SSRG International Journal of Economics and Management Studies Volume 6 Issue 11, 89-99, Nov 2019
ISSN: 2393 – 9125 / https://doi.org/10.14445/23939125/IJEMS-V6I11P110 ©2019 Seventh Sense Research Group®

Original Article

Cluster Relationships, Knowledge Flows, and Technical Innovations: An Exploration Study of Mold & Die Industry in Northern Taiwan

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Abstract - *Knowledge flows drive the formation of industry clusters; however, the smoothness of knowledge flow hinges on the patterns and clustering of the manufacturers in the industry, which in turn affects technical innovations. To clarify the relationship among cluster relationships, knowledge flows, and technical innovations, this paper examines the mould & die manufacturers in Sanchong, Xinzhuang, and Shulin districts in northern Taiwan. Data regarding an effective sample of 282 mould &die companies are collated via interviews. The empirical study indicates that; (1) there is no significant correlation between vertical collaborations and technical innovations. There is a significant negative correlation between horizontal competition and technical innovations. Resource sharing and technical innovations are significantly and positively correlated; (2)knowledge flows and technical innovations are significantly and positively correlated; (3) the greater the horizontal competition, the weaker the knowledge sharing, and hence, the fewer the technical innovations; (4) the greater the resource sharing, the better the knowledge flows, and then the stronger the technical innovations. These findings have profound managerial implications.*

Keywords - *Resource Sharing, Industry Cluster, Knowledge Flow, Technical Innovation, Mold &Die Industry*

I. INTRODUCTION

According to the 2013 Global Competitiveness Report, as published by the World Economic Forum, Taiwan ranks first in the world (by defeating Italy and Japan) in terms of industry cluster competitiveness. Hsinchu Science Park, Central Taiwan Science Park, and South Taiwan Science Park are all considered highly competitive clusters in Taiwan. How do such clusters come into being? What makes them competitive? Perhaps it is the geographical proximity of the companies within a cluster, which allows for easy communication and technical know-how sharing to boost competitiveness (Anderson, 1994; Porter, 2001; Hou, 2001); perhaps it is the vertical collaborations from an upper stream and midstream to downstream companies within a cluster, which allows them to gain complementary advantages(Luger, 2001; Bell et al., 2009); perhaps it is the geographic proximity of the companies within a cluster, which helps the formation of a network of contacts and symbiosis for technical innovations (Nonaka and Takuchi, 1995; McDonald and Vertova, 2001).

The development of industry clusters is driven by the need for easy communication information diffusion, the division of labour, and contact networks (Arimoto, Nakajima, and Okazaki, 2014; Felzensztein et al., 2014). This paper posits that knowledge sharing among companies in a cluster forms the basis of all three aforementioned drivers. In other words, the ease of knowledge flows depends on the intensity of information communication, collaboration, and contact networks (Smith, 1995; Breshi and Malerba, 2001). Porter (1998) indicated that companies within the same cluster share many resources, such as competencies, information, and infrastructure. Many studies have suggested that company relationships within a cluster affect the levels of knowledge sharing regarding products, processes, core technologies, resources, and channels (Malmberg and Maskell, 2002; Rosenfeld, 2002; Bell et al., 2009).

Malmberg and Maskell (2002), Rosenfeld (2002), and Bell et al. (2009) elaborated on the influence of company relationships regarding the degree of knowledge sharing in a cluster; however, their focus was on the classification of cluster types, and the intensity of knowledge flows across different types of clusters. This paper believes that the different positioning and roles assumed by companies naturally result in various levels of knowledge sharing within a cluster, which in turn affects the cooperation mechanism. Meanwhile, the companies in a cluster may be in vertical collaboration, horizontal competition, or both. Therefore, this paper argues that the co-competition partnerships within a cluster extend beyond knowledge flows and are, in fact, the determinants of the willingness to co-develop new technologies and pursue win-win symbiosis.

