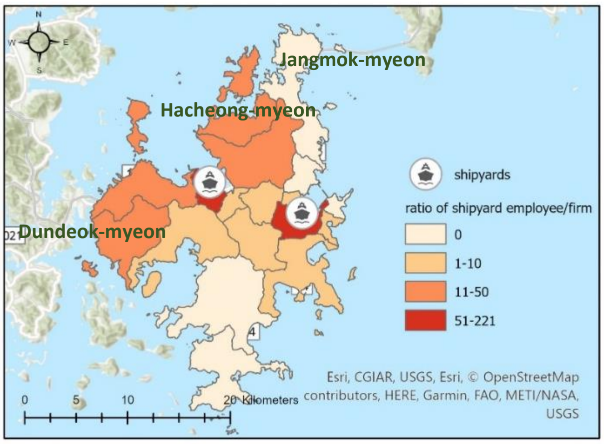
As an overview of the regional economic lock-in effects, the shipyards in Geoje have statistically significant relationship with GRDP and NTE. Treating the year as independent observations, the results indicate that one unit (person) increase of TSE increase GRDP by 9,400 won (approximately 6.92 euros[8]), and NTE by 0.64 (employee) with 1% level of significance. The population variable is added for the controlling factor in the model (Table 6). In summary, the regional GRDP and employment have positive relationships with the two shipyards, especially with the higher correlations of GRDP.

[7] 27. June. 2022 standard, using Google

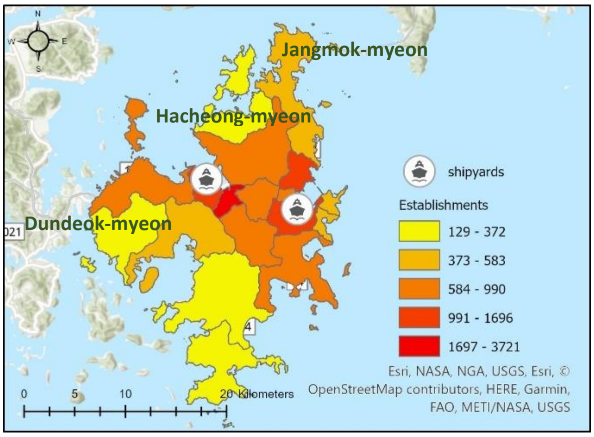
[8] 27. June 2022 standard, using Google

4.2. ***Spatial Regression Analysis with GIS:*** *spatial units into account*

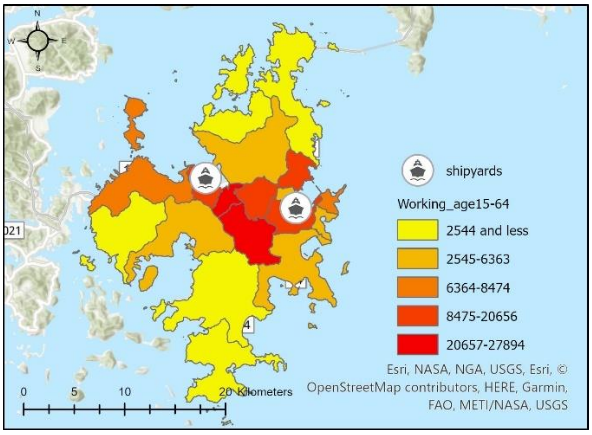
The average size of shipbuilding industry establishments in each division (Map 3) indicates which districts contain of bigger shipyards. The darker colour is the bigger establishment. As marked on the map, the districts, where the two major shipyards are located, are the darkest red. Five districts do not contain shipbuilding industry establishment: Jangmok-myeon, Okpo 2- dong, Nngpo-dong, Dongbu-myeon, and Nambu-myeon.



Map 3. The average size of the ship industry establishments in each division. The ratio is calculated by $= \frac{\textit{total number of ship industry edmployees}}{\textit{the total number of ship industry establishments}}$ in each division. This ratio indicates the average size of a ship industry establishment by employees. The legend classification indicates micro (less than 10), small (11-50), and medium and up (51 and up) firms by European Commission and the World Bank categories (Buculescu, 2013).

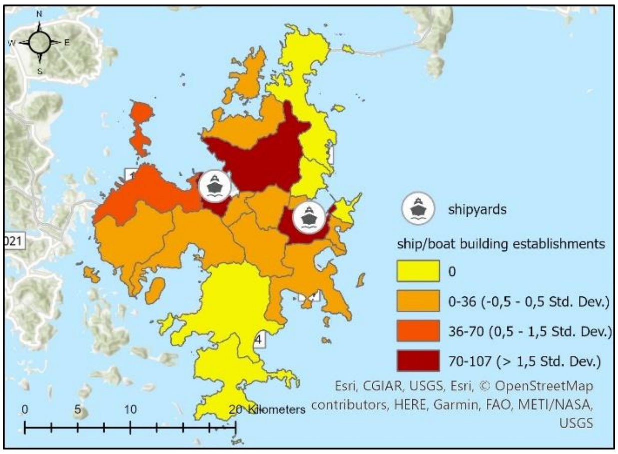


Map 4. Industrial establishments



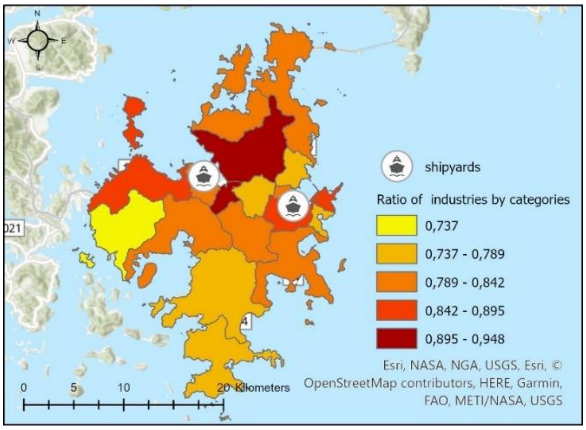
Map 5. Working population age 15-64

The proximity with the major shipyards indicates more establishments and working population (Map 4 and 5). The districts with micro and small size (averaged) shipbuilding establishments do not highly align with the total number of establishments and working population in each district (comparing Map 3 with Map 4 and 5), especially with Jangmok-myeon, Hacheong-myeon, and Dundeok-myeon. Janmok-myeon does not have any shipbuilding establishments, but more establishments than the other two districts with the shipbuilding establishments. The working population is clustered around the major shipyards' districts (Map 5); the districts between the two shipyards are concentrated with the working population. As the population data is using registered address, these districts indicate the main residential areas.

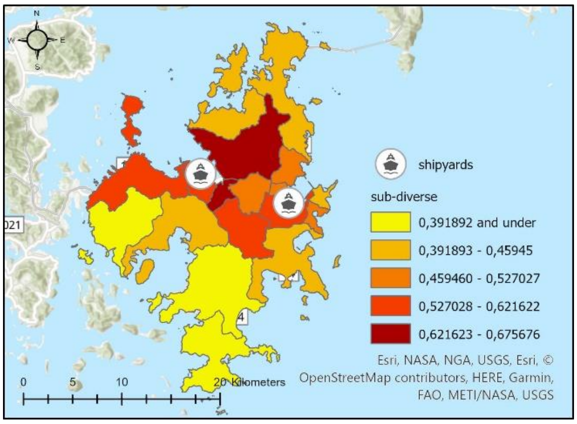


The ship and boat building establishments are clustered around the two major shipyards. This pattern aligns with the study of Woo (2004) (Map 6). In addition, the proximity with the major shipyards indicates more diverse economic structures (Map 7 and 8). Especially the industrial diversity with the sub-classification indicates the concentration of the districts centred around the shipyards.

Map 6. The number of ship and boat building establishments in each division.



Map 7. The industrial diversity by the main 19 industrial classifications



Map 8. The industrial diversity by the sub-74 industrial classifications

The ratio is calculated by $= \frac{total\ number\ of\ industrial\ types\ per\ division}{total\ industrial\ classifications}$. The higher number is the more diverse in terms of industrial types in each division.

These descriptive patterns indicate possible statistical relationships between the two major shipyards and regional economic *lock-ins*, indicated by multiple variables. However, it is important to verify the relationships with spatial statistical analysis. The following regression analyses with GIS investigate the statistically significant relationships between the shipbuilding industry and regional economic ripple effects. The Ordinary Least Squared (OLS) analysis with GIS indicates the statistically significant relationships between the shipbuilding industry and regional economy, indicated by the *total employees* and *industrial diversity*. The best model for each indicator is as follows:

Model (3)	**Model (4)**
Total number of employees = $\alpha + \beta_1$distance + β_2Establishment + $\beta_3$size + $\beta_4$working age + β_5Industiral Diversity (main categories) + ε	**Industrial Diversity** = $\alpha + \beta_1$distance + β_2Establishment + $\beta_3$size + $\beta_4$shipbuilding establishments + β_5Population+ ε

Table 7. OLS models with GIS

Employment

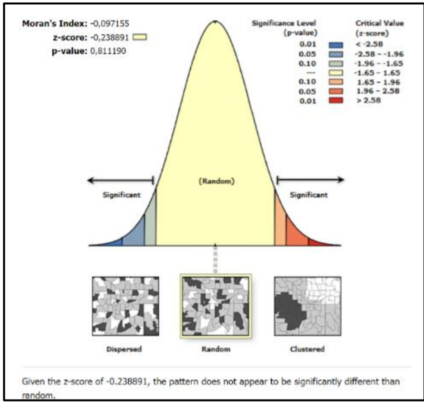
The total number of employees in each division correlates not only with the total number of establishments in each division, but also highly with the size of shipbuilding establishments with the coefficient of 125. 42 (p < 0,01). This result implies that the two major shipyards in Geoje indicates a statistically strong relationship with regional employment.

Summary of OLS Results - Model Variables

Variable	Coefficient [a]	StdError	t-Statistic	Probability [b]	Robust_SE	Robust_t	Robust_Pr [b]	VIF [c]
Intercept	4908,903569	7513,340706	0,653358	0,525843	6887,435248	0,712733	0,489633	--------
DISTANCE	-0,065220	0,163468	-0,398975	0,696926	0,084946	-0,767774	0,457457	1,567758
ESTABLISHMEN	4,787615	0,895615	5,345620	0,000173*	0,876475	5,462351	0,000143*	3,403782
SIZE	125,424097	7,190186	17,443791	0,000000*	11,517561	10,889814	0,000000*	1,246837
WORKING_AGE1	-0,051947	0,081554	-0,636967	0,536106	0,076403	-0,679916	0,509458	3,213943
INDUSTRIAL_D	-6602,197606	8889,514566	-0,742695	0,471950	8126,665746	-0,812412	0,432371	1,659305

OLS Diagnostics

Input Features:	18districts	Dependent Variable:	TOTAL_EMPLOYEES
Number of Observations:	18	Akaike's Information Criterion (AICc) [d]:	335,126209
Multiple R-Squared [d]:	0,977551	Adjusted R-Squared [d]:	0,968197
Joint F-Statistic [e]:	104,506671	Prob(>F), (5,12) degrees of freedom:	0,000000*
Joint Wald Statistic [e]:	290,064061	Prob(>chi-squared), (5) degrees of freedom:	0,000000*
Koenker (BP) Statistic [f]:	13,552953	Prob(>chi-squared), (5) degrees of freedom:	0,018713*
Jarque-Bera Statistic [g]:	2,911762	Prob(>chi-squared), (2) degrees of freedom:	0,233195



Model 3. The statistical results and model performance with the dependent variable 'total employees'. The model is statistically significant with the adjusted R-Squared, 0.97 (significant joint F-Statistics and joint Wald Statistics). Also, the model indicates no biased (Jarque-Bera Statistic, not significant) and random distributed residuals (Global Moran's I test). The inconsistent relationship (spatial non-stationary) between the dependent variable and explanatory variables is also indicated by the significant result of Koenker (BP) Statistic. Variance inflation factors (VIF) are less than 7.5 which indicates no multicollinearity issues. * An asterisk next to a number indicates a statistically significant p-value (p < 0,01).

Industrial diversity

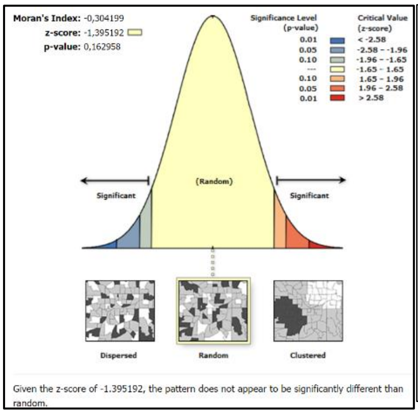
In the descriptive analysis, the industrial diversity with sub-73/74 categories indicates more concentrated patterns around the shipyards (Map 8). Therefore, the industrial diversity using the sub-categorise are incorporated as a dependent variable to explain the relationship between shipbuilding industry and regional economy (Model 4). Even though the correlations are low among the explanatory variables, it is important to highlight the three statistically significant variables: distance from the two major shipyards, the total number of shipbuilding establishments, and the average size of the shipbuilding establishments. The distance variable implies that the districts further away from the two shipyards are less diverse in industrial structures. This result supports the descriptive analysis, Map 8. Also, the divisions with more establishments of shipbuilding industry shows higher industrial diversity. However, the average size of the industry in each division indicates the negative correlation with industrial diversity. This result implies that industrial diversity in each division correlates positively to the number of the shipbuilding establishments, but negatively to the size of the establishments. As the map 7 and 8 show, the two districts with the major shipyards are not the most diverse in industrial diversity. This negative relationship cannot be explained with this analysis, but taking large land site requirement for shipbuilding industry into account, land use for other establishments might be limited in districts with bigger shipbuilding establishments.

Summary of OLS Results - Model Variables

Variable	Coefficient [a]	StdError	t-Statistic	Probability [b]	Robust_SE	Robust_t	Robust_Pr [b]	VIF [c]
Intercept	0,431529	0,026315	16,398876	0,000000*	0,021742	19,847634	0,000000*	--------
DISTANCE	-0,000009	0,000004	-2,121071	0,055427	0,000002	-3,740397	0,002826*	1,509057
ESTABLISHMEN	0,000035	0,000020	1,768596	0,102354	0,000011	3,176613	0,007975*	2,527505
SHIP_BOAT_BU	0,002106	0,000483	4,357098	0,000936*	0,000398	5,298121	0,000187*	2,740644
SIZE	-0,000626	0,000271	-2,310052	0,039469*	0,000221	-2,829796	0,015181*	2,701718
POPULATION	0,000003	0,000001	1,921043	0,078799	0,000001	2,333159	0,037849*	2,912994

OLS Diagnostics

Input Features:	18districts	Dependent Variable:	SUBDIVERSE
Number of Observations:	18	Akaike's Information Criterion (AICc) [d]:	-45,512973
Multiple R-Squared [d]:	0,886116	Adjusted R-Squared [d]:	0,838664
Joint F-Statistic [e]:	18,673988	Prob(>F), (5,12) degrees of freedom:	0,000014*
Joint Wald Statistic [e]:	293,982363	Prob(>chi-squared), (5) degrees of freedom:	0,000000*
Koenker (BP) Statistic [f]:	4,611072	Prob(>chi-squared), (5) degrees of freedom:	0,465161
Jarque-Bera Statistic [g]:	1,361808	Prob(>chi-squared), (2) degrees of freedom:	0,506159



Model 4. The statistical results and model performance with the dependent variable 'industrial diversity'. The model is statistically significant with the adjusted R-Squared, 0.83 (significant joint F-Statistics and joint Wald Statistics). Also, the model indicates no biased (Jarque-Bera Statistic, not significant) and random distributed residuals (Global Moran's I test). The consistent relationship (spatial stationary) between the dependent variable and explanatory variables is indicated by the insignificant result of Koenker (BP) Statistic. Variance inflation factors (VIF) are less than 7.5 which indicates no multicollinearity issues. * An asterisk next to a number indicates a statistically significant p-value ($p < 0{,}01$).

In summary, the spatial analyses, incorporating the spatial factor in the statistical models, indicate that the shipbuilding industry is an influential element of the local economy. The shipbuilding industry in Geoje relates to spatial patterns in economic indicators such as employment, industrial diversity, establishments' locations, and working population. The investigation in depth with OLS analysis with GIS shows statistically positive relationship with local employment and industrial diversity (except the size of shipbuilding establishments) with spatial factor in the models.

4.3. ***Spatial Econometrics***: Time and Spatial spillover effects into account

Employment

As the first step for searching the *best* model, all the eight models are performed with the following equation:

$$\textbf{Number of Employees (NE)} = \rho W^*\textbf{NE} + W^*\textbf{shipyards' establishments}^*\theta_1 + W^*\textbf{population}^*\theta_2 + W^*\textbf{size}^*\theta_3 + u,\ u=\lambda Wu+\varepsilon.$$

All the coefficients of direct effects are similar in magnitudes, directions (+ or -), and significance. However, the indirect variables show some different outcomes. For example, W x Population is significant in SDM, SDEM, and GNS models, but not in SLX model. In the same manner, W x u is significant in SEM model, but not in SAC, SDEM, and GNS. For the model performance, not only R^2 but also Log-likelihood are compared. Although the R^2 of SDEM is highest, the Log-likelihood is higher in SDM. In the same manner, Log-likelihood is highest in GNS, but the Log-likelihood Ratio Test (LR test) between SDM, and GNS is not significantly different (Table 8). Therefore, using SDM is rational to investigate further with dynamic and common factors.

	OLS	SAR	SEM	SLX	SAC	SDM	SDEM	GNS
Size (average employment per establishments)	38.87 (7.01)	35.527 (6.66)	36.566 (6.74)	39.509 (6.97)	36.54 (6.73)	38.659 (7.04)	38.562 (7.5)	38.531 (7.06)
SE (shipbuilding industry establishments	136.17 (7.99)	121.404 (7.28)	122.568 (7.4)	139.119 (7.92)	122.742 (7.39)	130.497 (7.83)	136.12 (8.3)	130.722 (7.83)
Population	0.174 (4.92)	0.170 (5.16)	0.179 (5.51)	0.164 (4.45)	0.179 (5.47)	0.158 (4.71)	0.158 (4.59)	0.156 (4.64)
W x TNE		-0.155 (-1.5)		-0.226 (-1.4)	-0.043 (-0.33)	-0.209 (-1.96)		-0.134 (-0.85)
W x Size				23.211 (1.95)		22.129 (1.71)	15.012 (1.57)	18.207 (1.27)
W x SE				51.613 (1.58)		13.438 (0.4)	22.323 (0.9)	-0.134 (0.000)
W x Population				0.192 (0.019)		0.207 (2.65)	0.149 (2.1)	0.188 (2.23)
Year	12.45 (0.45)			-2.125 (-0.06)				
W x u			-0.214 (-2.02)		-0.187 (-1.39)		-0.083 (-0.8)	-0.104 (-0.64)
R^2	0.353	0.3336	0.3507	0.382	0.3463	0.3630	0.3753	0.3594
Log-likelihood	-1662.5012	-1656.539	-1655.644	-1657.938	-1655.588	-1652.765	-1658.737	-1652.5492

Table 8. Estimation results using static spatial panel data models. The t-values are in the parentheses. The spatial and time-period fixed effects are included in the models. W is pre-specified binary contiguity matrix with row normalization. The within R^2 is compared because of using fixed effects in the models.

As a second step, the comparison (Table 9) among the non-dynamic model, the dynamic model, and the dynamic model with common factors are performed. This step is critical for the *best* model search because of considering the *habit persistence* and *cyclical sensitivity* into the models. In the comparison between the model (5) and (6), the dynamic model performs better with the higher R^2 and loglikelihood ratio, thus the model (6) is better. Some changes of coefficients are detected. The TNE spillover effect (ρ) is changed from negative to positive, and from significant to insignificant results. The population variable is not significant anymore in model (6). The comparison between the model (6) and (7), the dynamic SDM with common factors performs better than model (6) as the LR test result, LR chi2(36) = 245.22. The significant change is that the η is no longer significant; this means no longer significant habit persistence; previous year's TNE (the dependent variable) does not impact the current TNE in the neighbouring division. As a result of the model search, the dynamic SDM using binary contiguity weight matrix with common factors is the *best* performing model. The advantages of estimating with dynamic model are not only long- and short-term effect estimations but also detecting *habit persistence*. These abilities are beneficial for policy making point of views. Finally, for the stationary check, the following conditions must be satisfied: $\tau+\rho+\eta<1$ or $\tau+\eta<1$ if WY_t is not included. The model (6) and (7) in the Table 9 satisfy the stationary condition with 0.505 and 0.382.

$$Y_t=\tau Y_{t-1}+\rho WY_t+\eta WY_{t-1}+X_t\beta+WX_t\theta+\mu+\alpha_t\iota_N+u_t \qquad \text{(equation for the dynamic model)}$$

Determinants		(5)		(6)		(7)	
		Non-dynamic Spatial Durbin Model with fixed effects		Dynamic Spatial Durbin Model with lag WY_{t-1}		Dynamic Spatial Durbin Model with common factors	
TNE_{-1}	(τ)			0.758	(12.37)	0.413	(5.56)
W*TNE	(ρ)	-0.209	(-1.96)	0.106	(0.96)	0.033	(0.33)
$W*TNE_{-1}$	(η)			-0.359	(-2.18)	-0.064	(-0.42)
Size		38.659	(7.04)	36.473	(7.62)	23.659	(8.29)
SE		130.497	(7.83)	61.166	(3.87)	37.016	(3.65)
Population		0.158	(4.71)	0.08	(2.63)	0.065	(3.41)
W*Size		22.129	(1.71)	4.196	(0.36)	-7.069	(-1.3)
W* SE		13.438	(0.4)	27.848	(0.95)	11.067	(0.66)
W* Population		0.207	(2.65)	0.036	(0.51)	0.004	(0.09)
R2		0.3630		0.5641		0.9008	
LogL		-1652.765		-1480.5135		-1344.5185	

Table 9. Static, dynamic, and dynamic with common factors with SDM model comparison. All models are used the binary contiguity matrix for W. The spatial and time-period fixed effects are included in (5) and (6) models. The CSAs is added in model (7). The t-values are in parentheses.

According to model (7), the *best* model, the direct effect of dependent variable (TNE) presents habit persistence, which means that last year's TNE has statistically significant and positive relationship with current year's TNE. In addition, the direct effects of all three explanatory variables are statistically significant and positive to TNE. Most importantly, the variables of the shipbuilding establishment size and number of employees indicate that there are significant relationships between the shipbuilding industry and the local employment (model (7) in the Table 9), supporting the regression analysis with GIS result. However, spatial spillover effects are not indicated. Lastly, the short- and long-term direct effects of all explanatory variables are significant, but none of the indirect effects (Table 10). Another benefit of investigation with spatial econometrics is that the model indicates which spatial unit[9] presents statical significance, and statistically significant habit persistence (Map 9). The results of the model (7) indicate the divisions of Aju-dong, Jangpyung-dong, and Gohyun-dong are significantly sensitive, which means that these spatial units are sensitive or less resilient to employment changes. Aju-dong and Jangpyung-dong present significantly sensitive habit persistence, which means that these two units are sensitive or less resilient to the previous year's employment.

