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Knowledge Interaction and Spatial Dynamics in Industrial Districts

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Abstract: The knowledge economy plays a leading role in current socioeconomic development and has changed industrial development. This study addresses whether changes in industrial development have improved the knowledge innovation, technical level, and productive efficiency of industries. Taiwanese industries were typically labor and technology-intensive and policy-oriented manufacturing industries in the past. This study analyzes the change in the spatial distribution of industries in southern Taiwan, and further examines the effect of knowledge interactions between industries and the region on industrial development, as well as the restrictions and opportunities for future development. Industries in southern Taiwan have formed a solid foundation based on policies promoted in the past. Nevertheless, an over-reliance on policy guidance has impeded breakthroughs and motivation to learn. Analytical results indicate that industries with stable and changing clusters achieve sustainable economic growth by creating links for innovative knowledge interactions through collaboration with suppliers and competitors. Accordingly, knowledge sources depend not only on internal research and development but also on external interactions to stimulate innovation. Restated, the input of key knowledge generates a high output, provides opportunities for industry transformation, and decreases resource consumption to achieve environmental sustainability during development. Additionally, the ripple effect of innovation, research, and development enhances structural evolution in industries, generating sustainable economic development.

Keywords: southern Taiwan; industrial evolution; sustainability; industrial cluster; knowledge interaction; spatial dynamics

1. Introduction

Researchers are currently widely studying the reasons for rapid economic development from various aspects. This investigation first analyzes whether industrial clusters, which emphasize technology, products and production efficiency, promote regional development and innovation. High-density interaction promotes knowledge generation, circulation, diffusion and application. Industry decreases the unemployment rate, and enhances economic growth by promoting knowledge interaction within the region. Innovation, technology and learning are the driving forces for regional innovation. Knowledge and information improve local and global interactions [1].

Clusters increase the interactions between industries and promote innovation and higher employment [2,3]. Refs. [4,5] has indicated that business firms within limited geographical areas interact closely, and thus quickly receive crucial information and benefit from a spillover effect as a result of the formation of clusters, which become groups with common goals, in geographical areas of a limited size. Nonetheless, whether labor-intensive production with uni-directional knowledge transfer enables industrial development should be considered. Industries require different incentives at different stages of development. The lead of knowledge and technology enables clusters to evolve

concurrently [6]. The application of innovative knowledge used as the basis of economic development is critical at all stages of cluster development. Refs. [7,8] demonstrated that firms participating in knowledge networks benefit from sharing resources of innovative networks and acquiring knowledge about resources and technology, and urged the industry to develop along novel paths. Changes in development paths affect knowledge transfer, further causing inter-regional clustering, and increasing the flexibility of regional collaboration networks [9]. The transformation of the interactive mode thus stimulates the interactions between business firms, blurring regional boundaries and providing cross-regional and cross-industrial innovation.

Breaking away from the original research and development approach requires three characteristics: a reduction of path dependence during the innovation process [10]; an investment in innovation to motivate self-promotion and learning of obtainment of external information; and the knowledge to share resources and create opportunities for interacting with other users [11,12]. Clusters that adapt better to the environment can develop more flexibly. The knowledge base of industrial clusters affects their growth, decline and transformation during development [4]. Industry evolution has always been a complex issue. Many problems occur during the process of evolution, including the evolution of the industry life cycle, the form of knowledge interaction, spatial evolution and recovery ability. However, the primary task is to clarify whether clusters exist in the area where research is performed, then to analyze the status of the evolution of regional industry. The role of knowledge is then analyzed through further investigation in knowledge interaction, demand for space, changes and participating users during industry evolution analyses.

The objective of this study is to examine the spatial dynamics and knowledge interaction in the core area of southern Taiwan. Whether a firm can adapt to the environment and evolve depends on the knowledge interaction and delivery between the firms. This study determines whether industrial clusters exist; analyzes the ability of knowledge management and application by different types of industrial clusters; and further considers the future potential for industrial development. The research has the following aims: (1) to investigate the history of industrial development, evolution and knowledge innovation and interaction in the region; (2) to clarify the evolution of the major industry, and understanding the interaction networks of collaboration in the area; and (3) to analyze whether industry can apply and exchange knowledge and further adapt to future developments.

2. Literature Review

Many theories of economic competitiveness and policy focus on industrial clusters. The core of the cluster forms and develops through the interaction of innovative knowledge between businesses. The firms provide each other's requirements and create the critical factors for industrial activity during the development process. Firms may change their industrial structure and interaction method through the input of innovative knowledge, resulting in various demands regarding distribution and use of space. Innovative knowledge thus changes the space environment in an industrial region [13].

2.1. Industrial Cluster and the Meaning of Innovative Knowledge

2.1.1. Industrial Cluster

Porter first used the term "industrial cluster" in 1990, referring to a specific region where businesses are both competitors and cooperators and have common characteristics as well as supportive functions [14]. The interactions between technology and regions are based on technological innovation. Innovation directly influences regional development dynamics, and technological innovation adjusts the regional space. Innovation also changes the evolution and existence of industrial clusters, and further creates different network links, which enable collaboration and division of work during regional development [15,16]. This process creates the dynamic cycle for industries.

The interaction between technology and regional dynamics enables a cluster to evolve; creating different linkage structures is made possible during the interaction between technology and regional

dynamics. Conversely, the environmental incentives create individual differences and industrial characteristics [17,18]. Industrial clusters increase the overall competitiveness of each member through competition and cooperation. Furthermore, the competition and collaboration of clusters increases competitiveness, encourages interactions between clusters, promotes knowledge transfer and the spillover effect, generates opportunities for the redevelopment of surrounding areas, and further lowers the cost incurred by industrial failure. These findings indicate that knowledge and technology lead to the co-evolution of clusters [6]. Therefore, the ability of an industry to obtain knowledge represents the capability of evolution and viability [19–23].