There are many clusters comprised of small-and-medium enterprises (SMEs) in Taiwan, and the mould & die industry is a good example. Moulds are known as the mother of all industries. By the end of 2015, there were more than 3360 moulds & die manufacturers in Taiwan. The average number of employees per company was 11 people. As many as 52% of the mould & die suppliers are in northern Taiwan, notably Sanchong, Xinzhuang, and Shulin. In recent years, many Taiwanese mould & die manufacturers have moved to China, and such intense competition and industry exodus have altered the landscape in Taiwan, and in fact, reduced the resources available to the local Taiwanese mould & die industry. This paper seeks to explore how cooperation and competition among these industries continue in small clusters with limited resource capacities. By extending the classification of the cluster relationship types of Bell et al. (2009), this paper contends that the intensity of knowledge flows depends on the positioning of different companies within a cluster. In addition, the ease of knowledge sharing affects the level of technical innovations. In sum, this paper seeks to explore whether the cluster relationships in the mould & die industry in northern Taiwan influence knowledge flows, and hence, the technical innovations.

II. LITERATURE REVIEWANDHYPOTHESIS DEVELOPMENT

This paper samples the mould & die manufacturers in northern Taiwan. Different from Bell et al. (2009), this paper defines three types of company relationships within a cluster, i.e. vertical collaboration, horizontal competition, and resource sharing, and believes that these three relationships are, in fact, overlapping. Knowledge sharing is the give and take of knowledge flows between companies. Technical innovations are driving towards lighter, thinner, and smaller products, as well as the minimization of environmental impacts. Based on the above assumptions and definitions, this paper develops the following hypotheses:

A. Influence of Cluster Relationships on Technical Innovations

The geographic proximity of companies in a cluster benefits mutual learning, and hence, technical innovations (Nahapiet and Ghoshal, 1998). Some studies have indicated that the sharing of explicit and implicit knowledge within a cluster is conducive to technical innovations (Porter, 1998; Steinle and Schiele, 2002; Furman, Porter and Stern, 2002). Sainsbury (2002) suggested that the information flows from the upper and mid to the downstream in a cluster helps to generate new ideas. Tallman et al. (2004)pointed out that different cluster relationships affect the strength of technical innovations. Most literature supports that the clustering of companies is beneficial to knowledge flows and technical innovations.

In essence, the relative positioning of companies within a cluster affect the intensity of knowledge flows, and hence, the nature of technical innovations (Tristão et al., 2013). To be more exact, the relationships of vertical collaborations, horizontal competition, and resource sharing will all affect the joint efforts of the technical innovations within the cluster. This paper believes that, on the basis of the same resources, the speed of technical innovations by companies in vertical cooperation is faster, as such innovations achieve prosperity for all cluster members. For the companies in the horizontal competition of homogeneous products, technical innovations are essential to maintain and upgrade competitive advantages. The companies in resource sharing are proactive in leveraging cluster resources and driving technical innovations to boost competitiveness. Hence, this paper develops the following hypotheses:

H1: The greater the vertical collaborations in a cluster, the stronger the technical innovations.

H2: The greater the horizontal competition in a cluster, the stronger the technical innovations.

H3: The greater the resource sharing in a cluster, the stronger the technical innovations.

B. Influence of Knowledge Flows on Technical Innovations

The geographic proximity of companies in a cluster facilitates frequent knowledge flows (Porter, 1998; Breschi and Malerba, 2001; Cooke, 2001; Tsai, 2005). According to the perspective of organizational learning, companies in a cluster are more likely to experience knowledge spillovers (Jaffe, Trajtenberg and Henderson, 1993; Audretsch and Feldman, 1996). Some studies posit that the costs associated with knowledge transmission are relatively low in a cluster (Ghoshal and Bartlett, 1988; Gupta and Govindarajan, 2000). In sum, the influence of industry clusters on knowledge flows is well documented.

Knowledge flows encompass two levels, i.e. knowledge absorption and knowledge transfer (Cohen and Levinthal, 1990; Zahra and George, 2002). Knowledge absorption is to receive knowledge, while knowledge transfer is to provide knowledge. The “give and take” of knowledge flows carry different implications (Harem, Krogh and Roos, 1996; Gilbert and Cordey-Hayes, 1996; O’Dell and Grayson, 1998). While knowledge transfer should occur before knowledge absorption, knowledge flows must consist of two-way communication in order to facilitate organizational learning and innovations. Generally speaking, the more frequent the knowledge flows, the easier it is to obtain external information and drive technical innovations within a cluster, and the reverse is also true (Szulanksi, 1996). In sum, this paper suggests that the greater the knowledge flows, the stronger the momentum for technical innovations in a cluster. Hence, this paper develops the following hypothesis:

H4: The better the information flows in a cluster, the greater the technical innovations.