Determinants			(7)	
			Dynamic Spatial Durbin model with common factors	
Short-term	Size	direct effect	23.84	(8.53)
		indirect effect	-6.31	(-1.19)
	SE	direct effect	37.757	(3.69)
		indirect effect	13.567	(0.81)
	Population	direct effect	0.0655	(3.57)
		indirect effect	0.007	(0.17)
Long-term	Size	direct effect	41.07	(8.49)
		indirect effect	-13.318	(-1.46)
	SE	direct effect	64.12	(3.62)
		indirect effect	17.107	(0.61)
	Population	direct effect	0.112	(3.52)
		indirect effect	0.002	(0.03)

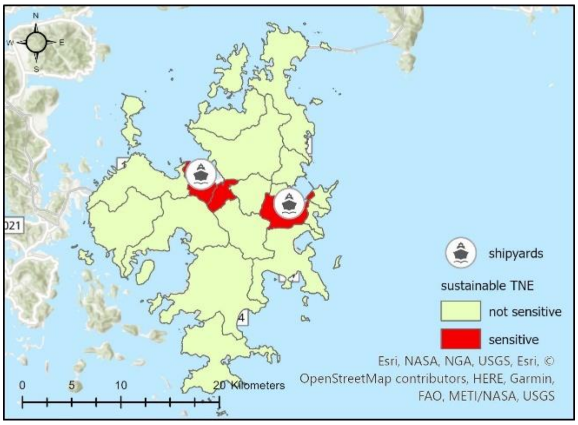


Table 10. The effects estimate of the short and long-term in the model (3) & **Map 9**. Significant spatial units

[9] The unit names of Geoje on the map is in Appendix.

Industrial diversity

Rewriting the basic model to 'Industrial Diversity' analysis is presented as followed:

Industrial Diversity (ID) = ρW***ID** + W***shipyards' establishments***θ_1+ W***population***θ_2 + W***size***θ_3 +u, u=λWu+ε

The variables of size and SE in all eight models indicate similar in magnitudes, directions (+ or -), and significance. However, the population variable changes the directions in the SDEM and GNS. The indirect variables show conflicting outcomes. For example, W x IDiversity is significant in SAR and SAC models, but not in SLX, SDM and GNS models. Also, this variable changes the direction in SLX model (positive). The W x size is insignificant in SDEM model, but significant in SLX, SDM, and GNS. The W x SE variable is significant in SDM and GNS, but not in SLX and SDEM. For the model performance by R^2 and Log-likelihood, the SDM is considered to perform the best. Although the R^2 of SDM is in the lower end, the Log-likelihood is high in SDM. The LR test results indicate the SDM and GNS outperformed the rest. The LR test between SDM, and GNS is not significantly different (Table 11), but the R^2 in the SDM is higher. Therefore, using SDM is rational to investigate further with dynamic and common factors. Although, dynamic GNS model with common factors can be performed, but is not proceeded further because of much needed model developments. Dynamic GNS model with common factors is most advanced development in spatial econometrics, which provides researchers work with not only space and time lags for the dependent variable, but also unit and time specific effects. Nonetheless, using this model for empirical research needs further discussions (Elhorst, 2021).

	OLS	SAR	SEM	SLX	SAC	SDM	SDEM	GNS
Size (average shipbuilding industry employees per establishment)	-0.0003 (-2.72)	-0.0003 (-2.44)	-0.0003 (-2.23)	-0.0003 (-2.28)	-0.0003 (-2.57)	-0.0002 (-1.66)	-0.0004 (-3.01)	-0.0002 (-1.86)
SE (shipbuilding industry establishments)	-0.0007 (-1.81)	-0.0004 (-1.13)	-0.0003 (-0.92)	-0.001 (-1.71)	-0.0004 (-1.26)	-0.0003 (-1.04)	-0.0005 (-1.25)	-0.0004 (-1.25)
Population	0.0000 (3.50)	0.0000 (4.35)	0.0000 (4.11)	0.0000 (3.92)	0.0000 (4.41)	0.0000 (5.00)	-0.0000 (4.08)	-0.0000 (5.08)
W x IDiversity		-0.233 (-2.47)		0.21 (1.84)	-0.314 (-2.06)	-0.183 (-1.88)		-0.019 (-0.12)
W x Size				0.001 (2.43)		0.0007 (2.75)	0.0002 (0.92)	0.0007 (2.94)
W x SE				0.0004 (0.71)		0.002 (2.34)	0.001 (1.52)	0.0016 (2.65)
W x Population				-0.0000 (-2.04)		-0.0000 (-1.18)	-0.0000 (-0.74)	-0.0000 (-1.64)
Year	0.0034 (5.61)			0.004 (4.89)				
W x u			-0.163 (-1.64)		0.106 (0.68)		0.305 (3.67)	-0.215 (-1.23)
R^2	0.303	0.169	0.1728	0.364	0.1679	0.1138	0.1867	0.0988
Log-likelihood	462.70968	483.0604	481.4502	471.7367	483.2624	489.2826	454.8688	490.0603

Table 11. Estimation results using static spatial panel data models. The t-values are in the parentheses. The spatial and time-period fixed effects are included in the models. W is pre-specified binary contiguity matrix with row normalization. Within R^2 is compared because of using fixed effects.

The comparison (Table 12) among the model (8), (9), and (10), the dynamic model (10) with the common factors performs the best with the higher R^2 and loglikelihood ratio. The R^2 is highest in the model (10), which the dependent variable can be explained almost 66% by the explanatory variables. Although the model (8) indicates the higher Log-likelihood, this does not significantly differ from the model (10). Some changes of coefficients are detected. The IDiversity spillover effect (ρ) is changed from negative to positive in the model (8) and (9), also switched to significant in the model (10). The notable aspect of this comparison is that all the neighbouring effects are insignificant in model (10). For the stationary check, the model (10) in the Table 12 satisfies the stationary condition with 0.55.

Determinants		(8)		(9)		(10)	
		Non-dynamic Spatial Durbin Model with fixed effects		Dynamic Spatial Durbin Model with lag WY_{t-1}		Dynamic Spatial Durbin Model with common factors	
$IDiversity_{-1}$	(τ)			0.44	(6.25)	0.365	(4.95)
W*Idiversity	(ρ)	-0.183	(-1.88)	0.139	(1.38)	0.225	(2.19)
$W*Idiversity_{-1}$	(η)			-0.012	(-0.08)	-0.04	(-0.27)
Size		- 0.0002	(-1.66)	-0.0002	(-1.73)	-0.0002	(-1.58)
SE		-0.0003	(-1.04)	-0.0004	(-1.29)	-0.0001	(-0.35)
Population		0.0000	(5.00)	0.0000	(3.65)	0.0000	(0.11)
W*Size		0.0007	(2.75)	0.0004	(1.61)	0.0003	(1.57)
W* SE		0.002	(2.34)	0.0011	(1.72)	0.0006	(1.24)
W* Population		-0.0000	(-1.18)	-0.0000	(-1.19)	-0.0000	(-0.45)
R^2		0.1138		0.2882		0.6583	
LogL		489.2826		397.1161		484.0422	

Table 12. Static, dynamic, and dynamic with common factors with SDM model comparison. All models are used the binary contiguity matrix for W. The spatial and time-period fixed effects are included in (8) and (9) models. The CSAs is added in model (10). The t-values are in parentheses.

The best model, the model (10), indicates that the *habit persistence* and *spatial spillover* in the dependent variable, even though the coefficients are low, almost to the 0. First, the previous year of industrial diversity (τ) matters; it affects the current year's industrial diversity positively by 36.5%. Second, the spatial spillover on the dependent variable (ρ) matters: the neighbouring divisions' industrial diversities relate its own industrial diversity by 22.5%. However, any other statistically significant relationships are not found in this analysis unlike the previous analysis with the employment. Similarly, the short- and long-term (in)direct effects of all explanatory variables are not significant (Table 13). In addition, the results of the model (10) indicate the eleven divisions[10] are significantly sensitive spatial units and the four units[11] present significantly sensitive habit persistence (Map 10).

Determinants			(10)	
			Dynamic Spatial Durbin model with common factors	
Short-term	Size	direct effect	-0.0002	(-1.67)
		indirect effect	0.0003	(1.74)
	SE	direct effect	-0.0001	(-0.38)
		indirect effect	0.0006	(1.26)
	Population	direct effect	0.0000	(0.17)
		indirect effect	-0.0000	(-0.46)
Long-term	Size	direct effect	-0.0003	(-1.75)
		indirect effect	0.0005	(1.84)
	SE	direct effect	-0.0003	(-0.46)
		indirect effect	0.0009	(1.22)
	Population	direct effect	0.0000	(0.21)
		indirect effect	-0.0000	(-0.46)

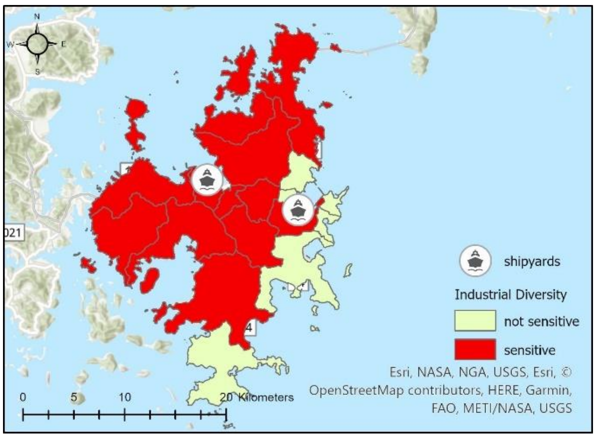


Table 13. The effects estimate of the short and long-term in the model (10) & **Map 10**. Significant spatial units

[10] Dongbu-myeon, Geoje-myeon, Sadng-myeon, Yeoncho-myeon, Hacheong-myeon, Jangmok-myeon, Aju-dong, Jangpyung-dong, Gohyun-dong, Sangmoon-dong, and Suyang-dong.
[11] Dunduck-myeon, Yeoncho-myeon, Jangpyung-dong, and Gohyun-dong.

In summary, the shipbuilding industry has relationships with the employment indicator, but not with the industrial diversity indicator with panel data. The spatial spillover effects are only shown in the industrial diversity variable, which means that own-industrial diversity influence its neighbouring spatial units. Both the analyses are interpreted with the dynamic SDM with common factors as the *best* model to explain the relationship.

5. Conclusion and discussion

This paper investigated the lock-in ripple effects of the shipbuilding industry on the local economy using a triangulation approach. In this investigation, three types of different quantitative analyses were performed: multiple regression, spatial analysis with GIS, and spatial analysis with spatial econometrics models. For the overview using multiple regression, the GRDP and employment (using total number of employees in Geoje) have statistically positive relationships. These results not only support previous studies on local economy *lock-in* effects (Hassink, 2010; Woo & Lee, 2018; Woo, 2004; Park, 2008), but also contributed a novel analytical exploration incorporating eighteen administrative divisions in Geoje. Adopting spatial factors in the rest two analyses provided not only detecting the spatial patterns but also different magnitudes of the effects across the individual spatial units. The spatial analysis with GIS provided the insights of how the lock-in indicators, employment and industrial diversity, are related to the shipbuilding industry. Both indicators show positive relationship with the industry, even though the low coefficients of variables were prevalent in the industrial diversity analysis. Although the spatial analysis with GIS delivered the fruitful insights, the over-the-year relationship cannot be analyzed with the GIS models. In this respect, the spatial analysis with spatial econometrics complemented the weakness of the spatial analysis with GIS, and provided critical information such as spillover effects and habit persistence. The employment indicator supports the spatial analysis with GIS result, but the industrial diversity indicator does not present any statistical relationships with the shipbuilding industry. However, the neighbouring effect of the industrial diversity variable is notably presented. Therefore, the hypothesis of the research, *the shipbuilding industry in Geoje induces ripple effects on local economies in term of the local employment and industrial diversity*, is not rejected. Although some might argue that statistical relationship is difficult to be asserted the causal effects (Reiter, 2000), under the evidences of previous studies and the path dependence theoretical framework, we can imply that the shipbuilding industry in Geoje impacts the local economy.

This research contributes the important insights of the Geoje specific local economy *lock-ins* along with the dominant industry in the *path dependence* of the regional development literature; the new analytical approach indicates the *lock-in* ripple effects and the spatial patterns with the shipbuilding industry. Although these analytical results mainly focus on functional lock-ins, which was investigated with the economic indicators, this paper also provides the initiation of policy discussions. As we discussed in the *Theoretical framework*, the central government involvements are still persistent (for recent examples, 2015-2017 investments, Woo & Lee, 2018; the most recent *smart and green* industry, Moon, 09.09.2021), although Hassink (2010) suggested a promising sign of less governmental subsidies over the years into the industry. These functional and political *lock-ins* limit endogenous innovations and the capability of self-restructuring the economic structure in Geoje (Hassink ,2010; Hassink & Shin, 2005; Woo & Lee, 2018). As such, the current economic structure in Geoje is seen as not stable nor resilient from external shocks. Moreover, heavy industries are continued to be a critical role in local, regional, and national levels, which means these functional and political lock-ins are difficult to be changed. Therefore, the effects of another governmental intervention, this time for the green and smart transition, has to be critically discussed regarding to how the industrial transformation impacts the local economy down the road. As Bailey et al., (2010) suggests with auto industry transformation under climate change pressure, the industry will innovate to survive through bringing R&D and green technology within its path dependences.

Reflecting on Martin and Sunley's (2006) de-locking framework into the Geoje case, this paper discusses the Geoje specific local policies towards to the more sustainable local economy with the research outcomes. Lester (2005) reports the role of universities connecting to local industrial transformation, thus to local economic innovations. In his report, he enumerates *the typology of the industrial transformation processes* as *indigenous creation, transplantation from elsewhere, diversification into technologically related industries,* and *upgrading of existing industries*. Martin and Sunley (2006) adopt these typology as de-locking mechanisms, adding *Heterogeneity and diversity* in the list. The shipbuilding industry in Geoje started with the *indigenous creation* triggered by the central government plans in 1970s. Once the island with primary industries such as fishing and farming developed totally new path to the centre of the international shipbuilding business. Now with the recent development, injecting new technologies in the Geoje shipbuilding industry is creating the de-locking process not only for the industry but also for the local economy. As the mechanisms of the *diversification into technologically related industries,* and *upgrading of existing industries* describe, the industrial transformation initiates "the foundations for a new trajectory of regional development and growth; or by a radical upgrading and enhancement of a region's industrial base through the infusion of new technologies, or by introducing new products and services" (p423).

Therefore, two main policy questions are discussed as follows. First, as we see the research outcomes of this paper, the local employment is strongly connected to the shipbuilding industry. This *upgrading of existing industries* in the shipbuilding industry can influence the local labour market with skilled and educated human capital. This new labour influx can induce creative labour force, thus more resilient to external shocks (Martin & Sunley, 2006). However, there should be a policy discussion about how to attract these creative groups to remain in Geoje after any shocks similar to the research of Glaeser (2005) with the Boston case. Second, this paper indicates the significant neighbouring effects of the industrial diversity in each spatial units in Geoje. The *diversification into technologically related industries* in the context of Geoje can diversify not only the shipbuilding industry itself, but also the local organizations and industries. This can be link with local economy towards to the *heterogeneity and diversity* which "promotes constant innovation and economic reconfiguration, avoiding 'lock-in' to a fixed structure" (p420). However, there should be a policy discussion how to link local (un)related firms to the industrial transformation to maximize the diversification effects on other local industries. A step forward, how to link the transformation to the local, regional, national, and international networks of new R&D and technology inputs should also be discussed. As several scholars suggest (see Grabher, 1993; Saxenian, 1996; Martin & Sunley, 2006), the loosely connected local network among economic agents can be discussed because this system "provide(s) both specialization and adaptability." (p420), thus more resilient local economy. Finally, the aforementioned two policy discussions are need to be based on profound research, as such funding research on local and regional economic development of Geoje needs to be discussed in policy level.

Investigating with a triangulation approach provided multi-angle interpretations of the outcomes, and a foothold for the local economy policy discussions in this critical juncture. However, several limitations on the research must be noted. First, the results of the industrial diversity contain very low coefficients, even though they are statistically significant. There should be further exploration of data and calculation for better statistical outcomes. Second, the absence of GRDP data in the division level could not provide the statistical outcomes with a main economic indicator. Third, an investigation with location data of establishments could have provided more sophisticated statistical relationships. Fourth, this research mainly focused on the relationship with local firms, thus it does not include any socio-cultural indicators. The main shipyards are also a big part of local contributions such as local tax, schools (Geoje University and Okpo international school), Daewoo hospital, and donations for cultural and social events (Bak, 03.11. 2017). Therefore, missing these indications lose broader economic impacts in Geoje. Taking these weaknesses into account, further research is suggested as follows: Incorporating more detailed datasets, such as location data with (un)related firms and employment in each firm, will provide the relationship between the industry and local firms rather than simply division level. In addition, a case study following the recent industrial transformation in Geoje will provide fruitful insights of place dependent path renewal as a regional development study. Lastly, comparison case study can provide important factors of different path creation and renewal under path dependence theoretical framework, especially with the current trend of industries transitioning to smart and green.

Literature

Anselin, L. (1988). *Spatial econometrics: methods and models* (Vol. 4). Springer Science & Business Media.

Anselin, L., & Getis, A. (1992). Spatial statistical analysis and geographic information systems. The Annals of Regional Science, 26(1), 19-33.

Arthur, B. (1988). Self-Reinforcing Mechanism in Economics: The Economy as an Evolving Complex System. *SFI Studies in the Sciences of Complexity, Perseus Books Publishing, LLC*.

Arthur, W. B. (1989). Competing technologies, increasing returns, and lock-in by historical events. *The economic journal*, *99*(394), 116-131.

Arthur, W. B. (1994). *Increasing returns and path dependence in the economy*. University of michigan Press.

Bailey, D., De Ruyter, A., Michie, J., & Tyler, P. (2010). Global restructuring and the auto industry. *Cambridge Journal of Regions, Economy and Society*, *3*(3), 311-318.

Bak, Seong-Ki (03.11.2007). Geoje's two major shipyards account for 70% of population and 50% of tax revenue. Haenam News. 거제 양대조선소 인구 70%·세수 50% 차지. 해남뉴스. Retrieved from: http://m.hnews.co.kr/news/articleView.html?idxno=15945 (29/06/2022)

Boschma, R., & Martin, R. (2010). *The handbook of evolutionary economic geography*. Edward Elgar Publishing.

Bryden, J. (2002, November). Rural development indicators and diversity in the European Union. In *conference on "Measuring rural diversity". Washington, DC. Available from http://citeseerx. ist. psu. edu/viewdoc/download*.

Buculescu, M. M. (2013). Harmonization process in defining small and medium-sized enterprises. Arguments for a quantitative definition versus a qualitative one. Theoretical and Applied Economics, 9(586), 103-114.

Darwin, C. (1859). The Origin of Species by Natural Selection. Murray, London

David, P. A. (1985). Clio and the Economics of QWERTY. *The American economic review*, *75*(2), 332-337.

David, P. A. (1994). Why are institutions the 'carriers of history'?: Path dependence and the evolution of conventions, organizations and institutions. *Structural change and economic dynamics*, *5*(2), 205-220.

David, P. A. (1997). Path dependence and the quest for historical economics: one more chorus of the ballad of QWERTY.

David, P. A. (2000). Path dependence, its critics and the quest for 'historical economics'. *Market Failure or Success*, 79.

David, P. A. (2007). Path dependence: a foundational concept for historical social science. *Cliometrica*, *1*(2), 91-114.

Dubin, R., Fotheringham, A. S., & Rogerson, P. A. (2009). Spatial weights. *The Sage handbook of spatial analysis,* 125-158.

Elhorst, J. P. (2005). Unconditional maximum likelihood estimation of linear and log-linear dynamic models for spatial panels. Geographical Analysis, 37(1), 85–106. https://doi.org/10.1111/j.1538-4632.2005.00577.x

Elhorst, J. P. (2021). The dynamic general nesting spatial econometric model for spatial panels with common factors: Further raising the bar. *Review of Regional Research*, 1-19.

Elhorst, J. P. (2014). Spatial econometrics: from cross-sectional data to spatial panels (Ser. Springerbriefs in regional science). Springer. https://doi.org/10.1007/978-3-642-40340-8

Elhorst, J.P., Gross, M., Tereanu, E. (2021) Cross-sectional dependence and spillovers in space and time: where spatial econometrics and Global VAR models meet. Journal of Economic Surveys 35(1):192-226

Essletzbichler, J., & Rigby, D. L. (2010). Generalized Darwinism and evolutionary economic geography. In *The handbook of evolutionary economic geography*. Edward Elgar Publishing.

Feriyanto, N. (2014). Determinant of gross regional domestic product (GRDP) in Yogyakarta special province. *Economic Journal of Emerging Markets*, 131-140.

Fincher, R. (1983). The inconsistency of eclecticism. *Environment and Planning A*, *15*(5), 607-622.

Fine, B. (2000). Endogenous growth theory: a critical assessment, Cambridge Journal of Economics, 24, 245-65.

Fuchs, G., & Wassermann, S. (2005). Chapter 11. Path dependency in Baden-Württemberg: Lock-in or breakthrough?. In *Rethinking regional innovation and change* (pp. 223-248). Springer, New York, NY.

Geoje City (2022). Two shipyards workers. November 2020 data. Retrieved from: https://www.geoje.go.kr/stat/index.geoje?menuCd=DOM_000009401003013003 (16. 05. 2022)

Ghazinoory, Narimani, & Tatina (2017). Neoclassical versus evolutionary economics in developing countries: Convergence of policy implications. *Journal of Evolutionary Economics*, *27*(3), 555-583.

Glaeser, E. L. (2005) Reinventing Boston, 1630–2003. Journal of Economic Geography, 5: 119–154.

Grabher, G. (1993). Chapter 12. The weakness of strong ties: the lock-in of regional development in the Ruhr area. The embedded firm: on the socioeconomics of industrial networks. Routledge.

Hassink, R. (2005). How to unlock regional economies from path dependency? From learning region to learning cluster. *European Planning Studies*, *13*(4), 521-535.

Hassink, R. (2010). Locked in decline? On the role of regional lock-ins in old industrial areas. In *The handbook of evolutionary economic geography*. Edward Elgar Publishing.

Hassink, R., & Shin, D. H. (2005). South Korea's shipbuilding industry: From a couple of Cathedrals in the desert to an innovative cluster. *Asian Journal of Technology Innovation*, *13*(2), 133-155.