2.1.2. The Life Cycle and Affecting Factors of Industrial Clusters

The evolution of local industry defines the direction of industrial development. The four phases of industrial development are formation, development, maturity and decline or renewal [24]. However, industrial innovation is always essential in all phases, because innovation in one industry contributes to the evolution of others and strengthens knowledge and application skills through learning, integration, interaction and system construction [6]. The interaction between business firms aids evolution by updating knowledge and application. Clusters with greater adaptability are more flexible. Therefore, critical knowledge in the clustering process affects the emergence, growth, decline and transformation of a cluster [4]. Different levels of innovation in the development process enable industries to continuously evolve and develop industrial strengths. Industries adopt different strategies to fit different innovation phases. Consequently, industrial evolution is a dynamic process, and the differences in access to knowledge will force industries to specialize.

2.2. The Impact of Knowledge Flow on Regional Development

The application of knowledge and accumulation of information is crucial to industrial development when economic development is based on a foundation of knowledge. Regions interacting with knowledge promote regional innovation and improve the flexibility of their regional collaborative networks [9]. The input of technology and knowledge during the development process of industry will promote companies that can learn and acquire knowledge, as well as apply innovation. Thus, knowledge interaction improves innovation in a region during industrial development. Knowledge supports industrial clusters and economic development because of the transformation of innovative activities. The continuous input of knowledge also increases the intensity of production networks. Furthermore, the formation of knowledge-based industrial development networks can cross regional boundaries [25].

2.2.1. Innovative Knowledge Networks: Knowledge, Innovation, and Space

Knowledge sources and knowledge delivery methods will lead to the differences in innovation and environment during the development process of industry. Creativity, innovation and knowledge become leading factors in industrial evolution. A region with much open innovation, such as learning, knowledge, innovation and creativity, becomes diverse, complex, resilient, dynamic and intangible [26–28] (Open innovation indicates that innovation sources depend not only on internal research and development, but also on external participation in the innovation model. Thus, the region not only depends on the internal interaction of innovative knowledge, but also always relies on the benefits of clustering to obtain the required knowledge. Although clustering relies on existing partners, it can promote the generation of innovative knowledge through continuous stimulation). Hence, the economic performance of a region depends on the ability of industry to manage and apply knowledge inside and outside the region [29].

An industry benefits the environmental space and the economic development regardless of whether it acts as a producer or a consumer in the development stage. The environment, industry, economy, knowledge and space develop via the interaction between the participants. Innovative knowledge that improves industrial development is formed by absorbing external knowledge and

combining it with internal knowledge [30–32]. The intensive interaction between participants increases the knowledge effect score, and thus enables the integration of knowledge, innovation, and space into innovative networks [33,34]. This correlation applies to management as well as to research and development. In the research and development process, the transformation of knowledge into commercial information or products drives the growth of the industry, economy and environment, and strengthens the knowledge and spatial specialization [16]. Industrial planning for the future requires spaces with attraction, favors the investment of talents and investors, and increases market transactions, competitiveness and capital. Furthermore, an industrial strategy also requires the creation of a favorable development environment within the knowledge-based economy; it makes knowledge, science, technology, research, education and innovation the driving forces for economic growth, and further modifies the environmental space.

2.2.2. Knowledge Transfer

Knowledge can function as a tool for recording, and even for production and transfer [35]. Knowledge as a book or information is known as static transfer, while that used in life or in a production system is known as dynamic exchange [36]. The industry can apply innovative information and form new ideas with the introduction of external knowledge and understanding. Thus, knowledge functions as both transfer and dynamic evolution. Knowledge transfer can be expressed either by science, technology and innovation (STI), which represent knowledge in books and papers, or by doing, using and interacting (DUI), which is not influenced by symbols and can be reached only through experience. Therefore, different modes of knowledge transfer require different environmental spaces. However, knowledge transfer always helps the construction of knowledge networks and the extension of the influence of the areas of knowledge, while the interaction frequency rises [37].

The two modes of knowledge acquisition are formal transfer and informal learning or interaction [38]. Formal transfer includes contractual research and consultation. Informal transfer refers to knowledge spillovers, in which experts or conferences offer professional knowledge. Dynamic knowledge is gained through learning within a group through informal interaction, and derives more knowledge sources from collaboration than formal transfer. However, dynamic knowledge is a collective learning process, in which network systems emerge through formal interactions, and knowledge sources are created through sharing and collaboration between R&D institutions. Raising the frequency of interaction increases the complexity of knowledge, and the difference in knowledge transfer determines the level of uncertainty. Different modes of transfer require different spatial environments. However, increasing the frequency of interaction leads to knowledge network construction, thus expanding the scope of the impact of knowledge.

2.3. Spatial Structure of Innovation and Knowledge Interaction

Different elements introduced to city development result in various types of industry and space. Trust between decision-makers in different organizations in regional clusters leads to reciprocity. Methods of production, knowledge dissemination and innovative ability affect the potential for regional development. Geographic limitations have previously interfered with knowledge interaction and transfer. Information and communication technology now enables the transfer and delivery of symbolic or encoded tacit knowledge via formal or informal systems. However, most non-symbolic knowledge, such as technology and revised tacit knowledge, requires interactive learning to be achieved. In the knowledge-based economy, changes in the interaction between producers and users encourage unexpected tacit knowledge. Open innovative interaction replaces traditional linear communication (Table 1).

Table 1. The analysis of knowledge interaction and spatial structure with innovation, based on [25,38–41].