C. Influence of Cluster Relationships and Knowledge Flows on Technical Innovations

In the context of resource sharing, the concentration and centrality of industry clusters (i.e. the presence of anchor companies) are beneficial to knowledge flows (Carroll and Hannan, 1995; Dobrev, 2000), as these two characteristics in a cluster facilitate the interactions, knowledge flows, and essential technical innovations with anchor companies (Carroll and Swaminathan, 2000; Dobrev et al., 2001; Carroll, Dobrev, and Swaminathan, 2003). In fact, the close proximity to anchor companies helps to drive knowledge transfer and absorption, and eventually, technical innovations.

Industry clusters are one of the requirements for the sustainable development of regional industries. This paper believes that concentration and centrality are inevitable given the limited resources for all three relationship types, i.e. vertical cooperation, horizontal competition, and resource sharing. However, geographic proximity remains important as it facilitates knowledge flows and technical innovations. Hannan et al. (2002) indicated that anchor companies are measured according to concentration or centrality and usually boast more market resources. Hence, organizational learning and technical innovations are more significant when located close to anchor companies. Based on the abovementioned, this paper develops the following hypotheses:

H5: The greater the vertical cooperation and the more frequent the knowledge flows in a cluster, the stronger the capability for technical innovations.

H6: The greater the horizontal competition and the more frequent the knowledge flows in a cluster, the stronger the capability for technical innovations.

H7: The greater the resource sharing and the more frequent the knowledge flows in a cluster, the stronger the capability for technical innovations.

III. RESEARCH METHOD

A. Research Structure

On the basis of the research motivations and literature review, this paper establishes a framework comprised of three constructs, i.e. cluster relationships, knowledge flows, and technical innovations (Figure 1). As shown in the illustration, cluster relationships can be vertical cooperation, horizontal competition, or resource sharing (i.e. a single construct with three variables). Both the intensity and strength of knowledge flows are single constructs with single variables.

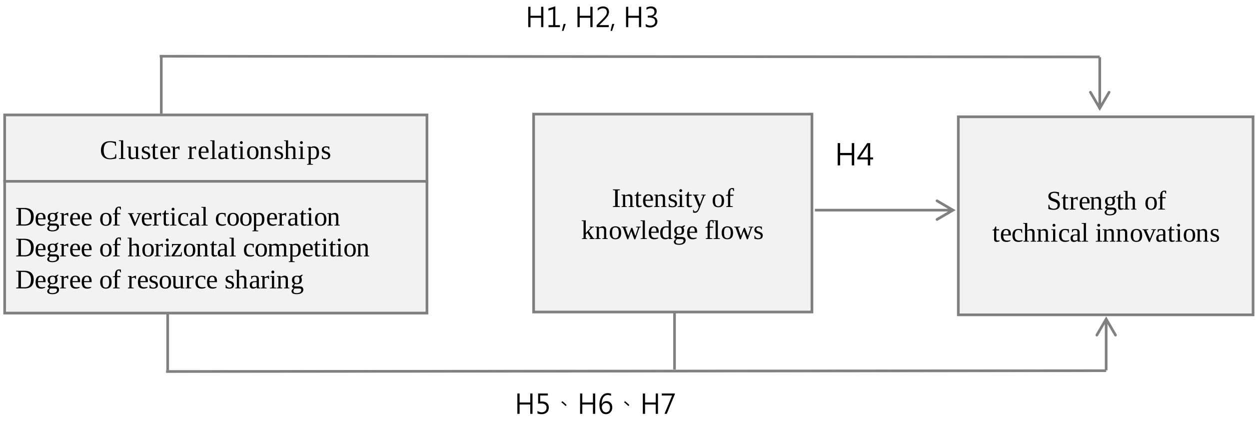

Fig. 1 Research Framework

Operational Definitions and Measurements of Variables

The operational definitions of the research variables are described as follows:

B. Cluster Relationships

a) Degree of vertical cooperation

Vertical cooperation refers to the collaborations between companies in the upper, mid, and downstream (e.g. raw material suppliers, channels, and customers). The questionnaire design of cluster relationships is modified from the measurements developed by Anderson (1994) and Porter (1998).