Kim, A. J. (1976). Industrialization and Growth Pole Development in the Republic of Korea: A Case Study of Ulsan Industrial Complex in the Context of Regional Development in the Southern Coastal Area. *United Nations Center for Regional Development, Growth Pole Strategy and Regional Development Planning in Asia. Nayoya: UNCRD*. Retrieved from: Lo, F. C., & Salih, K. (Eds.). (2013). *Growth pole strategy and regional development policy: Asian experience and alternative approaches*. Elsevier

KOSIS (2019). GRDP Reorganization Results as of 2015. Press Release. Local Income. Korean Statistical Information Service.

Kondratieff, N. D. (1925). The static and the dynamic view of economics. *The Quarterly Journal of Economics*, *39*(4), 575-583.

Koster, S., Brouwer, A. E., & van Leeuwen, E. S. (2020). Diversity as the key to success? Urban and rural employment dynamics in the Netherlands. *Regional studies, 54*(9), 1187-1199.

Lee, hojeong (09.09.2021). 'K-ship' is latest government industry project. Korea JoongAng Daily. In association with The New York Times. Retrieved from: https://koreajoongangdaily.joins.com/2021/09/09/business/economy/kship-moon-jaein-campaign-kseries/20210909185000806.html (14. 06. 2022)

LeSage, J. P. (1999). The theory and practice of spatial econometrics. *University of Toledo. Toledo, Ohio, 28*(11).

Lester, R. (2005). Universities, innovation, and the competitiveness of local economies. *A summary Report from the Local Innovation Systems Project: Phase I. Massachusetts Institute of Technology, Industrial Performance Center, Working Paper Series*.

Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. Journal of Economic Geography, 6(4), 395-437.

Martin, R., & Sunley, P. (2007). Complexity thinking and evolutionary economic geography. *Journal of economic geography*, *7*(5), 573-601.

Martin, R., & Sunley, P. (2010). The place of path dependence in an evolutionary perspective on the economic landscape. In *The handbook of evolutionary economic geography*. Edward Elgar Publishing

Metcalfe, J.S., J. Foster & R. Ramlogan (2006). Adaptive economic growth, Cambridge Journal of Economics, 30, 7-32.

Mehmetoglu, M., & Jakobsen, T. G. (2017). *Applied statistics using Stata: a guide for the social sciences*. Sage.

Ministry of Trade, Industry and Energy & Ministry of Oceans and Fisheries. (2021). K-조선·해운의 재도약, 상생협력을 통한 희망찬 미래. Retrieved from: https://www.mof.go.kr/upload/whitebook/44384/book.pdf (23.04. 2022)

Moon (09.09.2021). K-Shipbuilding Vision and Win-Win Cooperation Declaration Ceremony. President press conference. Retrived from: https://www1.president.go.kr/articles/11032

Park (1998). Globalization/Localization and Organization of economic space.세계화/지방화와 경제공간의 조직. *한국경제지리학회지*, *1*(1), 11-32.

Park, Moo-Suk (2008). The study on urban regeneration focusing on the cities of shipbuilding industry. Master's thesis. Gyeongsang National University, Graduate School of Industry. Retrieved from: https://scienceon.kisti.re.kr/srch/selectPORSrchArticle.do?cn=DIKO0011437649&dbt=DIKO (06. 03. 2021)

Penrose, E. T. (1952). Biological analogies in the theory of the firm. *The american economic review*, *42*(5), 804-819.

Reiter, J. (2000). Using statistics to determine causal relationships. *The American Mathematical Monthly*, *107*(1), 24-32.

Relevant ministries, The (09.09.2021). 세계 일등 조선 강국 실현을 위한 K-조선 재도약 전략. Ministry of Trade, Industry and Energy. Retrived from: https://www.motie.go.kr/motie/ne/presse/press2/bbs/bbsView.do?bbs_seq_n=164541&bbs_cd_n=81&cu 10 rrentPage=1&search_key_n=&cate_n=&dept_v=&search_val_v=#:~:text=%EC%A0%95%EB%B6%80% EB%8A%94%209%EC%9B%94%209,%EB%8F%84%EC%95%BD%20%EC%A0%84%EB%9E%B5%E F%BD%A3%EC%9D%84%20%EB%B0%9C%ED%91%9C%ED%96%88%EB%8B%A4.&text=%E3%85 %87%20%EF%BD %A2K%2D%EC%A1%B0%EC%84%A0%20%EC%9E%AC%EB%8F%84%EC%95% BD,%EC%8B%A4%ED%98%84%ED%95%98%EA%B8%B0%20%EC%9C%84%ED%95%9C%20%EC %A0%84%EB%9E %B5%EC%9D%B4%EB%8B%A4. (23.04. 2022)

Saxenian, A. (1996) Regional Advantage: Culture and Competition in Silicon Valley and Route 128. Harvard: Harvard University Press.

Schumpeter, J. A. (1939). *Business cycles* (Vol. 1, pp. 161-174). New York: Mcgraw-hill.

Schumpeter, J. A. (1942). *Capitalism, socialism and democracy*. London: Allen & Unwin.

Scott, A. J. (2006). *Geography and economy: three lectures*. OUP Oxford.

Shi, W., & Lee, L.-fei. (2017). Spatial dynamic panel data models with interactive fixed effects. Journal of Econometrics, 197(2), 323–347. https://doi.org/10.1016/j.jeconom.2016.12.001

Tilman, D., Wedln, D., Knops, J. (1996). Productivity and sustainability influenced by biodiversity in grassland ecosystems. Nature 379, 718–720.

Tran, H. P. D. (2011). *Industrial diversity and economic performance: A spatial analysis*. The University of Nebraska-Lincoln.

U.S. BUREAU OF LABOR STATISTICS (np). Business Employment Dynamics Size Class Data: Questions and Answers. Business Employment Dynamics. United States Department of Labor. Retrieved from: https://www.bls.gov/bdm/sizeclassqanda.htm#q5 (17.05.2022)

Walker, R. (2000). The geography of production. *A companion to economic geography*, 113-132.

Witt, U. (2003). The evolving economy : essays on the evolutionary approach to economics. Edward Elgar Pub.

Witt, U. (2006). Evolutionary concepts in economics and biology. Journal of Evolutionary Economics, 16(5), 473–476. https://doi.org/10.1007/s00191-006-0034-4

Witt, U. (2016). Chapter 3: On the proper interpretation of 'evolution' in economics and its implications for production theory. In *Rethinking Economic Evolution* (pp. 19-40). Edward Elgar Publishing.

Woo, Youn-Sub (2004). A Study on the Spatial Features of Shipbuilding Subcontract Structures. The Korean Geographical Society. Volume 39. No. 1. Page 116-131, 대한지리학회지 제 39 권 제 1 호 2004 (116~131).

Woo, Jung-Suk & Lee, Sung-Cheol. (2018). Regional Lock-ins in the Shipbuilding Industry in Geoje, Gyeongnam. Journal of Korean Association of Professional Geographers. 거제시 조선산업에 대한 지역경제의 잠김 효과. *국토지리학회지*, *52*(4), 567-580.

Xu, Z., Cheng, G., Chen, D., & Templet, P. H. (2002). Economic diversity, development capacity and sustainable development of China. *Ecological economics*, *40*(3), 369-378.

Appendix

Appendix I: Industrial classifications

A	Agriculture, forestry and fishing	1. agriculture
		2. forestry
		3. fishing
B	Mining	5. Coal, oil, and natural gas
		6. Metal
		7. Non-metallic mineral; excluding fuel use
		8. Mining supporting service
C	Manufacturing	10. Food
		11. Drinks
		12. Cigarette

		13. Textile products; excluding clothing
		14. Clothing, clothing accessories and fur products
		15. Leather, bags and shoes
		16. Lumber and wood products; excluding furniture
		17. Pulp, paper, and paper products
		18. Printing and record medium reproductions
		19. Coke, coal briquette, and oil refining products
		20. Chemicals and chemical products; excluding pharmaceutical
		21. Medical substances and pharmaceuticals
		22. Rubber and plastic products
		23. Non-metallic mineral products
		24. Primary metal
		25. Metal products; Excluding machines and furniture
		26. Electronic parts, computer, image, sound and communication equipment
		27. Medical, precision, optics and watches
		28. Electrical devices
		29. Other machines and equipment
		30. Automobile and trailer
		31. Other transport equipment
		32. Furniture
		33. Other manufacturing
		34. Repair service for industrial machines and equipment
D	Electricity, gas, steam and air conditioning suppliers	35. Electricity, gas, steam and air conditioning suppliers
E	Water, sewage and waste treatment, raw material recycling	36. Water
		37. Sewage, wastewater and manure processing industry
		38. collection, transport, processing of waste and recycling of raw materials
		39. Environmental purification and restoration
F	Construction	41. General construction
		42. Specialized construction
G	Whole sale and retail	45. Automobile and auto parts retail
		46. Wholesale and merchandising
		47. Retail; excluding automobile
H	Transportation and warehousing	49. Ground transportation and pipeline transportation
		50. Water transportation
		51. Air transportation
		52. Warehousing and transportation services
I	Accommodations and restaurants	55. Accommodations
		56. Restaurants and pubs
J	Information and communication	58. Publications
		59. Production and distribution of video and audio recordings
		60. Broadcasting
		61. Post and telecommunications
		62. Computer programming, systems integration and management
		63. Information services
K	Finance and insurance	64. Finance
		65. Insurance and pension
		66. Finance and insurance related service
L	Real estate	68. Real estate
M	Specialized, scientific and technical services	70. R&D
		71. Specialized services
		72. Architecture technology, engineering and other science and technology Services
		73. Other specialized, scientific and engineering services
N	Business facility management, business support and rental service	74. Business facility management and landscape services
		75. Business support services
		76. Rental services; excluding real estate
O	Public administration, national defence and social security	84. Public administration, national defence and social security

P	Education services	85. Education services
Q	Public health and social services	86. Public health
		87. Social services
R	Arts, sports and leisure	90. Creation, art, and leisure services
		91. Sports and entertainments
S	Associations and organizations, repair shops and other personal services	94. Associations and organizations
		95. Personal and consumer goods repair services
		96. Other personal services

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Reflection

Research process, methods & logbook

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Table of Contents

General reflection

1. Research choices

Topic choice

The topic '*quantitative analyses to find statistical and spatial patterns on local economy by a dominant industry'* of my research article came together nicely after my research master's coursework. Throughout the program I grew my research interests and methodological explorations. My interests have been laid in economic phenomena, regional economic disparities, regional development, island, and, most of all, the up-to-date technological adoption (in this case I am referring to digitalization and green energy transition).

Because of my interests in economics, I have mostly taken economic geographic courses and grown my specific interests in the evolutionary perspective. This perspective was combined with one island in South Korea, where the peripheral island hosts two of the biggest shipyards in the world. In the past ten years, having the dominant old industry has been seen negatively in Geoje due to the industrial recession. While I hoped to do research someday regarding to how to revitalize the local economy, the central government announced the industrial revitalization plan through smart and green industry in 2021. That was the moment that the research topic came together with my areas of interest. Therefore, I decided to study more about the shipbuilding industry and the ripple effects on the local economy and how this new governmental intervention can help to restructure the local economy. Issues with this type of old or/and heavy industry and regional economy have been important policy discussions because these industries are influential not only for the regional economy but also the national economy.

Under the climate change pressure or/and for better productivities, industries like auto (Bailey et al., 2010) and shipping industry like ports (Suh et al, 2006) have already been transitioning the industrial structures to smart and green. However, there have not been much studies done about how these types of industrial transition influence local economies, as such I wanted to initiate a study connecting a dominant industry and local economy. I hope that my research can be published at some point in relevant journals like Journal of Economic Geography, Regional Studies, International Journal of Urban and Regional research, and Journal of Evolutionary Economics. Besides of the topic relevance, much of the literature in this research are published in these journals, as such it would be a privilege to step into one of them.

Theoretical frame choice and conceptual framework

Place specific path creation, development, destruction, and renewal is the main idea of the *Path Dependence* theory in the *Evolutionary Economic Geography*, so is my research topic. It is difficult to have a clear divide among the three evolutionary theoretical frameworks: *Generalized Darwinism, Complexity Theory*, and *Path Dependence*. This is because evolving economic landscapes are through multi-agents' interaction, selection, and adoption (*Generalized Darwinism*) in complex economic system (*Complexity Theory*) under specifical historical events (*Path Dependence*). Nevertheless, it is certain that these overarching theoretical frames under evolutionary perspective creates unique *paths* in different regions. Additionally, the *lock-in* effects of the shipbuilding industry in Geoje have mostly studied under the path dependence theoretical framework. Therefore, it was sensible to develop the research framework with the *lock-ins* under the *Path Dependence* theory. Alternatively, the Complexity Theory might have incorporated because empirical applications focusing computations in economic studies are often adopted complexity thinking (Frenken, 2006). Also, the New Economic Geography (NEG) paradigm might have been used because it incorporates the complexity thinking for theories that could explain complex economic systems (Krugman, 1996). However, Marin and Sunley (2007) argue these approaches stating that a model search and any type of equilibrium thinking, which what the other two approaches focus, cannot capture the nature of complex economic landscapes in real life. Therefore, the Path *Dependence* framework was adopted for the spatial specific case study, taking the unique historical economic developments into account.

Therefore, this research initiates an investigation of *lock-in* ripple effects in local economy in the case of Geoje to provide a dialogue for policy approaches under Martin and Sunley's (2006) framework of the path dependence (Figure 1). Martin and Sunley (2006) argue about the view of *lock-in* often as a negative economic process, and suggest the positive process that "stimulate rising economic performance." (p416). Additionally, the path destruction and creation can occur complementary (red dashed arrow in Figure 1) under spatial specification. As the path dependence is an evolving process, they suggest the positive lock-in towards path renewal with the following *de-locking* mechanisms based on Lester's work of industrial transformation in 2003 and 2006 (the accessible document in 2005): indigenous creation, heterogeneity and diversity, transplantation from elsewhere, diversification into (technologically) related industries, and upgrading of existing industries. These mechanisms are often prevalent mutually depending on the place specific settings such as geography, institutions and regional capability of new adoption. Adopting the Martin and Sunley's (2006; 2010) framework, this research is **conceptualized Geoje specific path dependence** and lock-ins. The shipbuilding industry was planted in Geoje due to the geographical benefits not only of deep water and less sandbanks but also of proximity to other industrial clusters around the southern region (the phase 1 in the Figure 1; Hassink & Shin, 2005). This place dependent path creation led industrial and local economic lock-ins and eventually to the recessions after 2007 (the phase 2 in the Figure 1; Woo & Lee, 2018). However, the recent government intervention aims for a path renewal through new technological adaptation in the industry (the phase 3 in the Figure 1). In this critical juncture, a discussion of how the path renewal process in the industry impacts local economic renewal in Geoje is inevitable. Therefore, this paper scrutinizes the *lock-in* ripple effects on local economy with statistical analyses.

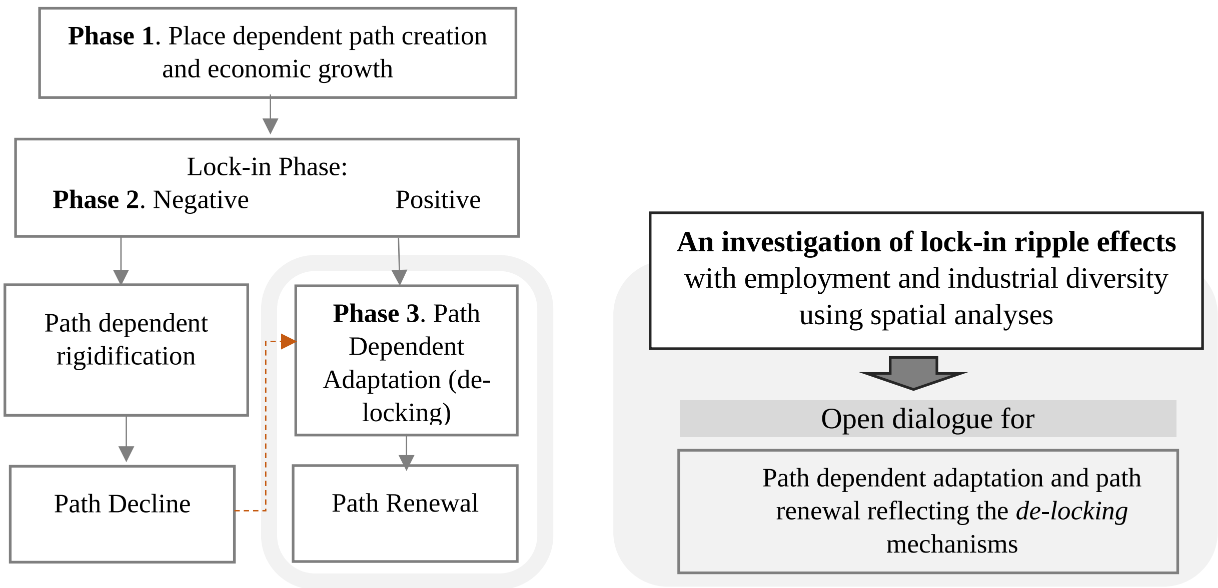


Figure 1. The conceptual framework based on the path dependence by Martin and Sunley (2006;2010, on the left) and research process (on the right)

Method choice

Unlike the research topic process which took me quite some time, the methodological process came along from the beginning of the thesis course. Even though I explored and enjoyed qualitative methods during my other research courses such as the Individual Research Training and the Research Internship, I wanted to investigate the topic with quantitative data. This is because the quantitative methods are suitable to observe the research relationship with broader overview outset (Gorard, 2004), especially for the exploration research like this. Furthermore, I wanted to observe spatial patterns with spatial data. Also, I found myself into statistical analyses, especially with more advanced spatial analyses such as using Geographical Information System (GIS) and spatial econometrics models. Therefore, three quantitative analyses were incorporated as an opportunity of the methodological exploration for my research topic. If I have a further research opportunity in this topic, I would like to learn more advanced spatial analyses for deeper investigations.

Result choices

I chose to use **two indicators** for the *lock-in* ripple effects: *employment* and *industrial diversity*. This choice is backed by previous studies such as Martin and Sunley (2006), Tran (2011), and Xu et al. (2002). However, other indicators such as GRDP, employment rate, and unemployment rate could have been a suitable option, if there was data providing these indicators in the administrative division level. I have contacted the Geoje statistics office to require the division level data with these indicators, but they only provide the datasets in the city level to the public. I am not quite sure about any possibilities of accessing the raw datasets with a research purpose, but it was off limit in this time.

For the multiple regression, there are two **statistical choices** I made. First, I chose the listwise deletion for treating missing values; the shipbuilding employees in 2010 and 2011 are missing. Initially, I ran the two analyses separately before 2010 and after 2011. The results before 2010 were not statically significant (Table 1 and 3), but the results after 2011 were (Table 2 and 4). The reason for not to use this analysis is that first, I wanted to observe longer term effects rather than the recent phenomena; second, the variable of Population with GRDP contains the negative coefficient, which I could not find any rational and empirical explanations. Therefore, I chose to the regression using the whole dataset, even though there is a danger, increasing standard errors, of using listwise deletion. Since the two missing values are considered as the Missing Completely At Random (at least this is my assumption), I chose the listwise deletion. Other alternative options to treat the missing data such as the pairwise deletion or categorical deletion, dummy variable adjustment, single or multiple imputations are not suitable because either the dataset is not relevant to those treatment (no pair and categorical variables), or not recommended due to biased estimates of coefficients (Mehmetoglu & Jakobsen, 2017).

Table 1. GRDP linear regression between 2000 -2009

GRDP100won	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Population	104.667	42.224	2.48	.042	4.824	204.51	**
TSE	59.98	68.761	0.87	.412	-102.612	222.573	
Constant	-17157505	5685720.3	-3.02	.019	-30602097	-3712912.4	**

Mean dependent var	5705868.000	SD dependent var	2378775.139
R-squared	0.979	Number of obs	10
F-test	167.128	Prob > F	0.000
Akaike crit. (AIC)	288.100	Bayesian crit. (BIC)	289.008

**** p<.01, ** p<.05, * p<.1*

Table 2. GRDP linear regression between 2012 - 2019

GRDP100won	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Population	-49.619	43.959	-1.13	.31	-162.62	63.382	
TSE	85.562	29.37	2.91	.033	10.064	161.059	**
Constant	17639890	10464353	1.69	.153	-9259585.4	44539365	
Mean dependent var		10857885.375	SD dependent var			1267719.702	
R-squared		0.631	Number of obs			8	
F-test		4.268	Prob > F			0.083	
Akaike crit. (AIC)		244.511	Bayesian crit. (BIC)			244.749	

**** p<.01, ** p<.05, * p<.1*

Table 3. NTE linear regression between 2000 - 2009

NTE	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
TSE	.351	.216	1.63	.148	-.159	.861	
Population	.616	.132	4.65	.002	.303	.93	***
Constant	-53081.118	17840.231	-2.98	.021	-95266.561	-10895.676	**
Mean dependent var		81465.200	SD dependent var			13881.309	
R-squared		0.994	Number of obs			10	
F-test		586.666	Prob > F			0.000	
Akaike crit. (AIC)		172.815	Bayesian crit. (BIC)			173.722	

**** p<.01, ** p<.05, * p<.1*

Table 4. NTE linear regression between 2011 - 2019

NTE	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
TSE	.657	.071	9.31	0	.476	.838	***
Population	.441	.106	4.17	.009	.169	.712	***
Constant	-29408.651	25146.405	-1.17	.295	-94049.543	35232.241	
Mean dependent var		122295.125	SD dependent var			10061.367	
R-squared		0.966	Number of obs			8	
F-test		71.329	Prob > F			0.000	
Akaike crit. (AIC)		148.014	Bayesian crit. (BIC)			148.253	

**** p<.01, ** p<.05, * p<.1*

The second statistical choice I made is the treating the year as independent observations in the multiple regression. I wanted to observe the lock-in relationships over the years and considered other options like time series analysis and wavelet analysis. However, other options are not appropriate because the economic process in a region is not like stock market, which have frequent time trends. As an outset of the relationship overview, the multiple regression is more suitable. However, statistical analysis with longitudinal data, which only contains one observation, was not appropriate. Therefore, I treated the year as each observation in the multiple regression analysis. This produced statistical outputs, but it is difficult to say about the sequential time relationship. Therefore, I adopted spatial econometrics analysis with panel data.

For the spatial analysis with GIS, the **Geographically Weighted Regression** (GWR) proceeded since the employment indicator presents the spatial non-stationary with the statistically significant Keonker test. However, the GWR analysis could not completed due to the ERROR 000641: "Too few records for analysis. This tool requires at least 20 feature(s) to compute results." on the arcgis pro analysis page. Therefore, the results of the spatial analysis with GIS were interpreted only by the OLS regression.

2. Reflection on ethical issues

Even though quantitative methods handle more objective data with numbers, an ethical issue might arise during research processes. The conceptual framework is designed based on accessible literature, as such the knowledge blocks can be biased. Buckley (2016) mentioned this issue as 'subaltern studies', thus research with biased information is bound to happen. As a result, there is a possibility that the research contains blind spots. However, the data collection was purely from the public accessible statistical datasets, analysis process does not contain any possible ethical issues. Lastly, as an extension to the ethical consideration, the FAIR data requirements of the University of Groningen will be used for the data management to meet Findable, Accessible, Interoperable, and Reusable guidelines (University of Groningen, 2021).