	Regional Innovation System (RIS)	**Knowledge Community Precincts (KCPs)**	**Knowledge Innovation Spaces (KISs)**
Spatial Structure	Inside the Region	Cross-Region	Inside and Outside the Region
	Interactive Relation	Network Interaction	Physical or Non-physical Interaction
Knowledge Interaction	Knowledge Transfer	Spatial Ambience	Diverse Interaction
	Explicit Knowledge = Tacit Knowledge	Tacit Knowledge > Explicit Knowledge	Explicit Knowledge, Tacit Knowledge and Mixed Knowledge
Ambient Knowledge	Fluctuation	Fluctuation	Permeation
Geographic Space	Gradual Expansion	Jumping or Displacement Type of Development	Integrated or Knowledge-Leading City Development

According to [42], spiral interaction and circulation spirals produce knowledge. The exchange of tacit knowledge externalizes this knowledge. The participants in a group combine and internalize knowledge from organizations and groups, transform tacit and explicit knowledge, and promote knowledge space and interactive knowledge networks. Complete networks, appropriately providing the crucial factors for industrial development, comprise innovative interactions, including knowledge spirals and the knowledge production cycle.

According to this knowledge production process and the territorial knowledge dynamics mentioned by [39], innovation comes from both regional knowledge interaction and external dynamic knowledge. An interaction network includes suppliers, consumers, universities and competitors in cooperative networks. Participants choose innovative knowledge and areas with the greatest potential for development when dynamic knowledge is introduced to a region. The input of innovation is ineffectual if the industry cannot accept innovation, transformation and application.

3. Research Design and Data Collection

This study discusses the dynamics of knowledge interaction and spatial development, focusing on the core areas of industrial development in southern Taiwan, namely Tainan and Kaohsiung. The study clarifies the phases of the evolution of industry and analyzes the industry dynamics, based on the examination of changes in the industrial structure in southern Taiwan, to identify the crucial factors for future industrial development.

(1). This study analyzes the main industries in southern Taiwan using descriptive statistics, and selects 18 major industries for curvilinear regression analysis from the location quotient and the Industry, Commerce and Service Census reported by Taiwan [43,44]. Owing to the limits of samples, this study combines similar industries and adopts a curvilinear regression analysis for sessions in 2001–2006, 2006–2011 and 2001–2011. The industrial development and spatial dynamics are illustrated from 42 regressions and the relative growth of employment and output.

(2). The research analyzes the key factors for industrial innovation using simple logistic regression based on data from the Third Industrial Innovation Survey in Taiwan (2011) [45]. The ratio of industries participating in innovative activities is further analyzed with Pearson's chi-squared test.

(3). The variables for innovative activities are independent. This study analyzes the relations between various aspects of innovation using logistic regression, based on dependent variables, 219 samples of industrial dynamics and 12 independent variables from four aspects of innovative activities. Furthermore, the ratio of innovation between the variables is investigated by the chi-squared test. The relations between industrial dynamics, innovative activities and knowledge exchange are thus elucidated.

4. Dynamic Evolution of the Major Industry

4.1. The Comparison and Analysis of Changes in the Industrial Structure

The transformation of the industrial structure and production methods in Tainan and Kaohsiung has resulted in changes in industry focus. Tainan and Kaohsiung have together become an economic community, with a large hinterland for industrial development. Besides the original industrial region, Southern Taiwan Science Park was established in 1995 (Southern Taiwan Science Park consists of two parks, including 1043 hectares of Tainan Park located in Xinshi District, Shanhua District, and Anding District, as well as 570 hectares of Kaohsiung Park located in Luzhu District, Gang shan District, and Yong'an District [44,46,47]).

Southern Taiwan was devoted to agriculture in the 1950s and 1960s, and later, in accordance with policy guidance, switched to heavy industry, manufacturing and services in the post-industrial society. Production methods have changed since the 2000s such that firms have become typically knowledge-intensive and technology-intensive [48]. Current industrial development has relied on production based on innovative knowledge (Figure 1) since the 1980s, when knowledge and technology-intensive methods of production became common with the establishment of industrial parks. This trend continued with the statute for moving to innovation-oriented industry in the 1990s, and the knowledge-oriented statute published in 2010. However, industry in southern Taiwan needs to be able to develop through innovative knowledge. This work combines literature with the analysis of industrial structure and clarifies the developmental phases of the industry in southern Taiwan, the interaction between participants and the application of innovative knowledge, and further provides a suitable development plan for industry in southern Taiwan.