There is a total of six questions, and some examples are given, as follows:

. Is your company willing to invest resources in the maintenance of cooperation with upstream suppliers in the cluster?

. Can your upstream suppliers in the cluster meet the component specifications and requirements of your new products?

. Does your company consult with upstream suppliers in the cluster regarding the R&D processes of new products?

b) Degree of horizontal competition

Horizontal competition refers to the companies that produce/offer similar products/services but share the information of products and markets. The questionnaire design of horizontal competition is modified from the measurements developed by Anderson (1994) and Porter (1998).

There is a total of five questions, and some examples are given, as follows:

. The production equipment of your company is largely the same as other manufacturers in the same cluster?

.Your company regularly purchases equipment from the suppliers in the cluster to enhance competitiveness.

. Your company competes head-to-head with other companies in horizontal competition in the cluster.

c) Degree of resource sharing

Resource sharing refers to the sharing of common resources, such as the raw materials, technologies, and labourers in a cluster. The questionnaire of resource sharing is modified from the measurements developed by Porter (1998) and Rosenfeld (2002).

There is a total of three questions, as follows:

. Does your company share the same source of raw materials with some of the peers in the cluster?

. Does your company share the same source of technologies or equipment with some of the peers in the cluster?

. Does your company share the same recruitment channel with some of the peers in the cluster?

d)The intensity of Knowledge Flows

The intensity of knowledge flows is the aggregation of the knowledge transferred and absorbed between organizations (Schulz, 2001). Knowledge flows are the process of knowledge travelling from knowledge producers to knowledge users. Gupta and Govindrajan(2000) stated that knowledge flows could be incoming or outgoing. Knowledge absorption is the acquisition of external knowledge and information via the cooperation and interaction of other companies. Knowledge transfer is the offering of knowledge and information required by other companies to achieve reciprocal benefits.

The questionnaire of knowledge flows is modified from the measurements by Gupta and Govindrajan (2000) and Schulz (2001).

There is a total of nine questions, and some examples are given, as follows:

. Is your company willing to accept the knowledge shared by others in the cluster?

. Does your company have access to formal channels for knowledge sharing (e.g. technical cooperation) in the cluster?

. Does your company have informal channels for knowledge sharing (e.g. staff mobility, word of mouth) in the cluster?

e) Strength of technical innovations

Technical innovations refer to the innovations in production technologies, as achieved through either the development of new know-how or the innovation of existing technologies and applications; it is a concept of relativity, and any incremental new elements in technology can be deemed as innovations. The questionnaire of technical innovations was modified from the measurements by Smil (2005).

There is a total of eight questions, and some examples are given, as follows:

. Does your company adopt state-of-the-art technology?

. Has your company launched a new technology completely different from what is currently available on the market?

. Does your company pay attention to technical innovations?

f) Data Collection

In order to examine the influence of cluster relationships and information flows on the strength of technical innovations, this paper samples the mould & die manufacturers in northern Taiwan. In order to ensure the recovery of effective questionnaires, in-person surveys were conducted with mould & die companies in Sanchong, Xinzhuang, and Shulin of northern Taiwan. The responsible persons of the sampled companies were invited to fill in the questionnaires, the survey was conducted for eight months, and a total of 301 questionnaires were collected. After eliminating 19 invalid questionnaires, this paper collated a total of 282 effective questionnaires.

IV. ANALYSIS AND DISCUSSION

A. Tests on Common Method Variance

Self-reported questionnaires rely on the respondents' answers during the (same source) same time point. While the perceptions of these respondents may lead to the categorization of information, it is not necessarily in the same sub-category, which may result in generalization in information processing due to the inter-correlation inflation of different constructs. These variances are introduced as a function of the same source, a.k.a. Common Method Variance (CMV) (Avolio, Yammarino, and Bass, 1991).

To avoid CMV biases, this paper conducts Harman's single factor testing, which analysis suggests that the maximum explained variances are

17.753%, 17.753%, and 9.22%, respectively, according to the initial eigenvalues, extracted sums, and rotation runs. As no single factor can explain the majority of variances, CMV biases are not pronounced in this study.