3. Reflection on the research process

The research process was smooth as the topic came naturally and also under Dr. Vos' great supervision. The earlier experiences in the Individual Research Training and the Research Internship were great practices for the thesis process, especially for the internship. During my internship at the Seoul National University, I had an opportunity to design research, initiating the topic, *digital divide and well-being in the Philippines*. With these previous experiences, I became more confident during the process. I was active not only in collecting data like contacting people and statistic offices in South Korea, but also communicating with Dr. Vos. In the beginning process, I did not have a clear overview of the specific research questions, design, and methods, but those became clear under the Dr. Vos' supervision. First few meetings were mainly focused on these specific details. Once the research questions and methodology were set, the meetings proceeded naturally towards the updates and feedback of research analyses. The specialties and works of Dr. Vos were very inspirational, even though her field is different than economic geography. Not only her specialty of statistical and spatial analyses was very helpful in practice, but also her caring personality ensured me that the thesis writing was on track throughout the research process. I greatly enjoyed every single meeting with Dr. Vos, sometime with coffee and lunch. I am very thankful to build a nice relationship with her, and hope that it even grows more in the future.

Reference

Bailey, D., De Ruyter, A., Michie, J., & Tyler, P. (2010). Global restructuring and the auto industry. *Cambridge Journal of Regions, Economy and Society*, *3*(3), 311-318.

Buckley, P. J. (2016). Historical research approaches to the analysis of internationalisation. *Management International Review*, *56*(6), 879-900.

Frenken, K. (2006). *Innovation, evolution and complexity theory*. Edward Elgar Publishing.

Gorard, S. (2004). Quantitative methods in social science. Continuum. Retrieved July 12, 2022, from INSERT-MISSING-URL.

Hassink, R., & Shin, D. H. (2005). South Korea's shipbuilding industry: From a couple of Cathedrals in the desert to an innovative cluster. *Asian Journal of Technology Innovation*, *13*(2), 133-155.

Krugman, P. (1996). *The self organizing economy*. John Wiley & Sons.

Lester, R. K. (2003) Universities and local systems of innovation: a strategic approach. ESRC Workshop on High-Tech Business: Clusters, Constraints, and Economic Development. Robinson College, Cambridge, 28 May 2003. Referenced in [Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. Journal of Economic Geography, 6(4), 395-437. P420.]

Lester, R. (2005). Universities, innovation, and the competitiveness of local economies. *A summary Report from the Local Innovation Systems Project: Phase I. Massachusetts Institute of Technology, Industrial Performance Center, Working Paper Series*.

Lester, R. K. (2006) Universities, innovation, and the competitiveness of local and national economies. Centre for Business Research 10-year Anniversary Summit on Innovation and Governance, University of Cambridge, UK, 29 March 2006. [Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. Journal of Economic Geography, 6(4), 395-437. P420.]

Martin, R., & Sunley, P. (2006). Path dependence and regional economic evolution. Journal of Economic Geography, 6(4), 395-437.

Martin, R., & Sunley, P. (2007). Complexity thinking and evolutionary economic geography. *Journal of economic geography*, *7*(5), 573-601.

Martin, R., & Sunley, P. (2010). The Place of Path Dependence in an Evolutionary Perspective on the Economic Landscape. [Chapter in: Boschma, R. and Martin. R. (2010) Handbook of Evolutionary Economic Geography, Chichester: Edward Elgar].

Mehmetoglu, M., & Jakobsen, T. G. (2017). *Applied statistics using Stata: a guide for the social sciences*. Sage.

Suh, J. H., Song, Y. J., Kim, Y. B., & Lee, K. S. (2006). 3D Simulator System of Performance Valuation for Next Generation Port Automation. In *2006 1ST IEEE Conference on Industrial Electronics and Applications* (pp. 1-6). IEEE.

Tran, H. P. D. (2011). *Industrial diversity and economic performance: A spatial analysis*. The University of Nebraska-Lincoln.

University of Groningen (2021). UG Data Policy 2021. Retrieved from: https://www.rug.nl/digital-competence-centre/ug-research-data-policy-2021.pdf

Woo, Jung-Suk & Lee, Sung-Cheol. (2018). Regional Lock-ins in the Shipbuilding Industry in Geoje, Gyeongnam. Journal of Korean Association of Professional Geographers. 거제시 조선산업에 대한 지역경제의 잠김 효과. *국토지리학회지*, *52*(4), 567-580.

Xu, Z., Cheng, G., Chen, D., & Templet, P. H. (2002). Economic diversity, development capacity and sustainable development of China. *Ecological economics*, *40*(3), 369-378.

Extra tables, maps and figures

1. Research questions

Main Question
To what extent is the Geoje economy locked-in to the shipbuilding industry in Geoje?
Sub-questions
1. To what extent does the shipbuilding industry have a relationship with employment? 2. To what extent does the shipbuilding industry have a relationship with industrial diversity? 3. What are policy discussions for the path renewal of the Geoje economy and economic sustainability?

Table 1. Research main question and sub-questions

2. Preparing data for analyses: Spatial Analysis with GIS

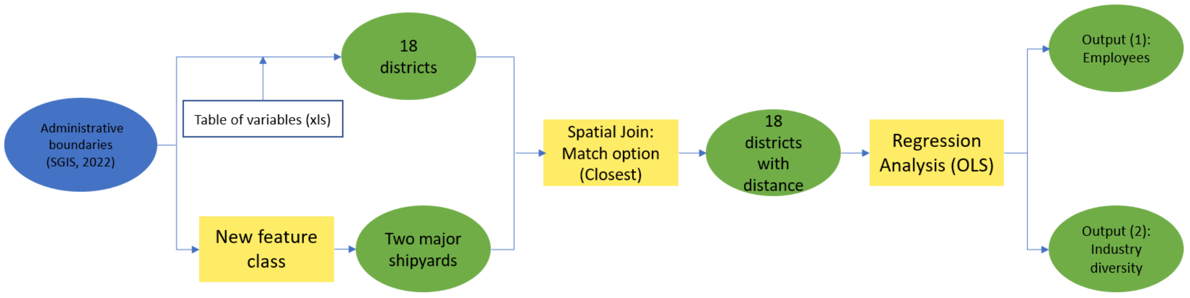


Figure 1. Geoprocessing flowchart

The preparation for producing maps and answering two sub-questions are as follows (also see the figure 1).
1. incorporating district shapefile into arcgis pro
2. importing excel file with variables
3. creating a feature class (point) for the two shipyards=> spatial join only with Aju-dong and Jangpyung-dong
4. Spatial join for calculating near proximity between the two-feature class. In this case, each district polygon to the closest distant to one of the point features (a shipyard).

3. Results

3.1. Multiple Regression with STATA

Linear regression (Listwise deletion as STATA default)

GRDP100won	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Population	54.647	16.915	3.23	.006	18.593	90.702	***
TSE	94.004	29.294	3.21	.006	31.566	156.442	***
Constant	-8705188	2497325.5	-3.49	.003	-14028111	-3382264.7	***

Mean dependent var	7995653.500	SD dependent var	3255286.018
R-squared	0.927	Number of obs	18
F-test	95.488	Prob > F	0.000
Akaike crit. (AIC)	548.747	Bayesian crit. (BIC)	551.418

*** *p<.01, ** p<.05, * p<.1*

==

Variance Inflation Factor (VIF) test
. estat vif

Variable	VIF	1/VIF
Population	**4.87**	**0.205356**
TSE	**4.87**	**0.205356**
Mean VIF	**4.87**	

==

Linear regression (Listwise deletion as STATA default)

NTE	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Population	.464	.029	15.92	0	.402	.527	***
TSE	.641	.051	12.69	0	.534	.749	***
Constant	-34386.112	4307.479	-7.98	0	-43567.286	-25204.937	***

Mean dependent var	99611.833	SD dependent var	24073.529
R-squared	0.996	Number of obs	18
F-test	1885.685	Prob > F	0.000
Akaike crit. (AIC)	319.692	Bayesian crit. (BIC)	322.363

*** *p<.01, ** p<.05, * p<.1*

==

estat vif

Variable	VIF	1/VIF
Population	**4.87**	**0.205356**
TSE	**4.87**	**0.205356**
Mean VIF	**4.87**	

==

Linear regression (2000-2009)

GRDP100won	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Population	104.667	42.224	2.48	.042	4.824	204.51	**
TSE	59.98	68.761	0.87	.412	-102.612	222.573	
Constant	-17157505	5685720.3	-3.02	.019	-30602097	-3712912.4	**

Mean dependent var	5705868.000	SD dependent var	2378775.139
R-squared	0.979	Number of obs	10
F-test	167.128	Prob > F	0.000
Akaike crit. (AIC)	288.100	Bayesian crit. (BIC)	289.008

*** *p<.01, ** p<.05, * p<.1*

==

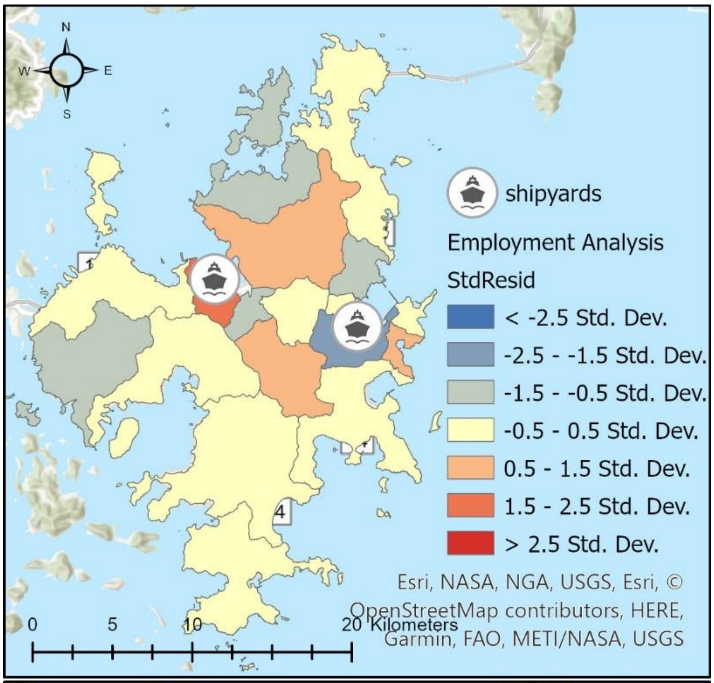
Linear regression (2012-2019)

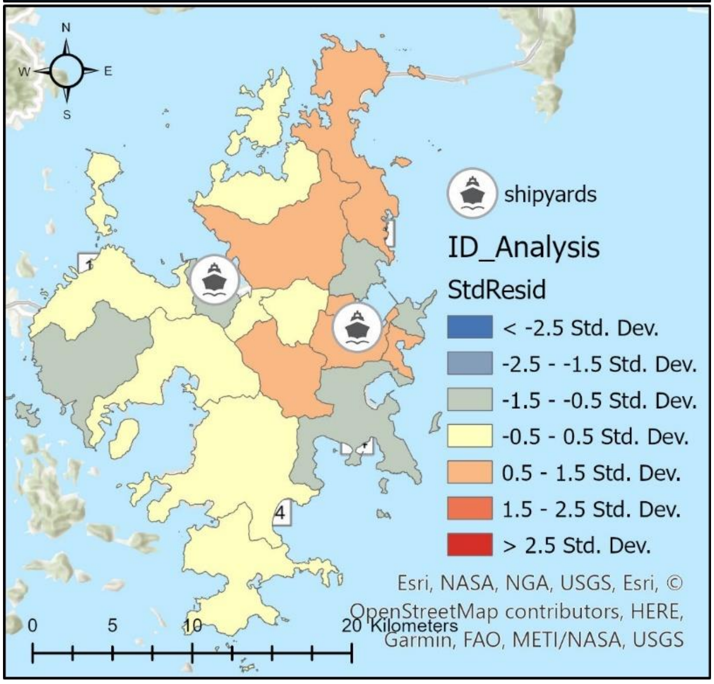
GRDP100won	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Population	-49.619	43.959	-1.13	.31	-162.62	63.382	
TSE	85.562	29.37	2.91	.033	10.064	161.059	**
Constant	17639890	10464353	1.69	.153	-9259585.4	44539365	

Mean dependent var	10857885.375	SD dependent var	1267719.702
R-squared	0.631	Number of obs	8
F-test	4.268	Prob > F	0.083
Akaike crit. (AIC)	244.511	Bayesian crit. (BIC)	244.749

*** *p<.01, ** p<.05, * p<.1*

3.2. Spatial Analysis with GIS: the OLS result maps





3.3. Spatial Econometrics with STATA

Cross-Sectional Dependence Exponent Estimation and Test
Panel Variable (i): Division
Time Variable (t): Year
Estimation of Cross-Sectional Exponent (alpha)

variable	alpha	Std.Err.	[95%Conf.	Interval]
TNE	0.524	279.677	-547.633	548.681

0.5 <= alpha < 1 implies strong cross-sectional dependence.
Pesaran (2015) test for weak cross-sectional dependence.
H0: errors are weakly cross-sectional dependent.

variable	CD	p-value	N_g	T
TNE	5.467	0.000	18	11

Variables are centered around zero.

Employment Analysis

OLS
Regression results

TNE	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
size	38.866	5.545	7.01	0	27.923	49.808	***
SE	136.168	17.032	7.99	0	102.555	169.78	***
Population	.174	.035	4.92	0	.104	.244	***
Year	12.448	27.613	0.45	.653	-42.047	66.944	
Constant	-24638.566	55564.121	-0.44	.658	-134296.27	85019.136	

Mean dependent var	6557.919	SD dependent var	10181.682
R-squared	0.353	Number of obs	198
F-test	24.038	Prob > F	0.000
Akaike crit. (AIC)	3335.002	Bayesian crit. (BIC)	3351.444

**** p<.01, ** p<.05, * p<.1*

SAR
Iteration 0: Log-likelihood = -1666.5528
Iteration 1: Log-likelihood = -1656.5882
Iteration 2: Log-likelihood = -1656.5388
Iteration 3: Log-likelihood = -1656.5386
Computing marginal effects standard errors using MC simulation...
SAR with spatial and time fixed-effects Number of obs = 198
Group variable: Division Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.3336
between = 0.8822
overall = 0.8723
Log-likelihood = -1656.5386

TNE	Coefficient	Std. err.	z	P>z	[95% conf.	interval]
Main						
size	35.527	5.333	6.660	0.000	25.074	45.979
SE	121.404	16.685	7.280	0.000	88.703	154.105
Population	0.170	0.033	5.160	0.000	0.106	0.235
Spatial						
rho	-0.155	0.103	-1.500	0.133	-0.358	0.047
Variance						
sigma2_e	1075564	1.08e+05	9.910	0.000	8.63e+05	1288185
LR_Direct						
size	36.054	5.555	6.490	0.000	25.166	46.942
SE	122.518	16.702	7.340	0.000	89.783	155.252
Population	0.176	0.032	5.480	0.000	0.113	0.239
LR_Indirect						
size	-4.966	3.225	-1.540	0.124	-11.287	1.354

SE	-16.839	10.818	-1.560	0.120	-38.041	4.363
Population	-0.024	0.016	-1.500	0.134	-0.055	0.007
LR_Total						
size	31.087	5.399	5.760	0.000	20.506	41.668
SE	105.679	17.070	6.190	0.000	72.222	139.136
Population	0.152	0.031	4.870	0.000	0.091	0.213

SEM

Iteration 0: Log-likelihood = -1659.9704
Iteration 1: Log-likelihood = -1655.6642
Iteration 2: Log-likelihood = -1655.6436
Iteration 3: Log-likelihood = -1655.6435
SEM with spatial and time fixed-effects Number of obs = 198
Group variable: Division Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.3507
between = 0.8939
overall = 0.8841
Mean of fixed-effects = 684.6855
Log-likelihood = -1655.6435

TNE	Coefficient	Std. erro.	z	P>z	[95% conf. interval]	
Main						
size	36.566	5.425	6.740	0.000	25.933	47.199
SE	122.568	16.566	7.400	0.000	90.098	155.037
Population	0.179	0.032	5.510	0.000	0.115	0.243
Spatial						
lambda	-0.214	0.106	-2.020	0.043	-0.421	-0.006
Variance						
sigma2_e	1059807	1.07e+05	9.880	0.000	8.50e+05	1270051

SLX

Regression results

TNE	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
size	39.509	5.665	6.97	0	28.327	50.691	***
SE	139.119	17.559	7.92	0	104.461	173.777	***
Population	.164	.037	4.45	0	.091	.236	***
w_TNE	-.226	.162	-1.40	.165	-.546	.094	
w_size	23.211	11.867	1.96	.052	-.213	46.636	*
w_SE	51.613	32.62	1.58	.115	-12.775	116.001	
w_pop	.192	.081	2.37	.019	.032	.352	**
Year	-2.125	37.03	-0.06	.954	-75.218	70.967	
Constant	1778.271	74457.046	0.02	.981	-145188.93	148745.47	

Mean dependent var	6557.919	SD dependent var	10181.682
R-squared	0.382 (within)/ 0.8741 (overall)	Number of obs	198
F-test	13.314	Prob > F	0.000
Akaike crit. (AIC)	3333.876	Bayesian crit. (BIC)	3363.470

*** *p<.01, ** p<.05, * p<.1*

SAC

Iteration 0: Log-likelihood = -1662.4511
Iteration 1: Log-likelihood = -1655.6888
Iteration 2: Log-likelihood = -1655.5879
Computing marginal effects standard errors using MC simulation...
SAC with spatial and time fixed-effects Number of obs = 198
Group variable: Division Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.3463
between = 0.8921
overall = 0.8822

Mean of fixed-effects = 963.8521
Log-likelihood = -1655.5879

TNE	Coefficient	Std. err.	z	P>z	[95%conf. interval]	
Main						
size	36.540	5.430	6.730	0.000	25.897	47.183
SE	122.742	16.608	7.390	0.000	90.191	155.294
Population	0.179	0.033	5.470	0.000	0.115	0.243
Spatial						
rho	-0.043	0.129	-0.330	0.741	-0.297	0.211
lambda	-0.187	0.134	-1.390	0.164	-0.450	0.076
Variance						
sigma2_e	1169537	1.08e+05	10.860	0.000	9.58e+05	1380676
LR_Direct						
size	36.917	5.612	6.580	0.000	25.918	47.915
SE	123.329	16.539	7.460	0.000	90.913	155.744
Population	0.184	0.032	5.810	0.000	0.122	0.246
LR_Indirect						
size	-1.181	4.673	-0.250	0.801	-10.339	7.978
SE	-4.018	15.632	-0.260	0.797	-34.656	26.620
Population	-0.005	0.024	-0.230	0.821	-0.052	0.041
LR_Total						
size	35.736	7.045	5.070	0.000	21.928	49.544
SE	119.311	21.717	5.490	0.000	76.747	161.874
Population	0.178	0.040	4.420	0.000	0.099	0.257

SDM

Warning: All regressors will be spatially lagged
Iteration 0: Log-likelihood = -1664.3956
Iteration 1: Log-likelihood = -1652.8143
Iteration 2: Log-likelihood = -1652.7656
Iteration 3: Log-likelihood = -1652.7654
Iteration 4: Log-likelihood = -1652.7654
Iteration 5: Log-likelihood = -1652.7654 (backed up)
…
Iteration 100: Log-likelihood = -1652.7654 (backed up)
convergence not achieved
Computing marginal effects standard errors using MC simulation...
SDM with spatial and time fixed-effects Number of obs = 198
Group variable: Division Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.3630
between = 0.8764
overall = 0.8673
Log-likelihood = -1652.7654

TNE	Coefficient	Std. err.	z	P>z	[95%	conf. interval]
Main						
size	38.659	5.490	7.040	0.000	27.900	49.419
SE	130.497	16.671	7.830	0.000	97.824	163.171
Population	0.158	0.033	4.710	0.000	0.092	0.223
Wx						
size	22.129	12.964	1.710	0.088	-3.280	47.538
SE	13.438	33.259	0.400	0.686	-51.749	78.625
Population	0.207	0.078	2.650	0.008	0.054	0.361
Spatial						
rho	-0.209	0.107	-1.960	0.050	-0.418	-0.000
Variance						
sigma2_e	1030390	1.04e+05	9.880	0.000	8.26e+05	1234830
LR_Direct						
size	38.137	5.614	6.790	0.000	27.134	49.139
SE	131.457	16.546	7.950	0.000	99.028	163.886
Population	0.152	0.034	4.530	0.000	0.086	0.218
LR_Indirect						
size	12.554	11.091	1.130	0.258	-9.184	34.292

SE	-11.369	29.438	-0.390	0.699	-69.066	46.328
Population	0.156	0.068	2.280	0.022	0.022	0.289
LR_Total						
size	50.691	12.890	3.930	0.000	25.427	75.955
SE	120.088	32.473	3.700	0.000	56.442	183.734
Population	0.308	0.067	4.560	0.000	0.175	0.440

SDEM

Iteration 0: Log-likelihood = -1660.2834
Iteration 1: Log-likelihood = -1658.7427
Iteration 2: Log-likelihood = -1658.7374
Iteration 3: Log-likelihood = -1658.7374
SEM with spatial fixed-effects Number of obs = 198
Group variable: Division Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.3753
between = 0.8735
overall = 0.8645
Log-likelihood = -1658.7374

TNE	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
size	38.562	5.139	7.500	0.000	28.489	48.634
SE	136.120	16.397	8.300	0.000	103.982	168.258
Population	0.158	0.034	4.590	0.000	0.090	0.225
w_size	15.012	9.566	1.570	0.117	-3.736	33.761
w_SE	22.323	24.816	0.900	0.368	-26.316	70.961
w_pop	0.149	0.071	2.100	0.035	0.010	0.287
Spatial						
lambda	-0.083	0.105	-0.800	0.426	-0.289	0.122
Variance						
sigma2_e	1104792	1.11e+05	9.940	0.000	8.87e+05	1322655

GNS

Iteration 0: Log-likelihood = -1659.6966
Iteration 1: Log-likelihood = -1652.6794
Iteration 2: Log-likelihood = -1652.5492
Computing marginal effects standard errors using MC simulation...
SAC with spatial and time fixed-effects Number of obs = 198
Group variable: Division Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.3594
between = 0.8773
overall = 0.8681
Log-likelihood = -1652.5492

TNE	Coefficient	Std. err	z	P>z	[95% conf. interval]	
Main						
size	38.531	5.459	7.060	0.000	27.832	49.230
SE	130.722	16.694	7.830	0.000	98.004	163.441
Population	0.156	0.034	4.640	0.000	0.090	0.223
w_size	18.207	14.300	1.270	0.203	-9.820	46.234
w_SE	-0.134	38.417	0.000	0.997	-75.430	75.161
w_pop	0.188	0.084	2.230	0.026	0.023	0.353
Spatial						
rho	-0.134	0.159	-0.850	0.397	-0.445	0.176
lambda	-0.104	0.163	-0.640	0.525	-0.423	0.216
Variance						
sigma2_e	1136049	1.04e+05	10.900	0.000	9.32e+05	1340274
LR_Direct						
size	39.208	5.711	6.870	0.000	28.015	50.402
SE	132.305	16.716	7.920	0.000	99.543	165.067
Population	0.162	0.033	4.930	0.000	0.098	0.227
w_size	18.553	14.118	1.310	0.189	-9.118	46.223

w_SE	0.900	38.574	0.020	0.981	-74.704	76.504
w_pop	0.192	0.082	2.330	0.020	0.031	0.354
LR_Indirect						
size	-4.426	5.935	-0.750	0.456	-16.058	7.206
SE	-14.750	19.923	-0.740	0.459	-53.800	24.299
Population	-0.019	0.024	-0.780	0.438	-0.066	0.029
w_size	-2.946	4.130	-0.710	0.476	-11.041	5.149
w_SE	-2.883	7.616	-0.380	0.705	-17.810	12.043
w_pop	-0.026	0.034	-0.780	0.435	-0.093	0.040
LR_Total						
size	34.783	7.447	4.670	0.000	20.187	49.378
SE	117.555	24.503	4.800	0.000	69.530	165.580
Population	0.143	0.034	4.170	0.000	0.076	0.211
w_size	15.607	11.782	1.320	0.185	-7.486	38.699
w_SE	-1.983	35.161	-0.060	0.955	-70.898	66.932
w_pop	0.166	0.068	2.440	0.015	0.032	0.300

Likelihood-ratio test
Assumption: sem nested within sdm

LR chi2(3) = 5.76
Prob > chi2 = 0.1241

Akaike's information criterion and Bayesian information criterion

```
-----------------------------------------------------------------------------
       Model |          N   ll(null)  ll(model)      df        AIC        BIC
-------------+---------------------------------------------------------------
         sem |        198          .  -1655.644       5   3321.287   3337.728
         sdm |        198          .  -1652.765       8   3321.531   3347.837
-----------------------------------------------------------------------------
```

. lrtest sem gns, stats

Likelihood-ratio test
Assumption: sem nested within gns

LR chi2(4) = 6.19
Prob > chi2 = 0.1855

Akaike's information criterion and Bayesian information criterion

```
-----------------------------------------------------------------------------
       Model |          N   ll(null)  ll(model)      df        AIC        BIC
-------------+---------------------------------------------------------------
         sem |        198          .  -1655.644       5   3321.287   3337.728
         gns |        198          .  -1652.549       9   3323.098   3352.693
-----------------------------------------------------------------------------
```

Note: BIC uses N = number of observations. See [R] BIC note.