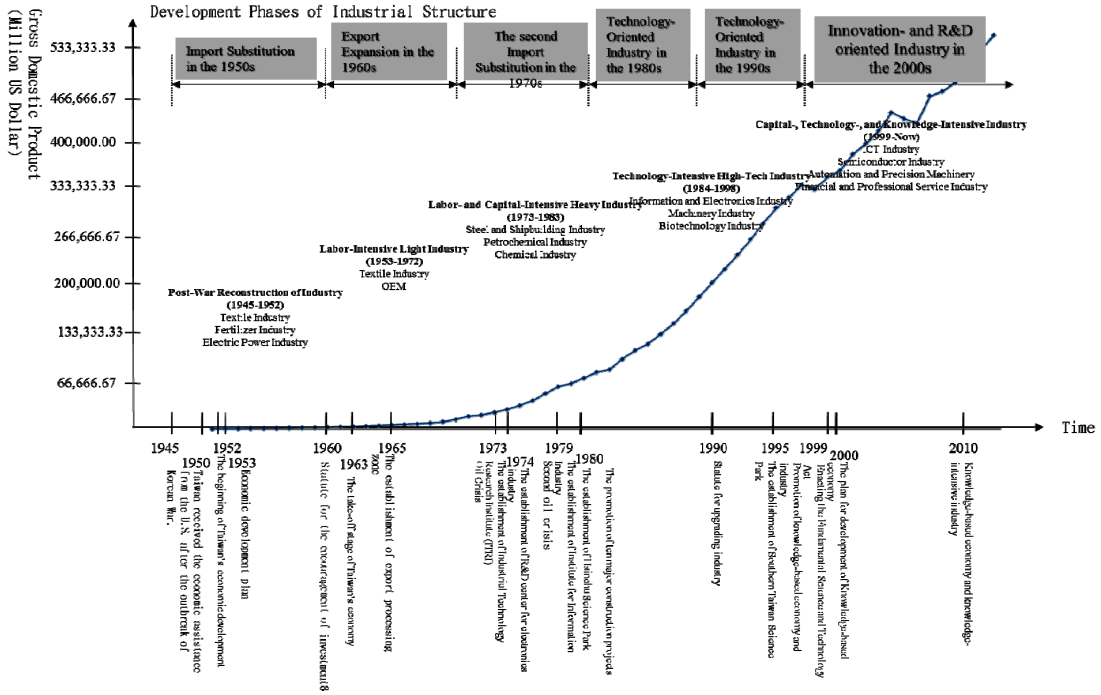

Figure 1. Changes in industrial development in southern Taiwan [49,50].

4.2. Analysis of Dynamics of Major Industry in Southern Taiwan

4.2.1. Location Quotient of Major Industry in Southern Taiwan

To understand industrial change in southern Taiwan, this study categorizes the industrial development in the region, and calculates the proportion of industry that is knowledge-based.

The location quotient from the survey data of industry, business and the service sector is examined to analyze the industrial evolution in southern Taiwan. The location quotient indicates that the service sector, which comprises transportation and warehousing (H), professional, scientific and technical services (M), education services (P), health care and social assistance (Q), arts, entertainment and recreation (R), and other services (S), has grown significantly (Location Quotient > 1 suggests an exporting industry.)

4.2.2. One-Way ANOVA for Major Industry in southern Taiwan

The study investigates the 72 major industries in southern Taiwan. Furthermore, it analyzes the location quotients from three past years (The three years are 2001, 2006 and 2011. The survey of industry, business and service industry is executed every five years. Therefore, the interval of the three times of survey is ten years) using one-way analysis of variance (ANOVA) for dependent samples, based on the industry categories of 2011 (Table 2). The significant differences ($p < 0.05$) indicated from the result show that the industrial development is in a changing state. Industry has two options for adapting to such fluctuation: increasing the proportion of innovation to avoid decline or failure, or finding sources of new information to pass the period of fluctuation.

Table 2. The analysis of location quotients of southern Taiwan from 2001 to 2011, using one-way ANOVA [47,50].

Variables	SS	DF	MS	F	*p*-Value	Critical Value
Between Groups	2.616102	1	2.616102	8.794762	0.003127 *	3.855211
Within Groups	201.6788	678	0.297461			
Sum	204.2949	679				

Note: * means significant different (*p*-value < 0.05).

5. Analysis of Spatial Dynamics for Major Industry

This investigation selects the major industries in southern Taiwan and employed curve fitting to determine whether an industrial cluster exists. Different industries need to be combined if the sample size of each individual industry is too small for regression analysis. Thus, to perform the regression analysis, chemical material manufacturing (18), chemical product manufacturing (19) and medical goods manufacturing (20) are combined into one group. Basic metal manufacturing (24) and fabricated metal products manufacturing (25) are also combined into one group. Motor vehicles and parts manufacturing (30) is combined with other transport equipment manufacturing (31), and support activities for transportation (52) is combined with warehousing and storage (53).

The dynamic regression of industries in southern Taiwan does not show any clusters according to [51] ([52] Defined three categories of industrial environment: (1) industries forming clusters, (2) equalization with firms, and (3) an environment intermediate between clustering and even distribution). Table 3 demonstrates that industries in southern Taiwan are in a transition state. Therefore, this study analyzes the state of industrial change with numbers of employees and output.

Table 3. Dynamic regression of the industry [52].

Cluster Dynamics	$\alpha 1$	$\alpha 2$	$\alpha 3$
Formation of Clusters	Significantly Negative	Significantly Positive	Insignificantly Positive
Equalization	One of them is significantly negative and none of them is significantly positive.		
Others (Clusters or Equalization)	Neither Clusters, nor Equalization (between Clusters and Equalization).		

Based on the analysis of the relative growth of employees, the emerging industries comprise support services, accommodation & food services, professional, scientific & technical services, and human health & social work services. Stagnant or maturing industries are education, transportation &

warehousing, construction, wholesale & retail trade, and arts, entertainment and recreation services. Industries with relative potential for growth and development comprise manufacturing, electricity & gas supply, water supply & remediation, and accommodation & food services. Transportation & warehousing, other services, information & communication, wholesale & retail trade, arts, entertainment and recreation services, and human health & social work services are stagnant or maturing industries.

According to the knowledge production process and territorial knowledge dynamics mentioned by [39], innovation comes from both regional knowledge interaction and external dynamic knowledge. After integrating the results of curve fitting and relative growth (Table 4), the industry and spatial dynamics of southern Taiwan were categorized into four groups; namely, cluster stability, adjustment, change and disappearance. This work analyzes whether the process of industrial development can utilize diverse knowledge, promote the possibility of development, and provide the crucial factors for long-term development.

Table 4. The dynamic regression of major industry from 2001 to 2011.