B. Reliability and Validity Analysis

a) Reliability Analysis

Reliability refers to the credibility of measured results and indicates the consistency or stability of the results when the same group of respondents are measured with the same tools. While reliability does not ensure validity, it is a prerequisite for testing high validity. This paper measures the reliability of the questionnaire with Cronbach's α. The research framework in this paper consists of three constructs, i.e. cluster relationships, knowledge flows, and technical innovations. As a construct, cluster relationships contain three variables, i.e. vertical cooperation, horizontal competition, and resource sharing. Knowledge transfers are a single construct of a single variable, with two concepts, i.e. knowledge absorption and knowledge transfer. Technical innovations are also of a single variable. Cronbach's α coefficients of all the variables are higher than 0.7, which is the threshold for high reliability (Wortzel, 1979). The detailed results are shown in Table 1.

Table 1 Reliability Analysis of Individual Variables

Research Variables	Measurement	No. of questions	Cronbach's α
Cluster relationships	Degree of vertical cooperation	6	0.790
	Degree of horizontal competition	5	0.702
	Degree of resource sharing	3	0.732
The intensity of knowledge flows		9	0.903
Strength of technical innovations		8	0.918

b) Validity Analysis

This paper evaluates the accuracy of the questionnaire with both content validity and constructs validity. The measurement, as based on literature review and the opinions of experienced practitioners in the mould & die industry, should carry a certain degree of content validity. This paper conducts factor analysis to obtain the KMO value (Kaiser- Meyer- Olkin measure of sampling adequacy) and performs Bartlett's test of sphericity to examine construct validity. Kaiser (1974) suggested that the greater the KMO value is above 0.6, and the closer the p-value of Bartlett's test of sphericity is to 0, the higher the commonality of the individual questions, and the more suitable it is to conduct factor analysis (Wu, 2007). The KMO values and Bartlett's test of sphericity of different variables are shown in Table 2. This paper then extracts the factors with eigenvalues greater than 1 through principal component analysis (a factor analysis technique), which is followed by assessing the factors for each construct with varimax rotation by selecting the factors with an absolute factor loading value higher than 0.5 and cumulative explained variables greater than 40%. The factor loadings of different variables in this paper are within the 0.506-0.892 range, and the total explained variances are between 47.133% and 63.992%, which all indicate good construct validity for the different variables, as shown in Table 2.

c) Sample Structure

Frequency distributions are used to present the structure of the sample data, such as the geographic locations of the companies, their categorization in the mould & die industry, the operating history of the companies, the number of employees, and the capitalization of the companies (Table 3).

As shown in Table 3, the mould & die manufacturers in northern Taiwan exhibit the following characteristics:

. They are mostly clustered in Sanchong, Xinzhuang, and Shulin. The majority of them supply plastic moulds and stamping tools to electronics and information technology manufacturers in northern Taiwan;

. Many Taiwanese set up their own businesses during the 1960~1990s; however, such businesses are on a small scale due to the relative difficulty in accessing funding from the less developed capital market;

. Most of the mould & die manufacturers started with tools for single manufacturing processes due to their limitations in equipment and technical know-how;

. In the early days, a typical mould & die company in Sanchong, Xinzhuang, and Shulin would hire 20~30 people; however, the number of employees per manufacturer has dropped to less than 10 as machines replace some labourers;

. SMEs are the pillar of the economy in Taiwan, particularly in the industrial sectors. The flexibility and vitality of SMEs are the sources of energy in many industries in Taiwan. The mould & die companies scattered among the streets and lanes of Sanchong, Xinzhuang, and Shulin are testimony of the Taiwanese spirit.

Table 2. Validity Analysis of Individual Variables

Research Variables		No. of questions	Factor loading	Eigenvalue	KMO	Bartlett's test of sphericity	Significance	Total variance explained %
Cluster relationships	Vertical cooperation	1	0.724	3.026	0.838	459.058	0.000	50.432
		2	0.506					
		3	0.721					
		4	0.787					
		5	0.759					
		6	0.729					
	Horizontal competition	7	0.608	2.357	0.705	303.974	0.000	47.133
		8	0.511					
		9	0.617					
		10	0.825					
		11	0.815					
	Resource sharing	12	0.765	1.952	0.660	183.404	0.000	65.080
		13	0.853					
		14	0.799					
Knowledge flows		10	0.774	5.120	0.910	1366.500	0.000	56.884
		11	0.693					
		12	0.735					
		13	0.568					
		14	0.844					
		15	0.836					
		16	0.783					
		17	0.740					
		18	0.778					
Technical innovations		1	0.677	5.119	0.886	1571.829	0.000	63.992
		2	0.786					
		3	0.679					
		4	0.810					
		5	0.877					
		6	0.861					
		7	0.787					
		8	0.892					