. lrtest sdm gns,stats

Likelihood-ratio test
Assumption: sdm nested within gns

LR chi2(1) = 0.43
Prob > chi2 = 0.5108

Akaike's information criterion and Bayesian information criterion

Model	N	ll(null)	ll(model)	df	AIC	BIC
sdm	198	.	-1652.765	8	3321.531	3347.837
gns	198	.	-1652.549	9	3323.098	3352.693

Note: BIC uses N = number of observations. See [R] BIC note.

Dynamic SDM
Warning: All regressors will be spatially lagged
Iteration 0: Log-likelihood = -1466.6945
Iteration 1: Log-likelihood = -1465.1779
Iteration 2: Log-likelihood = -1465.1754
Iteration 3: Log-likelihood = -1465.1754
Computing marginal effects standard errors using MC simulation...
Dynamic SDM with spatial and time fixed-effects Number of obs = 180
Group variable: Division Number of groups = 18
Time variable: Year Panel length = 10
R-sq: within = 0.5641
between = 0.9710
overall = 0.9639
Mean of fixed-effects = -11.8719
Log-likelihood = -1480.5135

TNE	Coefficient	Std.	err.	P>z	[95% conf. interval]	
Main						
TNE						
L1.	0.758	0.061	12.370	0.000	0.638	0.879
WTNE						
L1.	-0.359	0.165	-2.180	0.029	-0.682	-0.037
size	36.473	4.788	7.620	0.000	27.089	45.858
SE	61.166	15.793	3.870	0.000	30.212	92.120
Population	0.080	0.030	2.630	0.008	0.020	0.140
Wx						
size	4.196	11.615	0.360	0.718	-18.569	26.961
SE	27.848	29.360	0.950	0.343	-29.697	85.392
Population	0.036	0.072	0.510	0.614	-0.104	0.177
Spatial						
rho	0.106	0.111	0.960	0.337	-0.111	0.324
Variance						
sigma2_e	7.55e+05	72459.770	10.420	0.000	6.13e+05	8.97e+05
SR_Direct						
size	36.932	4.547	8.120	0.000	28.020	45.843
SE	61.383	16.193	3.790	0.000	29.645	93.121
Population	0.080	0.029	2.730	0.006	0.022	0.138
SR_Indirect						
size	1.373	10.413	0.130	0.895	-19.036	21.781
SE	22.225	27.913	0.800	0.426	-32.482	76.933
Population	0.027	0.067	0.400	0.689	-0.104	0.158
SR_Total						
size	38.304	12.282	3.120	0.002	14.232	62.377
SE	83.608	31.349	2.670	0.008	22.165	145.051
Population	0.107	0.066	1.610	0.108	-0.023	0.237
LR_Direct						
size	-66.017	13997	0.000	0.996	-2.75e+04	27367.610
SE	140.399	16554.610	0.010	0.993	-3.23e+04	32586.830
Population	0.365	16.410	0.020	0.982	-31.797	32.527
LR_Indirect						
size	126.934	13996.320	0.010	0.993	-2.73e+04	27559.210
SE	-7.264	16554.560	0.000	1.000	-3.25e+04	32439.070
Population	-0.195	16.409	-0.010	0.991	-32.356	31.965

LR_Total						
size	60.917	20.591	2.960	0.003	20.559	101.274
SE	133.135	52.757	2.520	0.012	29.734	236.536
Population	0.170	0.109	1.560	0.120	-0.044	0.384

Dynamic SDM with common factors

. xsmle TNE size SE Population TNEt*, wmat(W1) model(sdm) dlag(3) durbin(size SE Population) fe type(ind) effects nsim(500)

Iteration 0: Log-likelihood = -1342.732
Iteration 1: Log-likelihood = -1342.5663
Iteration 2: Log-likelihood = -1342.5663
Computing marginal effects standard errors using MC simulation...

Dynamic SDM with spatial fixed-effects Number of obs = 180

Group variable: Division Number of groups = 18
Time variable: Year Panel length = 10

R-sq: within = 0.9008
between = 0.9595
overall = 0.9561

Mean of fixed-effects = -9.7e+02
Log-likelihood = -1344.5185

TNE	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
TNE						
L1.	.4134884	.07438	5.56	0.000	.2677062	.5592705
WTNE						
L1.	-.0640278	.1511963	-0.42	0.672	-.3603671	.2323114
size	23.65851	2.853382	8.29	0.000	18.06598	29.25104
SE	37.01562	10.13309	3.65	0.000	17.15513	56.87612
Population	.0652338	.0191247	3.41	0.001	.0277501	.1027175
TNEt_일운면	-.1287876	.411879	-0.31	0.755	-.9360557	.6784805
TNEt_동부면	-.1315858	.3775983	-0.35	0.727	-.8716649	.6084934
TNEt_남부면	-.0118084	.375533	-0.03	0.975	-.7478396	.7242227
TNEt_거제면	-.2098284	.4158784	-0.50	0.614	-1.024935	.6052782
TNEt_둔덕면	.0528729	.38115	0.14	0.890	-.6941675	.7999132
TNEt_사등면	.2234648	.4836268	0.46	0.644	-.7244264	1.171356
TNEt_연초면	-.3222966	.4203935	-0.77	0.443	-1.146253	.5016595
TNEt_하청면	-.0638291	.4053976	-0.16	0.875	-.8583939	.7307356
TNEt_장목면	.0254603	.3883265	0.07	0.948	-.7356457	.7865662
TNEt_장승포동	.0663638	.4384666	0.15	0.880	-.793015	.9257426
TNEt_능포동	-.2326097	.3871905	-0.60	0.548	-.9914891	.5262697
TNEt_아주동	5.490645	.4263368	12.88	0.000	4.65504	6.32625
TNEt_옥포 1 동	.1179351	.4329758	0.27	0.785	-.7306818	.966552
TNEt_옥포 2 동	.0765863	.3845395	0.20	0.842	-.6770973	.8302698
TNEt_장평동	7.322897	.449428	16.29	0.000	6.442035	8.20376
TNEt_고현동	1.093031	.4248495	2.57	0.010	.2603412	1.92572
TNEt_상문동	.277729	.4001313	0.69	0.488	-.5065138	1.061972
TNEt_수양동	.1591893	.4097058	0.39	0.698	-.6438193	.9621979
TNEt1_일운면	.0776866	.4196332	0.19	0.853	-.7447793	.9001525
TNEt1_동부면	.0771167	.3476492	0.22	0.824	-.6042633	.7584967
TNEt1_남부면	-.0668399	.3441803	-0.19	0.846	-.7414209	.6077411
TNEt1_거제면	.0781419	.4376979	0.18	0.858	-.7797302	.9360141
TNEt1_둔덕면	-.1880072	.3592285	-0.52	0.601	-.8920822	.5160678
TNEt1_사등면	-.6418782	.5674775	-1.13	0.258	-1.754114	.4703574
TNEt1_연초면	-.268016	.3546591	-0.76	0.450	-.963135	.4271031
TNEt1_하청면	.1463289	.3499588	0.42	0.676	-.5395778	.8322356

TNEt1_장목면 -.0766257 .3474394 -0.22 0.825 -.7575943 .604343
TNEt1_장승포동 -.2395097 .4535051 -0.53 0.597 -1.128363 .6493439
TNEt1_능포동 .1335274 .3570147 0.37 0.708 -.5662086 .8332634
TNEt1_아주동 -1.407758 .6080068 -2.32 0.021 -2.59943 -.2160869
TNEt1_옥포 1 동 -.6523663 .421784 -1.55 0.122 -1.479048 .1743151
TNEt1_옥포 2 동 -.0554294 .3485609 -0.16 0.874 -.7385962 .6277373
TNEt1_장평동 -2.607832 .7952887 -3.28 0.001 -4.166569 -1.049095
TNEt1_고현동 -.690324 .4748545 -1.45 0.146 -1.621022 .2403737
TNEt1_상문동 -.1405424 .4035032 -0.35 0.728 -.931394 .6503093
TNEt1_수양동 -.112173 .4006394 -0.28 0.779 -.8974117 .6730657

Wx
size -7.068964 5.418154 -1.30 0.192 -17.68835 3.550423
SE 11.06676 16.81937 0.66 0.511 -21.8986 44.03212
Population .0035863 .0392235 0.09 0.927 -.0732903 .0804628

Spatial
rho .0328951 .0996178 0.33 0.741 -.1623521 .2281423

Variance
sigma2_e 193792.3 18571.11 10.44 0.000 157393.6 230191.1

SR_Direct
size 23.83977 2.795654 8.53 0.000 18.36039 29.31915
SE 37.75709 10.22386 3.69 0.000 17.71869 57.7955
Population .0654734 .0183381 3.57 0.000 .0295314 .1014153
TNEt_일운면 -.1079991 .4087647 -0.26 0.792 -.9091632 .693165
TNEt_동부면 -.132694 .3957502 -0.34 0.737 -.9083502 .6429622
TNEt_남부면 -.0242021 .361095 -0.07 0.947 -.7319352 .683531
TNEt_거제면 -.1797399 .4061934 -0.44 0.658 -.9758643 .6163844
TNEt_둔덕면 .0670788 .3829931 0.18 0.861 -.6835738 .8177315
TNEt_사등면 .2089824 .4549793 0.46 0.646 -.6827607 1.100725
TNEt_연초면 -.3110001 .4408153 -0.71 0.480 -1.174982 .5529821
TNEt_하청면 -.083804 .3996336 -0.21 0.834 -.8670713 .6994634
TNEt_장목면 .0431572 .3936981 0.11 0.913 -.728477 .8147914
TNEt_장승포동 .0498253 .4110594 0.12 0.904 -.7558363 .855487
TNEt_능포동 -.2323299 .3962112 -0.59 0.558 -1.00889 .5442298
TNEt_아주동 5.529783 .4369857 12.65 0.000 4.673307 6.386259
TNEt_옥포 1 동 .0982805 .4482395 0.22 0.826 -.7802527 .9768138
TNEt_옥포 2 동 .074287 .3897438 0.19 0.849 -.6895968 .8381709
TNEt_장평동 7.336685 .4567535 16.06 0.000 6.441464 8.231905
TNEt_고현동 1.076749 .4104532 2.62 0.009 .2722755 1.881223
TNEt_상문동 .2811916 .378578 0.74 0.458 -.4608076 1.023191
TNEt_수양동 .1524668 .417272 0.37 0.715 -.6653714 .9703049
TNEt1_일운면 .0626532 .4286525 0.15 0.884 -.7774903 .9027966
TNEt1_동부면 .0683285 .3734571 0.18 0.855 -.6636339 .800291
TNEt1_남부면 -.0604927 .3494061 -0.17 0.863 -.7453161 .6243308
TNEt1_거제면 .0725954 .4413495 0.16 0.869 -.7924338 .9376245
TNEt1_둔덕면 -.1951417 .340733 -0.57 0.567 -.8629661 .4726826
TNEt1_사등면 -.6171873 .5456078 -1.13 0.258 -1.686559 .4521843
TNEt1_연초면 -.234702 .3525589 -0.67 0.506 -.9257049 .4563008
TNEt1_하청면 .1485821 .3536171 0.42 0.674 -.5444945 .8416588
TNEt1_장목면 -.0934771 .36332 -0.26 0.797 -.8055711 .618617
TNEt1_장승포동 -.2227407 .4391261 -0.51 0.612 -1.083412 .6379305
TNEt1_능포동 .1256432 .3576697 0.35 0.725 -.5753766 .8266629
TNEt1_아주동 -1.450793 .6015127 -2.41 0.016 -2.629737 -.27185
TNEt1_옥포 1 동 -.6477296 .4233428 -1.53 0.126 -1.477466 .1820071
TNEt1_옥포 2 동 -.0758922 .3511728 -0.22 0.829 -.7641783 .6123939
TNEt1_장평동 -2.6378 .7952583 -3.32 0.001 -4.196478 -1.079122
TNEt1_고현동 -.6760406 .4743717 -1.43 0.154 -1.605792 .2537109
TNEt1_상문동 -.1321499 .3994132 -0.33 0.741 -.9149855 .6506856
TNEt1_수양동 -.1261016 .4031965 -0.31 0.754 -.9163523 .6641491

SR_Indirect
size -6.310103 5.319398 -1.19 0.236 -16.73593 4.115726
SE 13.5667 16.68062 0.81 0.416 -19.12671 46.26012
Population .0065653 .0386906 0.17 0.865 -.0692668 .0823975
TNEt_일운면 -.0169623 .0508363 -0.33 0.739 -.1165997 .0826751
TNEt_동부면 -.0034393 .0427457 -0.08 0.936 -.0872194 .0803408
TNEt_남부면 .0026772 .036244 0.07 0.941 -.0683597 .0737141
TNEt_거제면 -.0227547 .0560927 -0.41 0.685 -.1326944 .087185
TNEt_둔덕면 .0057222 .0440239 0.13 0.897 -.080563 .0920075
TNEt_사등면 -.0127982 .0558003 -0.23 0.819 -.1221648 .0965685
TNEt_연초면 -.0153952 .0549545 -0.28 0.779 -.123104 .0923137
TNEt_하청면 -.0052814 .0431147 -0.12 0.903 -.0897846 .0792217
TNEt_장목면 -.000151 .0415883 -0.00 0.997 -.0816625 .0813605
TNEt_장승포동 -.0133737 .0492497 -0.27 0.786 -.1099013 .0831539
TNEt_능포동 -.0104015 .048707 -0.21 0.831 -.1058655 .0850624
TNEt_아주동 .2331725 .5590157 0.42 0.677 -.8624781 1.328823
TNEt_옥포 1 동 -.01037 .0508288 -0.20 0.838 -.1099926 .0892526
TNEt_옥포 2 동 .0013936 .0415976 0.03 0.973 -.0801362 .0829235

TNEt_장평동	.3072339	.7425243	0.41	0.679	-1.148087	1.762555
TNEt_고현동	.0316573	.1095783	0.29	0.773	-.1831123	.2464269
TNEt_상문동	.0017835	.0464226	0.04	0.969	-.0892032	.0927701
TNEt_수양동	-.0074535	.0471084	-0.16	0.874	-.0997843	.0848773
TNEt1_일운면	.0059195	.0495148	0.12	0.905	-.0911278	.1029668
TNEt1_동부면	-.0004216	.0383399	-0.01	0.991	-.0755664	.0747231
TNEt1_남부면	-.0049328	.038525	-0.13	0.898	-.0804404	.0705748
TNEt1_거제면	.0105779	.0534373	0.20	0.843	-.0941573	.115313
TNEt1_둔덕면	-.0070926	.0404369	-0.18	0.861	-.0863474	.0721623
TNEt1_사등면	-.0188806	.0818039	-0.23	0.817	-.1792133	.1414521
TNEt1_연초면	-.006781	.0415393	-0.16	0.870	-.0881966	.0746346
TNEt1_하청면	.0100257	.0421257	0.24	0.812	-.0725391	.0925905
TNEt1_장목면	-.0008575	.0402673	-0.02	0.983	-.07978	.078065
TNEt1_장승포동	-.0034909	.0520342	-0.07	0.947	-.1054761	.0984942
TNEt1_능포동	.0048061	.0403199	0.12	0.905	-.0742195	.0838317
TNEt1_아주동	-.0574411	.1546837	-0.37	0.710	-.3606156	.2457334
TNEt1_옥포 1 동	-.0201443	.0736535	-0.27	0.784	-.1645025	.1242139
TNEt1_옥포 2 동	-.00194	.0382788	-0.05	0.960	-.076965	.073085
TNEt1_장평동	-.1071644	.278437	-0.38	0.700	-.6528909	.4385622
TNEt1_고현동	-.0242417	.0826835	-0.29	0.769	-.1862983	.137815
TNEt1_상문동	-.0053603	.0495824	-0.11	0.914	-.1025401	.0918195
TNEt1_수양동	.0014162	.0447308	0.03	0.975	-.0862545	.0890869

SR_Total

size	17.52966	6.13985	2.86	0.004	5.49578	29.56355
SE	51.3238	18.03885	2.85	0.004	15.9683	86.67929
Population	.0720387	.0400025	1.80	0.072	-.0063648	.1504422
TNEt_일운면	-.1249614	.432469	-0.29	0.773	-.9725851	.7226624
TNEt_동부면	-.1361333	.4116934	-0.33	0.741	-.9430375	.6707709
TNEt_남부면	-.0215249	.3738579	-0.06	0.954	-.7542729	.7112232
TNEt_거제면	-.2024947	.4330014	-0.47	0.640	-1.051162	.6461725
TNEt_둔덕면	.0728011	.4028317	0.18	0.857	-.7167346	.8623367
TNEt_사등면	.1961842	.4710416	0.42	0.677	-.7270404	1.119409
TNEt_연초면	-.3263952	.4578828	-0.71	0.476	-1.223829	.5710387
TNEt_하청면	-.0890854	.4172047	-0.21	0.831	-.9067916	.7286208
TNEt_장목면	.0430061	.4141885	0.10	0.917	-.7687884	.8548007
TNEt_장승포동	.0364516	.4316552	0.08	0.933	-.809577	.8824803
TNEt_능포동	-.2427314	.4105796	-0.59	0.554	-1.047453	.5619899
TNEt_아주동	5.762955	.7207152	8.00	0.000	4.350379	7.175531
TNEt_옥포 1 동	.0879105	.4718673	0.19	0.852	-.8369325	1.012754
TNEt_옥포 2 동	.0756807	.4093212	0.18	0.853	-.7265742	.8779355
TNEt_장평동	7.643919	.8578059	8.91	0.000	5.96265	9.325187
TNEt_고현동	1.108406	.4055496	2.73	0.006	.3135438	1.903269
TNEt_상문동	.2829751	.3896506	0.73	0.468	-.4807261	1.046676
TNEt_수양동	.1450133	.4315504	0.34	0.737	-.7008099	.9908364
TNEt1_일운면	.0685727	.452144	0.15	0.879	-.8176134	.9547587
TNEt1_동부면	.0679069	.3889824	0.17	0.861	-.6944845	.8302984
TNEt1_남부면	-.0654255	.3646672	-0.18	0.858	-.78016	.649309
TNEt1_거제면	.0831732	.4653484	0.18	0.858	-.828893	.9952394
TNEt1_둔덕면	-.2022343	.3547287	-0.57	0.569	-.8974898	.4930212
TNEt1_사등면	-.6360679	.5672996	-1.12	0.262	-1.747955	.4758188
TNEt1_연초면	-.2414831	.3637877	-0.66	0.507	-.9544939	.4715277
TNEt1_하청면	.1586078	.3723752	0.43	0.670	-.5712342	.8884499
TNEt1_장목면	-.0943346	.3801986	-0.25	0.804	-.8395102	.6508411
TNEt1_장승포동	-.2262317	.4563494	-0.50	0.620	-1.12066	.6681968
TNEt1_능포동	.1304493	.3706239	0.35	0.725	-.5959603	.8568588
TNEt1_아주동	-1.508234	.6356109	-2.37	0.018	-2.754009	-.2624599
TNEt1_옥포 1 동	-.6678739	.4353664	-1.53	0.125	-1.521176	.1854286
TNEt1_옥포 2 동	-.0778322	.3695009	-0.21	0.833	-.8020406	.6463762
TNEt1_장평동	-2.744964	.8645317	-3.18	0.001	-4.439415	-1.050513
TNEt1_고현동	-.7002823	.4949407	-1.41	0.157	-1.670348	.2697837
TNEt1_상문동	-.1375102	.4196543	-0.33	0.743	-.9600176	.6849972
TNEt1_수양동	-.1246854	.4194612	-0.30	0.766	-.9468142	.6974435