Industry Codes		Industry	Cluster Theory	Theory of Relative Growth		Industry Dynamics
Category	Class			Employment	Output Value	
C	08	Food Manufacturing	Other	-	+	Cluster Change
	11	Manufacture of Textiles	Other	+	-	Cluster Adjustment
	18	Manufacture of Chemical Material	Other	+	+	Stable Cluster
	19	Manufacture of Chemical Products				
	20	Manufacture of Pharmaceuticals and Medicinal Chemical Products				
	24	Manufacture of Basic Metals	Other	+	+	Stable Cluster
	25	Manufacture of Fabricated Metal Products				
	26	Manufacture of Electronic Parts and Components	Other	+	+	Stable Cluster
	30	Manufacture of Motor Vehicles and Parts	Other	-	+	Cluster Change
	31	Manufacture of Other Transport Equipment and Parts				
	33	Other Manufacturing	Other	-	-	Cluster Disappearance
H	52	Support Activities for Transportation	Other	-	-	Cluster Disappearance
	53	Warehousing and Storage				
J	62	Computer Systems Design Services	Other	+	+	Stable Cluster
M	72	Scientific Research and Development	Other	+	-	Cluster Adjustment
P	85	Education	Other	-	-	Cluster Disappearance
Q	86	Human Health Activities	Other	-	-	Cluster Disappearance
R	92	Gambling and Betting Activities	Other	-	-	Cluster Disappearance
S	96	Other Personal Service Activities	Other	+	+	Stable Cluster

Source: this study.

5.1. Cluster Stability

This analysis found that these manufacturing (industry category C) industries formed stable clusters with increasing employment and gross product: textiles (11), chemical materials (18), chemical products, pharmaceuticals and medicinal chemical products (20), basic metals (24), fabricated metal products (25), and electronic parts & components (26). Information & communication (industry category J), including computer systems design services, and other services (industry category S), such as other personal services, also form stable clusters. This type of industry could face an adjustment of its industrial structure, causing declining output and rising employment.

5.2. Cluster Adjustment

Industrial clusters of southern Taiwan in the adjustment state are professional, scientific and technical services (industry category C-33) and scientific research and development (industry category

M-72). The result demonstrates that the two industries are currently facing a transformation of clusters, indicating a rise in employment and decline in gross product. This industry could face an adjustment of its industrial structure, leading to decreased output with increased employment.

5.3. Cluster Change

In southern Taiwan, manufacture of food products (industry category C-08), motor vehicles & parts (industry category C-30), and other transport equipment & parts (industry category C-31) all belong to clusters, which exhibit rising employment and falling gross product. This situation is unusual. This study assumes that innovation input existing in an industry results in a fall in employment along with an increase in output. This assumption is analyzed and discussed in the next section.

5.4. Cluster Disappearance

Industries that show a reduction in both employment and gross product are support activities for transportation (52) and warehousing & storage (53) in the transportation & storage industry (industry category H), education industry (industry category P), human health activities (86) in human health & social work activities (industry category Q), and gambling and betting activities (92) in the arts, entertainment & recreation industry (industry category R). These industries are declining owing to a lack of input in innovation.

6. The Analysis of Innovative Activities of Major Industry in Southern Taiwan

This work classifies industrial evolution statuses based on industrial dynamics, employment and past output value into two groups; namely, cluster stability or change, and cluster adjustment or disappearance. A cross-sectional study of the survey data and information on innovative dynamics is also performed to analyze the evolutionary differences resulting from knowledge input during the development process (The survey of innovative activities is from the database of The Third Industrial Innovation Survey in Taiwan Area carried out by National Chengchi University with the authorization of Ministry of Science and Technology in 2013). The investigation is based on the dependent variables, classified according to the industrial dynamics, and independent variables including industrial innovation, regional sharing & collaboration, and information & knowledge (Table 5).

Table 5. The list of variables used in the analysis.

Dependent Variables (Industrial Dynamics)	**Independent Variables**	
Cluster Stability/Change Cluster Adjustment/Disappearance	Industrial Innovation	The percentage of product innovation/product innovation over the turnover; The percentage of process innovation/technology innovation over the turnover
	Regional Collaboration	Collaboration with the suppliers, competitors, and regional universities
	Knowledge and Information	Sources of knowledge and information/knowledge and information transfer

Source: this study.

6.1. Industrial Innovation

Industrial development is very important in southern Taiwan. The maintenance of industrial activities requires continuous innovation in knowledge-based industrial development. The industrial dynamics and innovative activities are analyzed to obtain the proportion of turnover resulting from product innovation, process innovation, technology innovation and industrial product innovation. The evolutionary dynamics of the industry are also investigated (Appendixs A and C).

6.1.1. Product Innovation

The Third Industrial Innovation Survey in Taiwan area for this study considers the factors promoting innovation in products and services (The Third Industrial Innovation Survey in Taiwan Area. (E99035) [Data file]. Available from Survey Research Data Archive, Center for Survey Research, Research Center for Humanities and Social Sciences, Academia Sinica Website: https://srda.sinica.edu.tw. doi:10.6141/TW-SRDAE99035-1 [45]). The overall product innovation and industrial dynamics are significantly correlated ($\chi^2 = 63.192$, $p < 0.05$), based on the result of the chi-square test. Therefore, an industry with stable or changing clusters focuses on the innovation of products and services and continuously innovates to maintain product competitiveness. Conversely, an industry with adjusting or disappearing clusters is currently decaying, and cannot develop or introduce innovative technologies.

Industries with stable or changing clusters in this survey comprise the manufacture of chemical materials and products, manufacture of pharmaceuticals & medicinal chemical products, manufacture of basic metals and fabricated metal products, manufacture of electronic & and components, and computer system design services. These industries focus on product innovation, but also rely on service innovation. However, industries with adjusting or disappearing clusters have low proportions of product or service innovation, as they cannot find sources of development and innovation.