d) Means, Standard Deviations, and Coefficients of Research Variables

Table 4 presents the correlation coefficients of research variables. All the coefficients are lower than or equal to 0.65, which is indicative of variable independence and a low likelihood of collinearity (Thomas and Williams, 1991).

e) Influence of Control Variables on Technical Innovations

Table 5 shows the examination of the influence of the control variables, such as geographic locations, sub-categorization, company history, number of employees, and company capitalization of technical innovations.

As shown in Model 1 in table 5, there is no obvious pattern regarding the effects of organizational characteristics, such as geographic locations, sub-categorization, company history, or the number of employees on technical innovations. This is perhaps due to the following:

(1) The sampled companies are all SMEs with limited scale and capitalization. Meanwhile, most of these manufacturers focus on products for single processes, and hence, find it difficult to drive technical innovations;

(2) The design and graphic personnel in the sampled companies cannot compete with industry upgrades or computerized moulding processes, which has an indirect and adverse effect on technical innovations;

(3) There has been an exodus of mould & die manufacturers from Taiwan to China due to the lower wages in China;

(4) The sampled companies experienced losses due to economic recessions over recent

years, which limits their R&D spending and hinders technical innovations.

Table 3. Frequency Distributions of Sample

Variables	Classification	No. of companies	%
Geographic location	Sanchong District	61	21.6
	Xinzhuang District	98	34.8
	Shulin District	123	43.6
Sub-category	Plastic molds	133	47.2
	Stamping tools	64	22.7
	Casting and forging tools	12	4.3
	Other moulds	23	8.2
	Outsourcing services and peripherals	50	17.7
Company history	1~5 years	31	11.0
	6~10 years	39	13.8
	11~15 years	41	14.5
	16~20 years	46	16.3
	More than 20 years	125	44.3
No. of employees	Less than 10 people	200	70.9
	10~29 people	60	21.3
	30~99 people	16	5.7
	100~199 people	2	0.7
	More than 200 people	4	1.4
Company capitalization	NT$ 5 million or less	157	55.7
	NT$ 5+ million ~ NT$ 10 million	68	24.1
	NT$ 10+ million ~ NT$ 15 million	21	7.4
	NT$ 15+ million ~ NT$ 20 million	11	3.9
	NT$ 20+ million ~NT$ 25 million	5	1.8
	NT$ 25 + million	20	7.1

Table 4. Coefficient Matrix of Research Variables

Research Variables	Average mean	Standard deviation	1.	2.	3.	4.	5.	6.	7.	8.
1. Company history	3.69	1.429	1							
2. No. of employees	1.40	0.754	0.321***	1						
3. Company capitalization	1.93	1.444	0.245***	0.581***	1					
4. Vertical cooperation	3.9879	0.50280	0.011	0.124**	0.105*	1				
5. Horizontal Competition	3.8670	0.56164	-0.070	-0.123**	-0.077	0.400***	1			
6. Resource sharing	3.6738	0.64000	-0.025	0.016	-0.070	0.388***	0.480***	1		
7. Knowledge flows	3.4805	0.63873	0.036	0.031	-0.048	-0.227***	-0.213***	0.339***	1	
8. Technical innovation	3.1306	0.75457	0.075	0.164***	0.174***	0.036	-0.030	0.177***	0.464***	1

Note: N=282; *p<0.1, **p<0.05, ***p<0.01 (2-tailed)

Table 5. Influence of Cluster Relationships and Knowledge Flows on Technical Innovations