LR_Direct

size	41.07004	4.837512	8.49	0.000	31.58869	50.55139
SE	64.1195	17.70695	3.62	0.000	29.41451	98.82449
Population	.1118639	.0317734	3.52	0.000	.0495891	.1741387
TNEt_일운면	-.1838662	.7007555	-0.26	0.793	-1.557322	1.189589
TNEt_동부면	-.2277166	.6780365	-0.34	0.737	-1.556644	1.10121
TNEt_남부면	-.0420366	.6189364	-0.07	0.946	-1.25513	1.171056
TNEt_거제면	-.3067451	.6964612	-0.44	0.660	-1.671784	1.058294
TNEt_둔덕면	.1149388	.6561075	0.18	0.861	-1.171008	1.400886
TNEt_사등면	.3601916	.7822815	0.46	0.645	-1.173052	1.893435
TNEt_연초면	-.5324153	.7556354	-0.70	0.481	-2.013433	.9486028
TNEt_하청면	-.1432445	.6847749	-0.21	0.834	-1.485379	1.19889
TNEt_장목면	.0741359	.6737858	0.11	0.912	-1.24646	1.394732
TNEt_장승포동	.0869974	.705378	0.12	0.902	-1.295518	1.469513

TNEt_능포동	-.3980364	.679674	-0.59	0.558	-1.730173	.9341003
TNEt_아주동	9.473534	.7535644	12.57	0.000	7.996575	10.95049
TNEt_옥포 1 동	.1695111	.768131	0.22	0.825	-1.335998	1.67502
TNEt_옥포 2 동	.1271595	.6672496	0.19	0.849	-1.180626	1.434945
TNEt_장평동	12.56958	.8005155	15.70	0.000	11.00059	14.13856
TNEt_고현동	1.846117	.7077098	2.61	0.009	.4590318	3.233203
TNEt_상문동	.4828634	.6495695	0.74	0.457	-.7902693	1.755996
TNEt_수양동	.2627622	.7162229	0.37	0.714	-1.141009	1.666533
TNEt1_일운면	.1071127	.7341602	0.15	0.884	-1.331815	1.54604
TNEt1_동부면	.1174188	.6396916	0.18	0.854	-1.136354	1.371191
TNEt1_남부면	-.1033515	.598914	-0.17	0.863	-1.277201	1.070498
TNEt1_거제면	.1240156	.7565297	0.16	0.870	-1.358755	1.606787
TNEt1_둔덕면	-.3346698	.5838639	-0.57	0.567	-1.479022	.8096824
TNEt1_사등면	-1.057814	.9357638	-1.13	0.258	-2.891877	.7762492
TNEt1_연초면	-.4023031	.6046062	-0.67	0.506	-1.58731	.7827034
TNEt1_하청면	.2539985	.6057631	0.42	0.675	-.9332754	1.441272
TNEt1_장목면	-.1604661	.6224139	-0.26	0.797	-1.380375	1.059443
TNEt1_장승포동	-.3820868	.7530952	-0.51	0.612	-1.858126	1.093953
TNEt1_능포동	.2154937	.6133607	0.35	0.725	-.9866712	1.417659
TNEt1_아주동	-2.485498	1.031141	-2.41	0.016	-4.506497	-.4644992
TNEt1_옥포 1 동	-1.110103	.7265093	-1.53	0.127	-2.534035	.3138289
TNEt1_옥포 2 동	-.1296399	.6013128	-0.22	0.829	-1.308191	1.048912
TNEt1_장평동	-4.519295	1.364914	-3.31	0.001	-7.194478	-1.844113
TNEt1_고현동	-1.158546	.813303	-1.42	0.154	-2.75259	.4354989
TNEt1_상문동	-.2265033	.6848883	-0.33	0.741	-1.56886	1.115853
TNEt1_수양동	-.216892	.6911512	-0.31	0.754	-1.571523	1.137739

LR_Indirect

size	-13.31769	9.1351	-1.46	0.145	-31.22215	4.586781
SE	17.10693	28.18754	0.61	0.544	-38.13965	72.3535
Population	.0021443	.0641527	0.03	0.973	-.1235928	.1278814
TNEt_일운면	-.0272547	.1269721	-0.21	0.830	-.2761155	.221606
TNEt_동부면	.0129215	.1125725	0.11	0.909	-.2077165	.2335596
TNEt_남부면	.011004	.0966779	0.11	0.909	-.1784812	.2004891
TNEt_거제면	-.0310195	.1414847	-0.22	0.826	-.3083244	.2462854
TNEt_둔덕면	.0042939	.1103645	0.04	0.969	-.2120165	.2206043
TNEt_사등면	-.0695471	.151218	-0.46	0.646	-.3659289	.2268348
TNEt_연초면	.0116435	.1477076	0.08	0.937	-.2778581	.3011451
TNEt_하청면	.0003513	.1102374	0.00	0.997	-.2157101	.2164127
TNEt_장목면	-.0076608	.101671	-0.08	0.940	-.2069322	.1916106
TNEt_장승포동	-.0440261	.1264657	-0.35	0.728	-.2918944	.2038422
TNEt_능포동	.0113443	.1317475	0.09	0.931	-.246876	.2695645
TNEt_아주동	-.3103761	1.508563	-0.21	0.837	-3.267106	2.646354
TNEt_옥포 1 동	-.0445648	.1261651	-0.35	0.724	-.2918438	.2027142
TNEt_옥포 2 동	-.0091816	.1024212	-0.09	0.929	-.2099234	.1915602
TNEt_장평동	-.4172092	2.007513	-0.21	0.835	-4.351863	3.517444
TNEt_고현동	-.0970543	.3117743	-0.31	0.756	-.7081207	.514012
TNEt_상문동	-.0426418	.1279099	-0.33	0.739	-.2933407	.208057
TNEt_수양동	-.0453923	.1280887	-0.35	0.723	-.2964416	.205657
TNEt1_일운면	.0055013	.1228383	0.04	0.964	-.2352574	.24626
TNEt1_동부면	-.0125122	.0990169	-0.13	0.899	-.2065818	.1815574
TNEt1_남부면	-.0029251	.0998066	-0.03	0.977	-.1985424	.1926923
TNEt1_거제면	.0166056	.1345835	0.12	0.902	-.2471733	.2803844
TNEt1_둔덕면	.0137398	.1066627	0.13	0.898	-.1953152	.2227948
TNEt1_사등면	.0544288	.2188554	0.25	0.804	-.37452	.4833776
TNEt1_연초면	.021745	.1137249	0.19	0.848	-.2011518	.2446418
TNEt1_하청면	.0014121	.1049488	0.01	0.989	-.2042838	.207108
TNEt1_장목면	.0135506	.1031365	0.13	0.895	-.1885933	.2156944
TNEt1_장승포동	.0284724	.1383069	0.21	0.837	-.2426042	.299549
TNEt1_능포동	-.0080371	.1088101	-0.07	0.941	-.221301	.2052269
TNEt1_아주동	.0917297	.4191099	0.22	0.827	-.7297107	.91317
TNEt1_옥포 1 동	.0558619	.2037543	0.27	0.784	-.3434891	.455213
TNEt1_옥포 2 동	.0083371	.0933212	0.09	0.929	-.1745691	.1912433
TNEt1_장평동	.1590238	.7516513	0.21	0.832	-1.314186	1.632233
TNEt1_고현동	.0493669	.2234057	0.22	0.825	-.3885003	.4872341
TNEt1_상문동	.008055	.1275285	0.06	0.950	-.2418962	.2580062
TNEt1_수양동	.0248285	.1182571	0.21	0.834	-.2069513	.2566082

LR_Total

size	27.75235	10.13857	2.74	0.006	7.881126	47.62358
SE	81.22643	29.60068	2.74	0.006	23.21017	139.2427
Population	.1140082	.0643567	1.77	0.076	-.0121287	.2401451
TNEt_일운면	-.211121	.7004976	-0.30	0.763	-1.584071	1.161829
TNEt_동부면	-.2147951	.656742	-0.33	0.744	-1.501986	1.072396
TNEt_남부면	-.0310327	.5939716	-0.05	0.958	-1.195196	1.13313
TNEt_거제면	-.3377646	.7074061	-0.48	0.633	-1.724255	1.048726
TNEt_둔덕면	.1192327	.6480286	0.18	0.854	-1.15088	1.389345
TNEt_사등면	.2906446	.7550354	0.38	0.700	-1.189198	1.770487

TNEt_연초면	-.5207717	.7320172	-0.71	0.477	-1.955499	.9139557
TNEt_하청면	-.1428932	.666843	-0.21	0.830	-1.449881	1.164095
TNEt_장목면	.0664751	.6644137	0.10	0.920	-1.235752	1.368702
TNEt_장승포동	.0429713	.6967151	0.06	0.951	-1.322565	1.408508
TNEt_능포동	-.3866921	.6557091	-0.59	0.555	-1.671858	.8984741
TNEt_아주동	9.163157	1.637401	5.60	0.000	5.95391	12.37241
TNEt_옥포 1 동	.1249463	.7599797	0.16	0.869	-1.364587	1.614479
TNEt_옥포 2 동	.1179779	.6560477	0.18	0.857	-1.167852	1.403808
TNEt_장평동	12.15237	2.055044	5.91	0.000	8.124554	16.18018
TNEt_고현동	1.749063	.6487679	2.70	0.007	.4775014	3.020625
TNEt_상문동	.4402216	.6192263	0.71	0.477	-.7734396	1.653883
TNEt_수양동	.2173699	.6885182	0.32	0.752	-1.132101	1.566841
TNEt1_일운면	.112614	.7287858	0.15	0.877	-1.31578	1.541008
TNEt1_동부면	.1049066	.620194	0.17	0.866	-1.110651	1.320465
TNEt1_남부면	-.1062766	.5835605	-0.18	0.855	-1.250034	1.037481
TNEt1_거제면	.1406211	.7514763	0.19	0.852	-1.332245	1.613488
TNEt1_둔덕면	-.32093	.5665454	-0.57	0.571	-1.431339	.7894785
TNEt1_사등면	-1.003385	.9097783	-1.10	0.270	-2.786518	.7797473
TNEt1_연초면	-.380558	.5782723	-0.66	0.510	-1.513951	.7528349
TNEt1_하청면	.2554106	.5993026	0.43	0.670	-.9192009	1.430022
TNEt1_장목면	-.1469155	.6093484	-0.24	0.809	-1.341216	1.047385
TNEt1_장승포동	-.3536143	.7296539	-0.48	0.628	-1.78371	1.076481
TNEt1_능포동	.2074566	.5910231	0.35	0.726	-.9509273	1.365841
TNEt1_아주동	-2.393768	1.05022	-2.28	0.023	-4.452162	-.335375
TNEt1_옥포 1 동	-1.054241	.6965511	-1.51	0.130	-2.419456	.310974
TNEt1_옥포 2 동	-.1213028	.5931005	-0.20	0.838	-1.283758	1.041153
TNEt1_장평동	-4.360271	1.485226	-2.94	0.003	-7.271261	-1.449282
TNEt1_고현동	-1.109179	.7989117	-1.39	0.165	-2.675017	.4566595
TNEt1_상문동	-.2184484	.6768849	-0.32	0.747	-1.545118	1.108222
TNEt1_수양동	-.1920636	.670326	-0.29	0.774	-1.505878	1.121751

LR test between dynamic SDM model with fixed effects and dynamic model with common factors
Likelihood-ratio test
Assumption: M1 nested within M2
LR chi2(36) = 245.22
Prob > chi2 = 0.0000

Industrial Diversity Analysis

Cross-Sectional Dependence Exponent Estimation and Test
Panel Variable (i): Divisions
Time Variable (t): Year
Estimation of Cross-Sectional Exponent (alpha)

variable	alpha	Std.Err.	[95%Conf.	Interval]
IDiversity	0.835	0.062	0.714	0.956

0.5 <= alpha < 1 implies strong cross-sectional dependence.
Pesaran (2015) test for weak cross-sectional dependence.
H0: errors are weakly cross-sectional dependent.

variable	CD	p-value	N_g	T
IDiversity	9.774	0.000	18	11

Variables are centered around zero.

OLS
Regression results

IDiversity	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
sizeaveragemploy m~t	0	0	-2.72	.007	-.001	0	***
SE	-.001	0	-1.81	.072	-.001	0	*
Population	0	0	3.50	.001	0	0	***
Year	.003	.001	5.61	0	.002	.005	***
Constant	-6.359	1.212	-5.25	0	-8.75	-3.968	***

Mean dependent var	0.462	SD dependent var	0.100
R-squared	0.303 (within)/	Number of obs	198

	0.0021 (overall)		
F-test	19.115	Prob > F	0.000
Akaike crit. (AIC)	-915.419	Bayesian crit. (BIC)	-898.978

**** p<.01, ** p<.05, * p<.1*

Log-likelihood: 462.70968

SAR

Iteration 0: Log-likelihood = 467.08533
Iteration 1: Log-likelihood = 482.82504
Iteration 2: Log-likelihood = 483.05868
Iteration 3: Log-likelihood = 483.0604
Iteration 4: Log-likelihood = 483.06042
Iteration 5: Log-likelihood = 483.06042
…
Iteration 99: Log-likelihood = 483.06042 (backed up)
Iteration 100: Log-likelihood = 483.06042 (backed up)
convergence not achieved
Computing marginal effects standard errors using MC simulation...
SAR with spatial and time fixed-effects Number of obs = 198
Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.1690
between = 0.0295
overall = 0.0351
Mean of fixed-effects = 0.5506
Log-likelihood = 483.0604

lDiversity	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
sizeaverageemploymentperest	-0.000	0.000	-2.440	0.015	-0.000	-0.000
SE	-0.000	0.000	-1.130	0.259	-0.001	0.000
Population	0.000	0.000	4.350	0.000	0.000	0.000
Spatial						
rho	-0.233	0.094	-2.470	0.013	-0.418	-0.048
Variance						
sigma2_e	0.000	0.000	9.880	0.000	0.000	0.001
LR_Direct						
sizeaverageemploymentperest	-0.000	0.000	-2.350	0.019	-0.000	-0.000
SE	-0.000	0.000	-1.150	0.252	-0.001	0.000
Population	0.000	0.000	4.650	0.000	0.000	0.000
LR_Indirect						
sizeaverageemploymentperest	0.000	0.000	1.810	0.070	-0.000	0.000
SE	0.000	0.000	1.020	0.308	-0.000	0.000
Population	-0.000	0.000	-2.310	0.021	-0.000	-0.000
LR_Total						
sizeaverageemploymentperest	-0.000	0.000	-2.260	0.024	-0.000	-0.000
SE	-0.000	0.000	-1.130	0.259	-0.001	0.000
Population	0.000	0.000	4.310	0.000	0.000	0.000

SEM

Iteration 0: Log-likelihood = 477.94254
Iteration 1: Log-likelihood = 481.43225
Iteration 2: Log-likelihood = 481.45018
Iteration 3: Log-likelihood = 481.4502
SEM with spatial and time fixed-effects Number of obs = 198
Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.1728
between = 0.0516
overall = 0.0576
Mean of fixed-effects = 0.4397

Log-likelihood = 481.4502

IDiversity	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
sizeaverageemploymentperest	-0.000	0.000	-2.230	0.026	-0.000	-0.000
SE	-0.000	0.000	-0.920	0.358	-0.001	0.000
Population	0.000	0.000	4.110	0.000	0.000	0.000
Spatial						
lambda	-0.163	0.099	-1.640	0.100	-0.358	0.032
Variance						
sigma2_e	0.000	0.000	9.910	0.000	0.000	0.001

SLX

Regression results

IDiversity	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
size	0	0	-2.28	.024	-.001	0	**
SE	-.001	0	-1.71	.089	-.001	0	*
Population	0	0	3.92	0	0	0	***
w_Idiversity	.21	.114	1.84	.067	-.015	.435	*
w_size	.001	0	2.43	.016	0	.001	**
w_SE	0	.001	0.71	.479	-.001	.002	
w_pop	0	0	-2.04	.042	0	0	**
Year	.004	.001	4.89	0	.003	.006	***
Constant	-8.404	1.765	-4.76	0	-11.888	-4.92	***

Mean dependent var	0.462	SD dependent var	0.100
R-squared	0.364	Number of obs	198
F-test	12.285	Prob > F	0.000
Akaike crit. (AIC)	-925.473	Bayesian crit. (BIC)	-895.879

**** p<.01, ** p<.05, * p<.1*

SAC

Iteration 0: Log-likelihood = 473.97238
Iteration 1: Log-likelihood = 483.05252
Iteration 2: Log-likelihood = 483.25816
Iteration 3: Log-likelihood = 483.26238
Computing marginal effects standard errors using MC simulation...
SAC with spatial and time fixed-effects Number of obs = 198
Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.1679
between = 0.0193
overall = 0.0243
Mean of fixed-effects = 0.5898
Log-likelihood = 483.2624

IDiversity	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
sizeaverageemploymentperest	-0.000	0.000	-2.570	0.010	-0.000	-0.000
SE	-0.000	0.000	-1.260	0.207	-0.001	0.000
Population	0.000	0.000	4.410	0.000	0.000	0.000
Spatial						
rho	-0.314	0.152	-2.060	0.039	-0.613	-0.016
lambda	0.106	0.155	0.680	0.495	-0.198	0.410
Variance						
sigma2_e	0.000	0.000	10.370	0.000	0.000	0.001
LR_Direct						
sizeaverageemploymentperest	-0.000	0.000	-2.460	0.014	-0.001	-0.000
SE	-0.000	0.000	-1.280	0.202	-0.001	0.000
Population	0.000	0.000	4.630	0.000	0.000	0.000
LR_Indirect						

sizeaverageemploy mentperest	0.000	0.000	1.650	0.099	-0.000	0.000
SE	0.000	0.000	1.070	0.286	-0.000	0.000
Population	-0.000	0.000	-1.970	0.049	-0.000	-0.000
LR_Total						
sizeaverageemploy mentperest	-0.000	0.000	-2.380	0.017	-0.000	-0.000
SE	-0.000	0.000	-1.260	0.209	-0.001	0.000
Population	0.000	0.000	4.160	0.000	0.000	0.000

SDM

Warning: All regressors will be spatially lagged
Iteration 0: Log-likelihood = 476.74556
Iteration 1: Log-likelihood = 489.15079
Iteration 2: Log-likelihood = 489.28262
Iteration 3: Log-likelihood = 489.28262 (backed up)
Iteration 4: Log-likelihood = 489.28262 (backed up)
…
Iteration 99: Log-likelihood = 489.28262 (backed up)
Iteration 100: Log-likelihood = 489.28262 (backed up)
convergence not achieved
Computing marginal effects standard errors using MC simulation...
SDM with spatial and time fixed-effects Number of obs = 198
Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.1138
between = 0.0838
overall = 0.0845
Mean of fixed-effects = 0.4877
Log-likelihood = 489.2826

lDiversity	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
sizeaverageemploy mentperest	-0.000	0.000	-1.660	0.098	-0.000	0.000
SE	-0.000	0.000	-1.040	0.299	-0.001	0.000
Population	0.000	0.000	5.000	0.000	0.000	0.000
Wx						
sizeaverageemploy mentperest	0.001	0.000	2.750	0.006	0.000	0.001
SE	0.002	0.001	2.340	0.020	0.000	0.003
Population	-0.000	0.000	-1.180	0.237	-0.000	0.000
Spatial						
rho	-0.183	0.098	-1.880	0.060	-0.375	0.008
Variance						
sigma2_e	0.000	0.000	9.900	0.000	0.000	0.000
LR_Direct						
sizeaverageemploy mentperest	-0.000	0.000	-1.890	0.059	-0.000	0.000
SE	-0.000	0.000	-1.280	0.202	-0.001	0.000
Population	0.000	0.000	5.320	0.000	0.000	0.000
LR_Indirect						
sizeaverageemploy mentperest	0.001	0.000	2.990	0.003	0.000	0.001
SE	0.001	0.001	2.480	0.013	0.000	0.003
Population	-0.000	0.000	-1.610	0.107	-0.000	0.000
LR_Total						
sizeaverageemploy mentperest	0.000	0.000	1.730	0.083	-0.000	0.001
SE	0.001	0.001	1.560	0.118	-0.000	0.002
Population	0.000	0.000	1.020	0.307	-0.000	0.000

SDEM

Iteration 0: Log-likelihood = 451.97596

Iteration 1: Log-likelihood = 454.80393
Iteration 2: Log-likelihood = 454.86872
Iteration 3: Log-likelihood = 454.86881
Iteration 4: Log-likelihood = 454.86881
SEM with spatial fixed-effects Number of obs = 198
Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.1867
between = 0.0131
overall = 0.0176
Mean of fixed-effects = 0.4314
Log-likelihood = 454.8688

IDiversity	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
sizeaverageemploymentperest	-0.000	0.000	-3.010	0.003	-0.001	-0.000
SE	-0.000	0.000	-1.250	0.213	-0.001	0.000
Population	0.000	0.000	4.080	0.000	0.000	0.000
w_size	0.000	0.000	0.920	0.359	-0.000	0.001
w_SE	0.001	0.001	1.520	0.128	-0.000	0.002
w_pop	-0.000	0.000	-0.740	0.462	-0.000	0.000
Spatial						
lambda	0.305	0.083	3.670	0.000	0.142	0.468
Variance						
sigma2_e	0.001	0.000	9.830	0.000	0.000	0.001

GNS
Iteration 0: Log-likelihood = 481.61484
Iteration 1: Log-likelihood = 489.81932
Iteration 2: Log-likelihood = 490.06026
Iteration 3: Log-likelihood = 490.06026 (backed up)
Computing marginal effects standard errors using MC simulation...
SAC with spatial and time fixed-effects Number of obs = 198
Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 11
R-sq: within = 0.0988
between = 0.0700
overall = 0.0707
Mean of fixed-effects = 0.4189
Log-likelihood = 490.0603

IDiversity	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
sizeaverageemploymentperest	-0.000	0.000	-1.860	0.063	-0.000	0.000
SE	-0.000	0.000	-1.250	0.213	-0.001	0.000
Population	0.000	0.000	5.080	0.000	0.000	0.000
w_size	0.001	0.000	2.940	0.003	0.000	0.001
w_SE	0.002	0.001	2.650	0.008	0.000	0.003
w_pop	-0.000	0.000	-1.640	0.101	-0.000	0.000
Spatial						
rho	-0.019	0.164	-0.120	0.907	-0.340	0.302
lambda	-0.215	0.175	-1.230	0.218	-0.558	0.127
Variance						
sigma2_e	0.000	0.000	10.760	0.000	0.000	0.001
LR_Direct						
sizeaverageemploymentperest	-0.000	0.000	-1.780	0.076	-0.000	0.000
SE	-0.000	0.000	-1.260	0.207	-0.001	0.000
Population	0.000	0.000	5.420	0.000	0.000	0.000
w_size	0.001	0.000	3.040	0.002	0.000	0.001
w_SE	0.002	0.001	2.720	0.006	0.000	0.003
w_pop	-0.000	0.000	-1.710	0.087	-0.000	0.000
LR_Indirect						

sizeaverageemploymentperest	-0.000	0.000	-0.070	0.948	-0.000	0.000
SE	-0.000	0.000	-0.070	0.945	-0.000	0.000
Population	0.000	0.000	0.020	0.983	-0.000	0.000
w_size	0.000	0.000	0.020	0.984	-0.000	0.000
w_SE	0.000	0.000	0.010	0.994	-0.001	0.001
w_pop	-0.000	0.000	-0.190	0.846	-0.000	0.000
LR_Total						
sizeaverageemploymentperest	-0.000	0.000	-1.640	0.100	-0.000	0.000
SE	-0.000	0.000	-1.210	0.226	-0.001	0.000
Population	0.000	0.000	3.660	0.000	0.000	0.000
w_size	0.001	0.000	2.570	0.010	0.000	0.001
w_SE	0.002	0.001	2.400	0.016	0.000	0.003
w_pop	-0.000	0.000	-1.520	0.130	-0.000	0.000

Likelihood-ratio test

. lrtest sac sdm, stats
Assumption: sac nested within sdm
LR chi2(2) = 12.04
Prob > chi2 = 0.0024

Akaike's information criterion and Bayesian information criterion

Model	N	ll(null)	ll(model)	df	AIC	BIC
sac	198	.	483.2624	6	-954.5248	-934.7951
sdm	198	.	489.2826	8	-962.5652	-936.2591

Note: BIC uses N = number of observations. See [R] BIC note.