6.1.2. The Ratio of Product Innovation to Overall Turnover

The ratio of product innovation to overall turnover in an industry is positively correlated with the prevalence of industrial dynamics of stable or changing clusters. In contrast, the correlation between the ratio of product innovation to overall turnover and the prevalence of adjusting or disappearing clusters is significantly negative. The proportion of industries with stable or changing clusters investing more than half of their overall turnover in activities of product innovation for industrial dynamics is 35.8%, whereas that of industries with adjusting or disappearing clusters is 26.3%. To state again, stable or changing clusters have a higher proportion of investment in product innovation than adjusting or disappearing clusters.

6.1.3. Process Innovation

The correlations of process innovation with stable or changing clusters and with adjusting or disappearing clusters are negative and positive, respectively. Process innovation is more difficult and requires more resources and training than product innovation and has a longer time-frame for achieving results. Therefore, industry in southern Taiwan primarily focuses on product innovation, which shows immediate outcomes. However, continuous observation indicates that industry in southern Taiwan is increasingly investing in process innovation.

6.1.4. The Proportion of Process Innovation to Overall Turnover

The correlation between industrial dynamics and the proportion of process innovation to overall turnover is not significant. The proportions for industries with adjusting or disappearing clusters and with stable or changing clusters are positively and negatively correlated, respectively. Product innovation may be easier to identify and distinguish than process innovation. Furthermore, smaller investment in process innovation than in product innovation leads to a lower proportion of process innovation to turnover. Hence, the effects of process innovation take longer to identify than those of process innovation.

6.2. Regional Sharing and Collaboration

Besides following the policy guidance and innovation input by the regional industry, industry in southern Taiwan should connect and integrate the adjacent resources, such as those upstream and downstream of the industry chain, universities, and research institutes, providing the industry with flexible and sustainable development. Relations between the industry and regional

collaboration, including suppliers, competitors and regional universities, are described as follows (Appendixs B and D).

6.2.1. Collaboration with the Suppliers

The results of the simple logistic regression reveal that collaboration with suppliers does not significantly affect the industry. However, collaboration with suppliers occurred in only a small proportion of industries with stable or changing clusters, or with adjusting or disappearing clusters, demonstrating infrequent interactions between the suppliers and industry in southern Taiwan. Collaboration with suppliers is the current trend for industrial development. It ensures the high quality of raw materials, reduces costs incurred by changing materials, receives appropriate knowledge support, rearranges the supply chain in response to environmental change, and ensures competitive advantages. Nevertheless, industry in southern Taiwan has not yet reached a stage of cooperation with suppliers.

6.2.2. Collaboration with Competitors

Simple logistic regression indicates that the correlation between industrial dynamics and the number of competitors is not significant. Very few cases of collaboration between the competitors were observed in either industries with both stable or changing clusters, or with adjusting or disappearing clusters, indicating that industry in southern Taiwan is fairly conservative, particularly concerning innovative information. Thus, competitors in industry in southern Taiwan do not benefit each other, and do not collaborate frequently.

6.2.3. Collaboration with the Regional Universities

The factors of collaboration with regional universities and adjusting or disappearing clusters are positively correlated. Industry–university collaboration introduces social and economic trends; offers diverse education resources; forms intensive network systems; incubates talent; and develops information and innovation to meet requirements of society. More industry–university collaborations occur in industries with adjusting or disappearing clusters than in those with stable or changing clusters, thus explaining the lack of the positive effect from the adjusting or disappearing cluster itself. Therefore, clusters collaborate with regional universities to acquire innovative knowledge and information.

6.3. The Knowledge Sources and Transfer of the Industry

According to the results of the simple regression and chi-square test, the sources and transfer of knowledge and information significantly influence the industrial dynamics of stable or changing clusters (Table 6). The clusters focus on both internal and external knowledge sources and further emphasize the significance of external knowledge (86.7%). As for knowledge transfer, the clusters employ both explicit and tacit knowledge, although the usage ratio is higher for tacit knowledge. Hence, industries with stable or changing industrial dynamics focus on their own research and development, as well as introducing external innovative knowledge.

The dynamics of adjusting or disappearing clusters rely more on external than internal knowledge sources, possibly because of the disappearance of the positive effects of the internal clusters. Therefore, their research and development tends to be based on external innovation. The level of tacit knowledge transfer is higher than that of explicit knowledge transfer, indicating that adjusting or disappearing industries are currently transforming (Table 7). Accordingly, adjusting or disappearing industries exchange tacit knowledge, which is faster than exchanging explicit knowledge.

Table 6. The parameter estimation of knowledge and information sources and transfer using logistic regression.

Industrial Dynamics	Estimation of B	S.E.	Wals	df	Significance	Exp(B)
Cluster Stability/Change	1.638	0.369	19.684	1	0.00	5.143
Cluster Adjustment/Disappearance	−1.638	-	-	-	-	-

Source: this study.

Table 7. The list of industrial dynamics, sources of information and knowledge, and knowledge transfer.

Industrial Dynamics	Internal Knowledge		External Knowledge		Explicit Knowledge		Tacit Knowledge	
	Yes	No	Yes	No	Yes	No	Yes	No
Cluster Stability/Change	56.7%	43.3%	86.7%	13.3%	61.7%	38.3%	70.0%	30.0%
Cluster Adjustment/Disappearance	35.4%	64.6%	53.5%	46.5%	29.3%	70.7%	42.4%	57.6%

Source: this study.

7. Diversities of Knowledge Spaces

Industrial dynamics and knowledge interaction demonstrate that the diverse innovation input and collaboration generate different knowledge spaces. Diverse knowledge spaces help knowledge expansion and introduction of innovative knowledge and also present new regions for development opportunities. This study analyzed the spatial dynamics, the knowledge, the ambiance and the type of change based on the innovation dynamics and network collaboration. The innovative knowledge spaces were classified into four groups.

7.1. Knowledge Stagnation

Knowledge flows externally to specific areas or regions. Industries must be in specific regions to acquire innovative knowledge. These industries lack learning motivations and cannot obtain key development factors at the appropriate times; i.e., the industries rely on the one-way provision of external knowledge and are unable to apply this knowledge to their region. The correlations between the industries and any innovative activities are positive, whereas the interactions between the industries and participants are negative. A lack of feedback from the innovative knowledge input causes knowledge development to stagnate. This analysis found no knowledge stagnation.

7.2. Permeation of Knowledge

Knowledge flow absorbs external innovation, while knowledge transforms and transfers in the internal networks of innovation. Industries that exhibit collaboration or competition with the suppliers, competitors and regional universities introduce and share external knowledge, and further transform, diffuse or spillover to other areas, resulting in knowledge diffusion and the permeation of knowledge. They also improved regional development by promoting interactions and the transformation of internal, external, explicit and tacit knowledge, and improve the capabilities of knowledge application and learning.

Industries in this category are manufacturing industries: food product manufacture (08), chemical material manufacture (18), chemical product manufacture (19), pharmaceutical and medicinal chemical product manufacture (20), basic metals (24), fabricated metal product manufacture (25), electronic part and component manufacture (26), motor vehicle & part manufacture (30), other transport equipment and part manufacture (31); service industries: computer systems design services (62) and other personal service activities (96) (Table 4). These industries were in the phases of stable development or innovation from 2001 to 2011, and diffused and permeated their knowledge.

7.3. Knowledge Fluctuation

Knowledge flow mainly relies on external knowledge sources and tacit knowledge. However, the industries will not be able to receive critical information and knowledge at the appropriate time with one-way supply from the research institutes. The unstable provision of information leads to an incapability of achieving maximum efficiency. Some benefits will be created when industry still fluctuates and obtains innovative knowledge at the appropriate time. The knowledge space, similar to the adjusting or disappearing industries, has been facing a changing status in the past decade. Industries that cannot accept innovative or apply knowledge are the manufacture of textiles (11), other manufacturing (33), support activities for transportation (52), warehousing and storage (53), scientific research and development (72), education (85), human health activities (86), and gambling & betting activities (92) (Table 4).

7.4. Knowledge Transfer and Distribution

This type of industrial dynamics lacks the interaction effect for innovative stimulation, so innovative knowledge cannot encourage regional development. This study has not identified any encouraging regional innovation that lacks industrial interaction. Industries are facing crisis and failure, and require more innovative energy and interaction to be revitalized in an environment characterized by knowledge transfer and distribution.

Based on the above, knowledge interactions, innovation, development and network collaboration of the regional industries require interactions with related industry players and the absorption of innovative energy. Continuous innovation, collaboration and knowledge transfer stimulate the ripple effect of knowledge and promote industrial circulation and development. Similar to the stable or changing clusters (Table 8), the renewal and transformation of the region offers continuous innovative energy directly or indirectly, promotes knowledge application, and further prevents the failure or disappearance of the industry. Declining industries, such as those in the "adjusting or disappearing" group, rarely collaborate or interact in the region. Having a single source of innovative information and knowledge, and differences in application capabilities, may cause industries to decline or disappear.

Table 8. The list of industrial dynamics, innovation and knowledge spaces.

Variables		Changes	
		Stable/Changing Clusters	**Adjusting/ Disappearing Clusters**
Product Innovation	Product Innovation	Positive Change *	Negative Change *
	The Percentage of Product Innovation over the Turnover	Positive Change	Negative Change
	Process Innovation	Negative Change	Positive Change
	The Percentage of Process Innovation over the Turnover	Negative Change	Positive Change
Regional Collaboration	Collaboration with Suppliers	Positive Change	Negative Change
	Collaboration with Competitors	Positive Change	Negative Change
	Collaboration with Regional Universities	Negative Change	Positive Change
Knowledge and Information	Sources of Knowledge and Information	External and Internal Knowledge *	External Knowledge *
	Knowledge and Information Transfer	Explicit and Tacit Knowledge *	No Transfer *
Knowledge Spaces	The Dynamics of Knowledge Spaces	Permeation of Knowledge	Knowledge Fluctuation

Note: * means significant (p-value < 0.05). Source: this study.

8. Conclusions

This investigation discusses how adjusting and disappearing industries obtain tacit knowledge and achieve process innovation through collaboration with regional universities, based on an analysis of industrial clusters, innovative knowledge spaces, interactions of firms, and the introduction of

innovative knowledge. The collaboration networks of stable or changing industries contain other entities such as suppliers and competitors. The diversity of knowledge innovation, including the interactions with internal, external, explicit and tacit knowledge, improves the effect of industrial activities on the environment by continuously increasing the range of possible clusters.

The industrial dynamics and knowledge interaction of southern Taiwan indicate that the ability of a firm to acquire and apply knowledge represents the potential and possibility for industrial development. Hence, future industrial development in southern Taiwan needs to focus first on the establishment of knowledge networks and the exchange platform, and this will further increase the possibilities of industrial application and innovation. The efficiency of knowledge transfer can be improved by the promotion of information technology (Figure 2). However, information technology can only improve knowledge expansion, and cannot transform knowledge to innovation. In other words, the implication and adsorption of knowledge cannot be transferred or delivered through media. Consequently, the ability of industries to acquire, apply and convert knowledge is key to creating innovation, increasing product specificity, reducing resources consumption and time costs, promoting the added value and differences among products, and stimulating industrial transformation and renewal.