Assumption: sdm nested within gns
LR chi2(1) = 1.56
Prob > chi2 = 0.2124

Akaike's information criterion and Bayesian information criterion

Model	N	ll(null)	ll(model)	df	AIC	BIC
sdm	198	.	489.2826	8	-962.5652	-936.2591
gns	198	.	490.0603	9	-962.1205	-932.5261

Note: BIC uses N = number of observations. See [R] BIC note.

Dynamic SDM

Warning: All regressors will be spatially lagged
Iteration 0: Log-likelihood = 452.95949
Iteration 1: Log-likelihood = 455.8847
Iteration 2: Log-likelihood = 455.89892
Iteration 3: Log-likelihood = 455.89895
Computing marginal effects standard errors using MC simulation...
Dynamic SDM with spatial and time fixed-effects Number of obs = 180
Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 10
R-sq: within = 0.2882

between = 0.5073
overall = 0.4899
Mean of fixed-effects = 0.3017
Log-likelihood = 397.1161

IDiversity	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
Main						
IDiversity						
L1.	0.440	0.070	6.250	0.000	0.302	0.578
WIDiversity						
L1.	-0.012	0.145	-0.080	0.935	-0.296	0.272
sizeaverageemploy mentperest	-0.000	0.000	-1.730	0.084	-0.000	0.000
SE	-0.000	0.000	-1.290	0.198	-0.001	0.000
Population	0.000	0.000	3.650	0.000	0.000	0.000
Wx						
sizeaverageemploy mentperest	0.000	0.000	1.610	0.108	-0.000	0.001
SE	0.001	0.001	1.720	0.085	-0.000	0.002
Population	-0.000	0.000	-1.190	0.233	-0.000	0.000
Spatial						
rho	0.139	0.100	1.380	0.166	-0.058	0.335
Variance						
sigma2_e	0.000	0.000	10.410	0.000	0.000	0.000
SR_Direct						
sizeaverageemploy mentperest	-0.000	0.000	-1.880	0.060	-0.000	0.000
SE	-0.000	0.000	-1.340	0.181	-0.001	0.000
Population	0.000	0.000	3.820	0.000	0.000	0.000
SR_Indirect						
sizeaverageemploy mentperest	0.000	0.000	1.800	0.071	-0.000	0.001
SE	0.001	0.001	1.830	0.068	-0.000	0.002
Population	-0.000	0.000	-1.460	0.144	-0.000	0.000
SR_Total						
sizeaverageemploy mentperest	0.000	0.000	0.860	0.390	-0.000	0.001
SE	0.001	0.001	0.970	0.330	-0.001	0.002
Population	0.000	0.000	0.440	0.661	-0.000	0.000
LR_Direct						
sizeaverageemploy mentperest	-0.000	0.000	-2.010	0.044	-0.001	-0.000
SE	-0.001	0.001	-1.430	0.154	-0.002	0.000
Population	0.000	0.000	3.710	0.000	0.000	0.000
LR_Indirect						
sizeaverageemploy mentperest	0.001	0.000	1.900	0.057	-0.000	0.002
SE	0.002	0.001	1.890	0.059	-0.000	0.004
Population	-0.000	0.000	-1.620	0.104	-0.000	0.000
LR_Total						
sizeaverageemploy mentperest	0.000	0.000	0.850	0.394	-0.001	0.001
SE	0.001	0.001	0.960	0.336	-0.001	0.003
Population	0.000	0.000	0.430	0.669	-0.000	0.000

Dynamic SDM with CF
. asdoc xsmle IDiversity size SE Population IDiversityt*, wmat(W1) model(sdm) dlag(3) durbin(size SE Population) fe type(ind) effects nsim(500)
(File Myfile.doc already exists, option append was assumed)
Iteration 0: Log-likelihood = 480.83236
Iteration 1: Log-likelihood = 485.77346
Iteration 2: Log-likelihood = 485.81543

Iteration 3: Log-likelihood = 485.81557
Iteration 4: Log-likelihood = 485.81557
Computing marginal effects standard errors using MC simulation...

Dynamic SDM with spatial fixed-effects Number of obs = 180

Group variable: Divisions Number of groups = 18
Time variable: Year Panel length = 10

R-sq: within = 0.6583
between = 0.2847
overall = 0.2442

Mean of fixed-effects = 0.0044

Log-likelihood = 484.0422

IDiversity Coefficient Std. err. z P>z [95% conf. interval]

Main
IDiversity
L1. .3645246 .0736827 4.95 0.000 .2201092 .5089401

WIDiversity
L1. -.0400051 .1479325 -0.27 0.787 -.3299474 .2499372

sizeaverageemploymentperest -.0001811 .0001146 -1.58 0.114 -.0004056 .0000435
SE -.0001194 .0003424 -0.35 0.727 -.0007905 .0005516
Population 1.17e-07 1.08e-06 0.11 0.914 -1.99e-06 2.22e-06
IDiversityt_일운면 .6804882 .5271858 1.29 0.197 -.352777 1.713753
IDiversityt_동부면 1.688623 .4920291 3.43 0.001 .7242632 2.652982
IDiversityt_남부면 .8087771 .4931145 1.64 0.101 -.1577096 1.775264
IDiversityt_거제면 1.330336 .4948918 2.69 0.007 .3603659 2.300306
IDiversityt_둔덕면 -.0550606 .4916456 -0.11 0.911 -1.018668 .9085471
IDiversityt_사등면 1.474054 .4966748 2.97 0.003 .5005894 2.447519
IDiversityt_연초면 2.234484 .4896824 4.56 0.000 1.274724 3.194244
IDiversityt_하청면 1.372998 .5073047 2.71 0.007 .3786987 2.367297
IDiversityt_장목면 1.201717 .4878959 2.46 0.014 .245459 2.157976
IDiversityt_장승포동 .0513553 .5012737 0.10 0.918 -.9311232 1.033834
IDiversityt_능포동 .3330496 .4815216 0.69 0.489 -.6107154 1.276815
IDiversityt_아주동 2.027831 .5568333 3.64 0.000 .9364576 3.119204
IDiversityt_옥포 1 동 .9873534 .5165015 1.91 0.056 -.0249709 1.999678
IDiversityt_옥포 2 동 .3439773 .4904379 0.70 0.483 -.6172634 1.305218
IDiversityt_장평동 1.775819 .526027 3.38 0.001 .744825 2.806813
IDiversityt_고현동 1.670174 .5321138 3.14 0.002 .6272496 2.713097
IDiversityt_상문동 3.074028 .5149124 5.97 0.000 2.064818 4.083237
IDiversityt_수양동 1.679411 .5205188 3.23 0.001 .6592124 2.699609
IDiversityt1_일운면 .5558626 .8111822 0.69 0.493 -1.034025 2.145751
IDiversityt1_동부면 -1.406302 .7872238 -1.79 0.074 -2.949232 .1366282
IDiversityt1_남부면 .8081977 .7790145 1.04 0.300 -.7186427 2.335038
IDiversityt1_거제면 -.9879763 .7989209 -1.24 0.216 -2.553832 .5778798
IDiversityt1_둔덕면 1.753668 .8176977 2.14 0.032 .1510102 3.356326
IDiversityt1_사등면 -.6859587 .8758864 -0.78 0.434 -2.402665 1.030747
IDiversityt1_연초면 -1.877654 .7958902 -2.36 0.018 -3.43757 -.317738
IDiversityt1_하청면 .2662286 .8618034 0.31 0.757 -1.422875 1.955332
IDiversityt1_장목면 1.063643 .824425 1.29 0.197 -.5521999 2.679487
IDiversityt1_장승포동 .3718718 .8299997 0.45 0.654 -1.254898 1.998641
IDiversityt1_능포동 .0204793 .7944946 0.03 0.979 -1.536702 1.57766
IDiversityt1_아주동 -.3002357 .8914062 -0.34 0.736 -2.04736 1.446888
IDiversityt1_옥포 1 동 -.2393152 .8186494 -0.29 0.770 -1.843838 1.365208
IDiversityt1_옥포 2 동 -.0797475 .7896472 -0.10 0.920 -1.627428 1.467933
IDiversityt1_장평동 -2.175221 .859876 -2.53 0.011 -3.860547 -.4898948
IDiversityt1_고현동 -1.983653 .8153285 -2.43 0.015 -3.581668 -.3856385
IDiversityt1_상문동 -1.393033 .8268149 -1.68 0.092 -3.01356 .2274944
IDiversityt1_수양동 -.324933 .8049712 -0.40 0.686 -1.902647 1.252782

Wx
sizeaverageemploymentperest .0003142 .0002001 1.57 0.116 -.0000779 .0007063
SE .0006366 .0005123 1.24 0.214 -.0003675 .0016408
Population -9.08e-07 2.02e-06 -0.45 0.653 -4.86e-06 3.05e-06

Spatial
rho .2249722 .1026345 2.19 0.028 .0238123 .4261321

Variance
sigma2_e .0002876 .0000277 10.37 0.000 .0002332 .0003419

SR_Direct
sizeaverageemploymentperest -.0001898 .0001134 -1.67 0.094 -.0004122 .0000325
SE -.0001374 .0003608 -0.38 0.703 -.0008444 .0005697
Population 1.84e-07 1.07e-06 0.17 0.863 -1.91e-06 2.28e-06
IDiversityt_일운면 .7242526 .538111 1.35 0.178 -.3304256 1.778931
IDiversityt_동부면 1.721286 .5303086 3.25 0.001 .6818998 2.760671
IDiversityt_남부면 .8085795 .4866533 1.66 0.097 -.1452435 1.762402
IDiversityt_거제면 1.398273 .4999568 2.80 0.005 .4183759 2.378171
IDiversityt_둔덕면 -.0322613 .504384 -0.06 0.949 -1.020836 .9563131
IDiversityt_사등면 1.485623 .4888398 3.04 0.002 .5275144 2.443731
IDiversityt_연초면 2.304579 .5369676 4.29 0.000 1.252141 3.357016
IDiversityt_하청면 1.377514 .518298 2.66 0.008 .3616686 2.393359
IDiversityt_장목면 1.244446 .5130156 2.43 0.015 .2389541 2.249938
IDiversityt_장승포동 .032037 .483771 0.07 0.947 -.9161367 .9802107
IDiversityt_능포동 .3473391 .5022702 0.69 0.489 -.6370925 1.331771
IDiversityt_아주동 2.129972 .572807 3.72 0.000 1.007291 3.252653
IDiversityt_옥포 1 동 .998291 .5499705 1.82 0.069 -.0796314 2.076213
IDiversityt_옥포 2 동 .3517656 .5107218 0.69 0.491 -.6492307 1.352762
IDiversityt_장평동 1.831664 .5513259 3.32 0.001 .7510848 2.912243
IDiversityt_고현동 1.682396 .5386663 3.12 0.002 .6266299 2.738163
IDiversityt_상문동 3.128695 .5014058 6.24 0.000 2.145957 4.111432
IDiversityt_수양동 1.695246 .5323122 3.18 0.001 .6519337 2.738559
IDiversityt1_일운면 .5181758 .8358528 0.62 0.535 -1.120066 2.156417
IDiversityt1_동부면 -1.445671 .8609398 -1.68 0.093 -3.133082 .2417403
IDiversityt1_남부면 .8377221 .7954636 1.05 0.292 -.7213578 2.396802
IDiversityt1_거제면 -1.034458 .7984983 -1.30 0.195 -2.599486 .5305696
IDiversityt1_둔덕면 1.765417 .7781202 2.27 0.023 .2403293 3.290504
IDiversityt1_사등면 -.661612 .8766797 -0.75 0.450 -2.379873 1.056649
IDiversityt1_연초면 -1.849228 .8210186 -2.25 0.024 -3.458395 -.2400612
IDiversityt1_하청면 .2966745 .8823347 0.34 0.737 -1.43267 2.026019
IDiversityt1_장목면 1.047598 .880222 1.19 0.234 -.6776058 2.772801
IDiversityt1_장승포동 .4119747 .8235018 0.50 0.617 -1.202059 2.026009
IDiversityt1_능포동 -.0200839 .8106467 -0.02 0.980 -1.608922 1.568754
IDiversityt1_아주동 -.3744877 .8731944 -0.43 0.668 -2.085917 1.336942
IDiversityt1_옥포 1 동 -.2328036 .8422862 -0.28 0.782 -1.883654 1.418047
IDiversityt1_옥포 2 동 -.1214356 .7971922 -0.15 0.879 -1.683904 1.441032
IDiversityt1_장평동 -2.228982 .8604567 -2.59 0.010 -3.915446 -.5425179
IDiversityt1_고현동 -1.984991 .8377437 -2.37 0.018 -3.626939 -.3430434
IDiversityt1_상문동 -1.409033 .833009 -1.69 0.091 -3.0417 .2236351
IDiversityt1_수양동 -.3636118 .8180571 -0.44 0.657 -1.966974 1.239751

SR_Indirect
sizeaverageemploymentperest .0003033 .0001748 1.74 0.083 -.0000393 .0006459
SE .0005749 .0004567 1.26 0.208 -.0003201 .0014699
Population -8.27e-07 1.78e-06 -0.46 0.642 -4.32e-06 2.66e-06
IDiversityt_일운면 -.1532813 .1443305 -1.06 0.288 -.436164 .1296013
IDiversityt_동부면 -.3399612 .1869577 -1.82 0.069 -.7063914 .0264691
IDiversityt_남부면 -.1637145 .1298907 -1.26 0.208 -.4182957 .0908666
IDiversityt_거제면 -.2790319 .1681743 -1.66 0.097 -.6086475 .0505837
IDiversityt_둔덕면 -.003462 .1057615 -0.03 0.974 -.2107507 .2038268
IDiversityt_사등면 -.2894515 .1629361 -1.78 0.076 -.6088004 .0298975
IDiversityt_연초면 -.4529548 .2337466 -1.94 0.053 -.9110897 .0051802
IDiversityt_하청면 -.2768128 .1702087 -1.63 0.104 -.6104158 .0567902
IDiversityt_장목면 -.245423 .1540407 -1.59 0.111 -.5473371 .0564912
IDiversityt_장승포동 -.0129267 .0989228 -0.13 0.896 -.2068119 .1809585
IDiversityt_능포동 -.0651078 .1106986 -0.59 0.556 -.282073 .1518575
IDiversityt_아주동 -.4184269 .2183675 -1.92 0.055 -.8464192 .0095655
IDiversityt_옥포 1 동 -.2052887 .1519522 -1.35 0.177 -.5031095 .0925321
IDiversityt_옥포 2 동 -.0785037 .1131353 -0.69 0.488 -.3002448 .1432373
IDiversityt_장평동 -.3608728 .2038644 -1.77 0.077 -.7604397 .038694
IDiversityt_고현동 -.3360524 .1943732 -1.73 0.084 -.7170169 .0449121
IDiversityt_상문동 -.6083528 .2802858 -2.17 0.030 -1.157703 -.0590026
IDiversityt_수양동 -.3378336 .1958042 -1.73 0.084 -.7216027 .0459355
IDiversityt1_일운면 -.0940034 .1735188 -0.54 0.588 -.434094 .2460872
IDiversityt1_동부면 .2771006 .2110115 1.31 0.189 -.1364745 .6906756
IDiversityt1_남부면 -.1514829 .1724863 -0.88 0.380 -.4895499 .186584
IDiversityt1_거제면 .206128 .1906077 1.08 0.280 -.1674562 .5797123
IDiversityt1_둔덕면 -.3304839 .1992483 -1.66 0.097 -.7210034 .0600355
IDiversityt1_사등면 .1249732 .1909502 0.65 0.513 -.2492823 .4992287
IDiversityt1_연초면 .3603003 .2342618 1.54 0.124 -.0988444 .8194451
IDiversityt1_하청면 -.0547952 .184543 -0.30 0.767 -.4164927 .3069024
IDiversityt1_장목면 -.2008827 .1947873 -1.03 0.302 -.5826588 .1808934
IDiversityt1_장승포동 -.0805417 .1770987 -0.45 0.649 -.4276487 .2665653

IDiversityt1_능포동 .008257 .1770225 0.05 0.963 -.3387007 .3552146
IDiversityt1_아주동 .0756333 .1835315 0.41 0.680 -.2840817 .4353484
IDiversityt1_옥포 1 동 .0502957 .1810221 0.28 0.781 -.3045011 .4050925
IDiversityt1_옥포 2 동 .0236231 .1634421 0.14 0.885 -.2967175 .3439638
IDiversityt1_장평동 .4325087 .2550429 1.70 0.090 -.0673663 .9323836
IDiversityt1_고현동 .3854331 .2370467 1.63 0.104 -.0791699 .8500361
IDiversityt1_상문동 .2682839 .2052075 1.31 0.191 -.1339154 .6704832
IDiversityt1_수양동 .0786275 .175544 0.45 0.654 -.2654324 .4226873

SR_Total
sizeaverageemploymentperest .0001135 .0001734 0.65 0.513 -.0002264 .0004534
SE .0004375 .0004267 1.03 0.305 -.0003989 .0012739
Population -6.43e-07 1.71e-06 -0.38 0.707 -3.99e-06 2.71e-06
IDiversityt_일운면 .5709712 .4157781 1.37 0.170 -.2439389 1.385881
IDiversityt_동부면 1.381324 .4117977 3.35 0.001 .5742158 2.188433
IDiversityt_남부면 .6448649 .3836558 1.68 0.093 -.1070865 1.396816
IDiversityt_거제면 1.119241 .381191 2.94 0.003 .3721206 1.866362
IDiversityt_둔덕면 -.0357233 .406321 -0.09 0.930 -.8320978 .7606513
IDiversityt_사등면 1.196171 .3936614 3.04 0.002 .4246093 1.967734
IDiversityt_연초면 1.851624 .4147439 4.46 0.000 1.038741 2.664507
IDiversityt_하청면 1.100701 .3950646 2.79 0.005 .3263889 1.875013
IDiversityt_장목면 .9990233 .4087981 2.44 0.015 .1977938 1.800253
IDiversityt_장승포동 .0191103 .3933182 0.05 0.961 -.7517792 .7899998
IDiversityt_능포동 .2822313 .4045849 0.70 0.485 -.5107405 1.075203
IDiversityt_아주동 1.711545 .4506567 3.80 0.000 .828274 2.594816
IDiversityt_옥포 1 동 .7930023 .427227 1.86 0.063 -.0443472 1.630352
IDiversityt_옥포 2 동 .2732619 .4096113 0.67 0.505 -.5295615 1.076085
IDiversityt_장평동 1.470791 .4277649 3.44 0.001 .6323872 2.309195
IDiversityt_고현동 1.346344 .4095364 3.29 0.001 .5436674 2.149021
IDiversityt_상문동 2.520342 .41412 6.09 0.000 1.708682 3.332002
IDiversityt_수양동 1.357413 .4022915 3.37 0.001 .5689361 2.14589
IDiversityt1_일운면 .4241724 .6831981 0.62 0.535 -.9148713 1.763216
IDiversityt1_동부면 -1.16857 .7035258 -1.66 0.097 -2.547456 .210315
IDiversityt1_남부면 .6862392 .6571325 1.04 0.296 -.6017169 1.974195
IDiversityt1_거제면 -.8283303 .639605 -1.30 0.195 -2.081933 .4252724
IDiversityt1_둔덕면 1.434933 .6544979 2.19 0.028 .1521404 2.717725
IDiversityt1_사등면 -.5366388 .7092816 -0.76 0.449 -1.926805 .8535276
IDiversityt1_연초면 -1.488928 .6600468 -2.26 0.024 -2.782596 -.1952598
IDiversityt1_하청면 .2418793 .715807 0.34 0.735 -1.161077 1.644835
IDiversityt1_장목면 .8467149 .7248341 1.17 0.243 -.5739339 2.267364
IDiversityt1_장승포동 .331433 .6662302 0.50 0.619 -.9743541 1.63722
IDiversityt1_능포동 -.0118269 .6470173 -0.02 0.985 -1.279957 1.256304
IDiversityt1_아주동 -.2988544 .7070772 -0.42 0.673 -1.6847 1.086991
IDiversityt1_옥포 1 동 -.1825079 .6768815 -0.27 0.787 -1.509171 1.144156
IDiversityt1_옥포 2 동 -.0978125 .6476852 -0.15 0.880 -1.367252 1.171627
IDiversityt1_장평동 -1.796473 .7020471 -2.56 0.011 -3.17246 -.4204863
IDiversityt1_고현동 -1.599558 .6828421 -2.34 0.019 -2.937904 -.261212
IDiversityt1_상문동 -1.140749 .6845397 -1.67 0.096 -2.482422 .2009246
IDiversityt1_수양동 -.2849843 .6591617 -0.43 0.665 -1.576918 1.006949