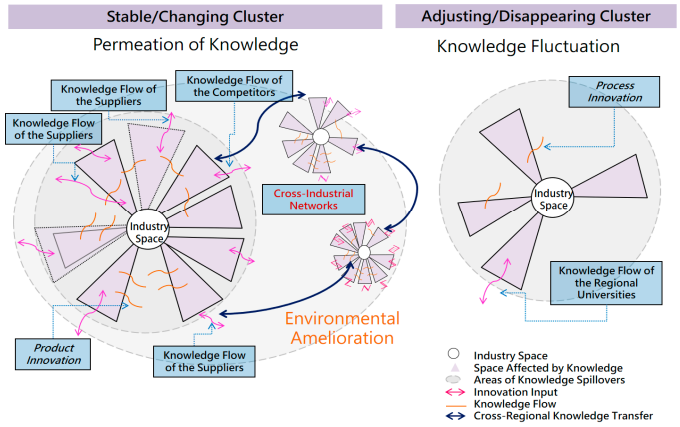

Figure 2. Diagram of industrial dynamics and knowledge interactions in southern Taiwan. [Source: this study].

The continuous input of innovation will lead to brand-new innovation strategies and development approaches based on the enhancement of industrial competitiveness and restoration. The further introduction of innovative knowledge improves industrial and economic efficiency, and further creates an industrial space full of innovative knowledge during economic development.

Future research could conduct a comprehensive discussion and analysis of the dynamics of all industries in the northern and central regions of Taiwan, in order to gain a thorough understanding of the development cycle, innovation knowledge and the local cooperation system of Taiwan's various industries in terms of their relevance and interaction.

This study adopts survey data from business sectors, as well as the Third Industrial Innovation Survey in Taiwan Area, for statistical analysis. Accordingly, data collection has some limitations, which are examined in this study. First, the list of industry categories changes annually. This work employs the industry categories of 2011 to meet the changes in time, space, industry and fit completeness. Values of zero in the analytical results are due to the changes in space and time, lack of survey data, or protection of personal information. Moreover, the Third Industrial Innovation Survey in Taiwan Area does not include all industries. Some of the industrial information cannot be accurately presented in this study because of the sampling methods used in the survey.

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Appendix A

Table A1. Parameter estimation of logistic regression, and product and process innovation.

Product Innovation						
Industrial Dynamics	**Estimation of B**	**S.E.**	**Wals**	**df**	**Significance**	**Exp(B)**
Cluster Stability/Change	2.428	0.326	55.55	1	0.00 *	11.34
Cluster Adjustment/Disappearance	−2.428	-	-	-	-	-
The Percentage of Product Innovation over the Overall Turnover						
Industrial Dynamics	**Estimation of B**	**S.E.**	**Wals**	**df**	**Significance**	**Exp(B)**
Cluster Stability/Change	0.007	0.004	3.291	1	0.07	1.007
Cluster Adjustment/Disappearance	−0.007	-	-	-	-	-
Process Innovation						
Industrial Dynamics	**Estimation of B**	**S.E.**	**Wals**	**df**	**Significance**	**Exp(B)**
Cluster Stability/Change	−0.127	0.426	0.089	1	0.766	0.881
Cluster Adjustment/Disappearance	0.127	-	-	-	-	-
The Percentage of Technology Innovation over the Overall Turnover						
Industrial Dynamics	**Estimation of B**	**S.E.**	**Wals**	**df**	**Significance**	**Exp(B)**
Cluster Stability/Change	−0.010	0.07	1.915	1	0.166	0.99
Cluster Adjustment/Disappearance	0.015	-	-	-	-	-

* denotes significant (p-value < 0.05).

Appendix B

Table A2. Parameter estimation of industrial collaboration and logistic regression.

Collaboration with Suppliers						
Industrial Dynamics	**Estimation of B**	**S.E.**	**Wals**	**df**	**Significance**	**Exp(B)**
Cluster Stability/Change	0.656	0.312	4.418	1	0.036 *	1.928
Cluster Adjustment/Disappearance	−0.656	-	-	-	-	-
Collaboration with Competitors						
Industrial Dynamics	**Estimation of B**	**S.E.**	**Wals**	**df**	**Significance**	**Exp(B)**
Cluster Stability/Change	0.774	0.471	2.698	1	0.10	2.169
Cluster Adjustment/Disappearance	−0.774	-	-	-	-	-
Collaboration with Regional Universities						
Industrial Dynamics	**Estimation of B**	**S.E.**	**Wals**	**df**	**Significance**	**Exp(B)**
Cluster Stability/Change	−0.539	0.349	2.385	1	0.123	0.583
Cluster Adjustment/Disappearance	0.539	-	-	-	-	-

* denotes significant (p-value < 0.05).

Appendix C

Table A3. Industrial dynamics and percentage of innovation (%).

Industrial Dynamics	Product Innovation		Service Innovation		Percentage of Product Innovation over the Turnover		Percentage of Technology Innovation over the Turnover	
	Yes	No	Yes	No	0–50	51–100	0–14	15–100
Cluster Stability/Change	45.0	55.0	40.8	59.2	64.2	35.8	61.7	38.3
Cluster Adjustment/Disappearance	17.2	82.8	14.1	85.9	73.7	26.3	56.6	43.4

Appendix D

Table A4. Industrial dynamics and collaboration with the participants (%).

Industrial Dynamics	Collaboration with Suppliers		Collaboration with Competitors		Collaboration with Regional Universities	
	Yes	No	Yes	No	Yes	No
Cluster Stability/Change	34.2	65.8	14.2	85.8	15.0	85.0
Cluster Adjustment/Disappearance	21.2	78.8	7.1	92.9	23.2	76.8

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