LR_Direct
sizeaverageemploymentperest -.0003349 .0001911 -1.75 0.080 -.0007096 .0000397
SE -.0002787 .0006112 -0.46 0.648 -.0014766 .0009193
Population 3.84e-07 1.81e-06 0.21 0.832 -3.16e-06 3.93e-06
IDiversityt_일운면 1.191219 .8959833 1.33 0.184 -.5648758 2.947314
IDiversityt_동부면 2.816709 .8867576 3.18 0.001 1.078696 4.554722
IDiversityt_남부면 1.325518 .8057236 1.65 0.100 -.253671 2.904707
IDiversityt_거제면 2.289807 .8386733 2.73 0.006 .6460374 3.933577
IDiversityt_둔덕면 -.0473789 .8256067 -0.06 0.954 -1.665538 1.570781
IDiversityt_사등면 2.429502 .811802 2.99 0.003 .8383992 4.020605
IDiversityt_연초면 3.771052 .9151537 4.12 0.000 1.977383 5.56472
IDiversityt_하청면 2.256705 .8685988 2.60 0.009 .5542829 3.959128
IDiversityt_장목면 2.036759 .8510453 2.39 0.017 .3687411 3.704777
IDiversityt_장승포동 .0559776 .7904338 0.07 0.944 -1.493244 1.605199
IDiversityt_능포동 .5667839 .8230785 0.69 0.491 -1.04642 2.179988
IDiversityt_아주동 3.48461 .960539 3.63 0.000 1.601988 5.367232
IDiversityt_옥포 1 동 1.637752 .9128486 1.79 0.073 -.1513981 3.426903
IDiversityt_옥포 2 동 .5802224 .8383087 0.69 0.489 -1.062832 2.223277
IDiversityt_장평동 2.997962 .9280627 3.23 0.001 1.178993 4.816931
IDiversityt_고현동 2.755486 .908126 3.03 0.002 .9755916 4.53538
IDiversityt_상문동 5.115781 .863502 5.92 0.000 3.423348 6.808214
IDiversityt_수양동 2.776345 .8998684 3.09 0.002 1.012635 4.540054
IDiversityt1_일운면 .8426541 1.364951 0.62 0.537 -1.832601 3.51791
IDiversityt1_동부면 -2.361837 1.409055 -1.68 0.094 -5.123535 .3998611
IDiversityt1_남부면 1.364329 1.297829 1.05 0.293 -1.179368 3.908027
IDiversityt1_거제면 -1.693475 1.311597 -1.29 0.197 -4.264158 .8772067
IDiversityt1_둔덕면 2.879555 1.266174 2.27 0.023 .3978999 5.361211
IDiversityt1_사등면 -1.079286 1.435081 -0.75 0.452 -3.891993 1.733421

IDiversityt1_연초면 -3.024039 1.355148 -2.23 0.026 -5.68008 -.3679983
IDiversityt1_하청면 .4837863 1.442983 0.34 0.737 -2.344409 3.311981
IDiversityt1_장목면 1.711552 1.436527 1.19 0.233 -1.103989 4.527094
IDiversityt1_장승포동 .6740907 1.348785 0.50 0.617 -1.969479 3.317661
IDiversityt1_능포동 -.034722 1.330968 -0.03 0.979 -2.643372 2.573928
IDiversityt1_아주동 -.6133171 1.427767 -0.43 0.668 -3.411689 2.185055
IDiversityt1_옥포 1 동 -.3829571 1.380999 -0.28 0.782 -3.089666 2.323752
IDiversityt1_옥포 2 동 -.1978501 1.30214 -0.15 0.879 -2.749998 2.354298
IDiversityt1_장평동 -3.64404 1.417163 -2.57 0.010 -6.421627 -.866452
IDiversityt1_고현동 -3.244764 1.377707 -2.36 0.019 -5.945021 -.5445071
IDiversityt1_상문동 -2.301579 1.364331 -1.69 0.092 -4.975619 .3724602
IDiversityt1_수양동 -.5992362 1.340068 -0.45 0.655 -3.225722 2.02725

LR_Indirect
sizeaveragemploymentperest .0004903 .0002666 1.84 0.066 -.0000321 .0010128
SE .0008757 .0007188 1.22 0.223 -.0005332 .0022845
Population -1.26e-06 2.72e-06 -0.46 0.643 -6.59e-06 4.07e-06
IDiversityt_일운면 -.4162826 .3790697 -1.10 0.272 -1.159246 .3266804
IDiversityt_동부면 -.9316019 .4693872 -1.98 0.047 -1.851584 -.0116198
IDiversityt_남부면 -.4471969 .3382921 -1.32 0.186 -1.110237 .2158435
IDiversityt_거제면 -.7636165 .4266788 -1.79 0.074 -1.599892 .0726586
IDiversityt_둔덕면 -.0056709 .2855428 -0.02 0.984 -.5653244 .5539826
IDiversityt_사등면 -.7950277 .4089313 -1.94 0.052 -1.596518 .0064628
IDiversityt_연초면 -1.24272 .5791756 -2.15 0.032 -2.377884 -.107557
IDiversityt_하청면 -.7566559 .4330944 -1.75 0.081 -1.605505 .0921936
IDiversityt_장목면 -.6730518 .3937045 -1.71 0.087 -1.444698 .0985948
IDiversityt_장승포동 -.0327654 .2678293 -0.12 0.903 -.5577011 .4921703
IDiversityt_능포동 -.1799547 .2953149 -0.61 0.542 -.7587614 .3988519
IDiversityt_아주동 -1.147716 .5435913 -2.11 0.035 -2.213135 -.0822966
IDiversityt_옥포 1 동 -.5592642 .3946125 -1.42 0.156 -1.332691 .2141621
IDiversityt_옥포 2 동 -.2114549 .3028279 -0.70 0.485 -.8049866 .3820768
IDiversityt_장평동 -.9898445 .5111959 -1.94 0.053 -1.99177 .012081
IDiversityt_고현동 -.9195624 .4894196 -1.88 0.060 -1.878807 .0396824
IDiversityt_상문동 -1.671543 .6799819 -2.46 0.014 -3.004283 -.3388027
IDiversityt_수양동 -.9249064 .4933617 -1.87 0.061 -1.891878 .0420648
IDiversityt1_일운면 -.2605355 .4666107 -0.56 0.577 -1.175076 .6540046
IDiversityt1_동부면 .762987 .5484374 1.39 0.164 -.3119306 1.837904
IDiversityt1_남부면 -.421121 .4571132 -0.92 0.357 -1.317046 .4748045
IDiversityt1_거제면 .5639872 .5018548 1.12 0.261 -.4196301 1.547604
IDiversityt1_둔덕면 -.9130784 .508394 -1.80 0.072 -1.909512 .0833555
IDiversityt1_사등면 .3445108 .5097851 0.68 0.499 -.6546496 1.343671
IDiversityt1_연초면 .9896097 .5989023 1.65 0.098 -.1842172 2.163437
IDiversityt1_하청면 -.1518937 .4975175 -0.31 0.760 -1.12701 .8232226
IDiversityt1_장목면 -.5530311 .5144529 -1.07 0.282 -1.56134 .4552781
IDiversityt1_장승포동 -.2212939 .4750224 -0.47 0.641 -1.152321 .709733
IDiversityt1_능포동 .0207444 .4757915 0.04 0.965 -.9117898 .9532786
IDiversityt1_아주동 .2064039 .4934774 0.42 0.676 -.760794 1.173602
IDiversityt1_옥포 1 동 .1359504 .4873865 0.28 0.780 -.8193096 1.091211
IDiversityt1_옥포 2 동 .0645924 .4415538 0.15 0.884 -.8008371 .930022
IDiversityt1_장평동 1.188599 .6460173 1.84 0.066 -.0775722 2.454769
IDiversityt1_고현동 1.058704 .6032603 1.75 0.079 -.1236649 2.241072
IDiversityt1_상문동 .739909 .533726 1.39 0.166 -.3061747 1.785993
IDiversityt1_수양동 .2130921 .4719962 0.45 0.652 -.7120033 1.138188

LR_Total
sizeaveragemploymentperest .0001554 .0002382 0.65 0.514 -.0003115 .0006223
SE .000597 .0005874 1.02 0.309 -.0005542 .0017482
Population -8.75e-07 2.35e-06 -0.37 0.709 -5.48e-06 3.73e-06
IDiversityt_일운면 .7749367 .5644769 1.37 0.170 -.3314178 1.881291
IDiversityt_동부면 1.885107 .5671166 3.32 0.001 .773579 2.996635
IDiversityt_남부면 .8783212 .5248766 1.67 0.094 -.1504181 1.907061
IDiversityt_거제면 1.52619 .5198552 2.94 0.003 .5072929 2.545088
IDiversityt_둔덕면 -.0530497 .5560445 -0.10 0.924 -1.142877 1.036777
IDiversityt_사등면 1.634474 .549039 2.98 0.003 .5583775 2.710571
IDiversityt_연초면 2.528331 .5824054 4.34 0.000 1.386838 3.669825
IDiversityt_하청면 1.500049 .5380862 2.79 0.005 .4454198 2.554679
IDiversityt_장목면 1.363708 .5642508 2.42 0.016 .2577962 2.469619
IDiversityt_장승포동 .0232123 .5400471 0.04 0.966 -1.035261 1.081685
IDiversityt_능포동 .3868292 .5547118 0.70 0.486 -.7003858 1.474044
IDiversityt_아주동 2.336894 .6277315 3.72 0.000 1.106563 3.567225
IDiversityt_옥포 1 동 1.078488 .5809936 1.86 0.063 -.0602384 2.217215
IDiversityt_옥포 2 동 .3687675 .5605703 0.66 0.511 -.7299301 1.467465
IDiversityt_장평동 2.008118 .5927324 3.39 0.001 .8463835 3.169852
IDiversityt_고현동 1.835923 .5617425 3.27 0.001 .7349284 2.936919
IDiversityt_상문동 3.444238 .6110334 5.64 0.000 2.246635 4.641842
IDiversityt_수양동 1.851438 .5511573 3.36 0.001 .7711898 2.931687
IDiversityt1_일운면 .5821186 .940802 0.62 0.536 -1.261819 2.426057
IDiversityt1_동부면 -1.59885 .9726864 -1.64 0.100 -3.50528 .3075806

IDiversityt1_남부면	.9432083	.9105687	1.04	0.300	-.8414735	2.72789
IDiversityt1_거제면	-1.129488	.8763674	-1.29	0.197	-2.847137	.5881604
IDiversityt1_둔덕면	1.966477	.915543	2.15	0.032	.1720458	3.760908
IDiversityt1_사등면	-.7347753	.9738081	-0.75	0.451	-2.643404	1.173853
IDiversityt1_연초면	-2.034429	.9123891	-2.23	0.026	-3.822679	-.2461794
IDiversityt1_하청면	.3318925	.9827715	0.34	0.736	-1.594304	2.258089
IDiversityt1_장목면	1.158521	1.002933	1.16	0.248	-.8071906	3.124233
IDiversityt1_장승포동	.4527968	.9146704	0.50	0.621	-1.339924	2.245518
IDiversityt1_능포동	-.0139776	.8832675	-0.02	0.987	-1.74515	1.717195
IDiversityt1_아주동	-.4069132	.9699488	-0.42	0.675	-2.307978	1.494152
IDiversityt1_옥포 1 동	-.2470066	.9262511	-0.27	0.790	-2.062425	1.568412
IDiversityt1_옥포 2 동	-.1332576	.8890432	-0.15	0.881	-1.87575	1.609235
IDiversityt1_장평동	-2.455441	.9773007	-2.51	0.012	-4.370915	-.5399668
IDiversityt1_고현동	-2.18606	.9486485	-2.30	0.021	-4.045377	-.3267434
IDiversityt1_상문동	-1.56167	.9494284	-1.64	0.100	-3.422516	.2991753
IDiversityt1_수양동	-.386144	.9027528	-0.43	0.669	-2.155507	1.383219

Likelihood-ratio test
Assumption: DSDM nested within DSDMC

LR chi2(36) = 59.83
Prob > chi2 = 0.0076

Akaike's information criterion and Bayesian information criterion

Model	N	ll(null)	ll(model)	df	AIC	BIC
DSDM	180	.	455.8989	10	-891.7979	-859.8683
DSDMC	180	.	485.8156	46	-879.6311	-732.7551

Note: BIC uses N = number of observations. See [R] BIC note.

Logbook

February 2022			
Week	Goals	Date	Outcome
1	~~• Finding a supervisor~~ ~~• Collecting literature~~ • Building conceptual model	07	- Meeting with Dr. Vos - Drafting the topic & methods: *'Where did they go and who will be here?'* with Spatial Analysis on labour mobility in Geoje Island
		08	- Literature collection · Ministry of Trade, Industry and Energy & Ministry of Oceans and Fisheries (2022). "Reform of K-shipbuilding · marine transport, hopeful future through mutual developing cooperation". Publication registration number 11-145000-000169-01 · Geoje-Do statistics website https://www.geoje.go.kr/stat/index.geoje?contentsSid=9634#n · Zimmermann, K. F. (2005). European labour mobility: challenges and potentials. *De economist*, *153*(4), 425-450. - Proposal writing · Introduction, conceptual model, and methods
		09	- Confirming with Dr. Vos about being the supervisor! - Checking what kind of data is accessible about Geoje-Do - Tried to form the main research question.
		10	Spatial Econometrics Class
		11	Birthday
Week	Goals	Date	Outcomes
2	• ~~Supervisor meeting~~ • Building conceptual model • Outline of the thesis • Building the Introduction, Theoretical Framework, & Literature Review	14	- Literature collection · Erin Kenney (2017). "Super-Port to the World?" An Impact Assessment of the Midwest Inland Port Master's thesis. MIT. · All relevant ministries 관계부처일동 (9.9.2021). Strategies for accomplishing K-shipbuilding revitalization towards to world best shipbuilding country. 세계 일등 조선 강국 실현을 위한 K-조선 재도약 전략
		15	- News Articles about K-shipbuilding strategies
		16	
		17	Spatial Econometrics Class
		18	1st official supervisor meeting - A general brainstorming about the topic and methods: adopting ecological agent-based GIS model to historical economic analysis in Geoje-Do. 1. Build a model 2. Test a model with what already happened 3. Estimate the prediction of future outcome
Week	Goals	Date	Outcomes
3	• Building conceptual model ~~• Outline of the thesis~~ • Building the Introduction, Theoretical Framework, & Literature Review	21	- maximum entropy modelling: Youtube videos & reading - Youtube video of "Species distribution modelling"
		22	- Studying Bayesian Model - Scharfenaker, E., & Yang, J. (2020). Maximum entropy economics. *The European Physical Journal Special Topics*, *229*(9), 1577-1590. - Bayesian Belief Network Model: Stafford, R., Williams, R. L., & Herbert, R. J. (2015). Simple, policy friendly, ecological

			interaction models from uncertain data and expert opinion. *Ocean & Coastal Management*, *118*, 88-96.
		23	- Data search: number of firms and employees in each geo-unit in the island, but not location data. - Sent an email to the Geoje office of big data statistics asking about any location data => response: no location data available from their office
		24	Spatial Econometrics Class
		25	- Collecting Korean literature about the shipbuilding business and the local economy - Learning about spatial cross-sectional and panel data & spatial econometrics with specifications.

March 2022			
Week	Goals	Date	Outcome
4	• Building conceptual model ~~• Data Search~~ • Building the Introduction, Theoretical Framework, & Literature Review	27/2	- Data search > SGIS^{PLUS}: sent an email to about getting firm location data & administrative border data that can be incorporated in ArcGIS. I cannot access because of an issue with making account there. This source mostly provides number of firms, employees > Korean Local Information Research and Development Institute localdata.go.kr: Firm location data in excel file
		1	
		2	우정석, & 이승철. (2018). 거제시 조선산업에 대한 지역경제의 잠김 효과. *국토지리학회지*, *52*(4), 567-580.
		3	Meeting with Dr. Vos > instead of tackling it from a model search/building, trying to approach from the easiest steps like simple OLS regression analysis with GIS. > Check wavelet analysis
		4	Geo promotion conference
Week	Goals	Date	Outcomes
5	~~• Make an Excel sheet for data analysis~~ ~~• Buildining conceptual model~~ ~~• Building the Introduction,~~ Theoretical Framework, & Literature Review	7	- District data requested to SGIS - Exploring about time series analysis. Vector Autoregressive Analysis might be an option for an initial model. - Seminar: Urban Models, Ron Boschma > It was very useful for my theoretical and conceptual frameworks. Also, my research questions can be reshaped by his relatedness model. - Making an excel file for aggregating all the data I need.
		8	- Econometrics Class - Building the excel file - Collecting Ron Boschma's literature
		9	- Meeting with Bart for time series and wavelet analysis - Building conceptual model, aims, research questions, and methods
		10	- Building the excel file - Constructing a table for the datasets I am using for the research in word doc.
		11	- Reported the weekly updates to Dr. Vos - Building the excel file

			- Sent an email again to the Geoje City Hall office to get more data of the number of employees of the both shipyards and for a clarification of some value changes among datasets.
Week	Goals	Date	Outcomes
6	• Spatial regression analysis • Check Ron Boschma's diversification model • Diversification opportunities map	14	- Building an excel file for spatial econometrics models - Boschma, R. (2017). Relatedness as driver of regional diversification: A research agenda. *Regional Studies*, *51*(3), 351-364.
		15	- got an email back from Geoje City Hall office. - Building an excel file for GIS analysis
		16	- Data search for the spatial econometrics' models - Contacting KOSIS and Geoje City Hall (GCH) for the unemployment rate in district level units. - Tackling with datasets to see the feasibility of doing spatial econometrics analysis
		17	Meeting with Dr. Vos - received answers from KOSIS and GCH. They do not have a dataset in a district level. - Making slides for the thesis outline
		18	
Week	Goals	Date	Outcomes
7	~~• Draft of Introduction, Theoretical Framework, & Literature Review~~	21	- Sent an email to Alvertos to get some advice for spatial econometrics analysis.
		22	- Reading "Handbook of Evolutionary Economic Geography" by Boschma and Martin (2010): three main theories - Making notes
		23	- Reading "Handbook of Evolutionary Economic Geography" by Boschma and Martin (2010): three main theories - Writing & making a table
		24	- Reading "Handbook of Evolutionary Economic Geography" by Boschma and Martin (2010): Path dependence - Writing
		25	- Reading "Handbook of Evolutionary Economic Geography" by Boschma and Martin (2010) - Writing
Week	Goals	Date	Outcomes
8	~~• Coding~~	28	- Data coding for spatial econometrics
		29	- Meeting with Alvertos: getting advices for the spatial analysis with econometrics models. It is possible with the data I have, but add more control variables. - Data coding for spatial econometrics
		30	- Data coding for spatial econometrics - Try out the analysis
		31	- Data coding for spatial analysis with GIS
		1	- Data coding for spatial analysis with GIS

April 2022			
Week	Goals	Date	Outcome
9	• Methodology	4	- Editing the methodology design - Method and methodology writing
		5	- Method literature reading: statistical literature
		6	- Method and methodology writing
		7	- Updating coding

		8	- Method and methodology editing
Week	Goals	Date	Outcomes
10	• Testing analyses ~~• Updated coding~~	11	- Testing analysis with STATA
		12	Updating the thesis to Dr. Vos > Spatial econometrics
		13	- Producing data table: source, purpose, duration etc.
		14	- coding: adding and editing variables
		15	- coding: adding and editing variables
Week	Goals	Date	Outcomes
11	~~• Literature Review~~ ~~• Testing analyses~~	18	- editing: evolutionary economic geography
		19	- editing: path dependence
		20	- editing: lock-ins in Geoje and other regions
		21	- editing: policy discussion literature
		22	- Testing analysis with GIS
Week	Goals	Date	Outcomes
12	~~• Mid-point reflection and editing~~	25	Moving
		26	
		27	- Reading the draft from the beginning and see that everything matches each other; theory to research questions, and to methodology
		28	- Editing the draft
		29	- PhD application submission (actually on 30th)

May 2022			
Week	Goals	Date	Outcome
13	• Break	2	
		3	
		4	
		5	
		6	
Week	Goals	Date	Outcomes
14	• Refreshing the draft and getting ready for producing analytical results	9	- Reading and editing the draft
		10	- Final check for the research design and methodological design
		11	Meeting with Dr. Vos > Mid-point check if the draft flows logically > Statistical details
		12	- PhD interview preparation
		13	PhD Interview
Week	Goals	Date	Outcomes
15	~~• Finishing coding~~ ~~• Testing analyses~~	16	- Multiple regression coding
		17	- Multiple regression/ Spatial econometrics coding
		18	- Spatial econometrics coding
		19	- Spatial econometrics literature/coding
		20	- Testing spatial econometrics with STATA
Week	Goals	Date	Outcomes
16	• ~~Spatial regression analysis with GIS~~ • ~~Producing maps~~ • ~~Writing results~~	23	OLS with GIS, coding
		24	Descriptive GIS analysis > producing maps and writing the results
		25	OLS with GIS analysis > producing statistical results

		26	OLS with GIS analysis > producing statistical results
		27	Meeting with Dr. Vos > Reporting the OLS analysis with GIS results (1) and (2) > Discussing possible further analysis and statistical points: Grouping Analysis

June 2022			
Week 17	Goals	Date	Outcome
	• ~~Spatial econometrics analysis~~ • ~~writing the results~~	30/05	OLS results writing
		31/05	Spatial Econometrics coding
		1	Spatial Econometrics analysis (1)
		2	Spatial Econometrics analysis (1)
		3	- Meeting with Dr. Vos > Reporting the Spatial Econometrics result (1) > Discussing possible further analysis and statistical points: instead of borders, using point data, if the data is available; log transformation > Discussing time lines: draft deadline 29/06 by morning; final thesis before 18/07 -Spatial Econometrics analysis (2)
Week 18	Goals	Date	Outcomes
	• ~~Multiple regression analysis~~ • ~~Spatial econometrics analysis~~ • ~~writing the results~~	6	Spatial Econometrics analysis (2)
		7	Spatial Econometrics analysis (2)
		8	Spatial Econometrics analysis (2)
		9	Multiple Regression analysis
		10	Multiple Regression analysis
Week 19	Goals	Date	Outcomes
	• ~~Making GRD presentation slides~~ ~~• Editing the abstract~~ ~~• Editing the introduction~~ • Editing the literature review	13	GRD presentation slides
		14	- GRD presentation slides - Thesis writing: Abstract & Introduction editing
		15	- Thesis writing: conceptual model & literature review editing
		16	- Thesis writing: literature review editing
		17	- Thesis writing: literature review editing
Week 20	Goals	Date	Outcomes
	~~• Editing the methodology~~ ~~• Editing the results~~ • Writing the conclusion and discussion	20	- Meeting with Dr. Vos > reporting the results and outline > getting advice for the presentation
		21	- Thesis writing: literature review editing
		22	- Thesis writing: literature review /methodology editing
		23	Graduate Research Day - Presentation
		24	- Thesis writing: methodology/ results editing
Week 21	Goals	Date	Outcomes
	~~• Writing the conclusion and discussion~~ ~~• Sending the draft~~	27	- Thesis writing: results editing
		28	- Thesis writing: conclusion editing
		29	- Thesis writing: conclusion editing The draft deadline; until the morning
		30	- Got the first feedback - Map editing for the thesis & reflection

		01/07	- Reflection editing

July 2022			
Week	Goals	Date	Outcome
22	~~• Editing~~ • Logbook & reflection	4	- Going through the thesis with the evaluation form - Putting notes missing points & the parts that need to be edited
		5	- Introduction/theoretical and conceptual frameworks editing
		6	- Reading more about policy discussion literature and writing
		7	- Methodology/results/conclusion editing
		8	- Conclusion editing The updated draft deadline; until the morning
Week	Goals	Date	Outcomes
23	• Editing • Logbook & reflection • Submitting the final thesis	11	- Meeting with Dr. Vos > Editing parts that need more clarity > Reorganize methods and results sections > Parts that can be more elaborated in the reflection documents > GWR possible
		12	- Editing the article (thesis) based on the feedback
		13	- Reflection writing - Grammar check
		14	- Final check
		15	**The final submission: Thesis + Reflection + Logbook**