Research Variables	Model 1	Model 2	Model 3	Model 4
Constant	2.796***	2.454***	0.810***	1.534***
Sanchong district	0.048	0.046	0.034	0.012
Shulin district	0.026	0.031	0.026	0.035
Plastic molds	0.023	0.052	0.028	0.032
Stamping tools	-0.014	-0.002	-0.002	-0.016
Casting and forging tools	-0.018	-0.013	0.001	-0.006
Other molds	0.014	0.044	0.030	0.021
Company history	0.015	0.019	-0.000	0.004
No. of employees	0.101	0.069	0.063	0.041
Company capitalization	0.119	0.149**	0.164**	0.179***
Cluster relationships				
Vertical cooperation		-0.039		-0.101
Horizontal competition		-0.118*		-0.161**
Resource sharing		0.267***		0.119**
Knowledge flows			0.446***	0.424***
R^2	0.040	0.091	0.259	0.291
Adjusted R^2	0.008	0.050	0.229	0.253
F	1.264	2.233**	8.579***	7.814***

Note: 1. N=282; *p<0.1; ** p<0.05; ***p<0.01 (2-tailed).
2. The reference group consists of the companies in Xinzhuang District and the sub-category of mould processing and peripherals.

A. Influence of Cluster Relationships on Technical Innovations

Model 2 in Table 5 is the examination of the influence of cluster relationships on technical innovations, as based on Model 1. The results suggest that vertical cooperation exhibits an inverse, but no significant influence, over technical innovations (β= - 0.039, p> 0.1). Horizontal competition reports a significant and negative influence on technical innovations (β= - 0.118, p< 0.1). These findings reject H1 and H2, possibly because the mould & die manufacturers in northern Taiwan are micro-companies, each with 8~10 employees. They all seek survival in their Specialized fields and there is no vertical cooperation or horizontal competition in the ecosystem. However, resource sharing boasts significant and positive effects on technical innovations (β= 0.267, p< 0.01). This result supports H3, possibly because the regional resources in northern Taiwan are favourable for plastic moulding and press stamp suppliers (approximately 80% of the sample). In other words, the industry landscape is the outcome of symbiosis on the basis of resource sharing. Tsai and Ghoshal (1998)indicated that such concentration and centrality in the industry helps to accelerate technical innovations. The ecosystem of the mould & die manufacturers in northern Taiwan is a great example of centralization and the centrality of a cluster, which boosts the capability of the suppliers of peripherals in technical innovations on the foundation of shared resources.

B. Influence of Knowledge Flows on Technical Innovations

Model 3 in Table 5 is the validation of the influence of knowledge flows on technical innovations, as based on Model 1. The results suggest that knowledge flows have a positive and significant influence on technical innovations (β= 0.446, p<0.01), which supports H4. It can be observed that the geographic proximity of the mould & die manufacturers in northern Taiwan essentially create a platform of knowledge flows and technical innovations, as the company members frequently visit each other. The field investigations conducted by the author reveal that the sampled mould & die companies are usually small in scale and located next to each other. Thus, people from different manufacturers meet and share resources. This network of contacts provides social and emotional support, as well as a catalyst for knowledge sharing and technical innovations (Granovetter, 1973; Krackhardt, 1992; Lin, 1999).

C. Influence of Cluster Relationships and Knowledge Flows on Technical Innovations

Based on the presumption of the influence of knowledge flows on technical innovations (β=0.424, p<0.01), this paper combines Model 2, Model 3, and Model 4 in order to explore whether the degree of vertical cooperation affects the strength of technical innovations (in the same way as knowledge flows). The results suggest no significant influence (β=-0.101, p>0.1), and hence, H5 is rejected. The greater the horizontal competition, the weaker the knowledge flows and the fewer technical innovations (β=-0.161, p<0.05), which is contrary to H6. This is probably because the struggle for resources and the fight for survival become an obstacle for knowledge flows and technical innovations. However, the influence of resource sharing on technical innovations is significant and positive ($\beta=0.119$, $p<0.1$), which supports H7.These findings suggest that geographic proximity benefits the interactions and resource sharing between companies and facilitates mutual learning and technical innovations, which is consistent with the literature (Stuart, 2000; Ernst, 2001; Pamela and Poonam, 2012).

V. CONCLUSION AND MANAGERIAL IMPLICATIONS

A. Research Conclusion

SMEs are an important force in economic development and the creators of economic miracles in Taiwan. In fact, the formation of industry clusters (e.g. the gathering of small and medium mould & die manufacturers) plays a pivotal role in the process. However, the competition for low-cost economies, such as India and China, has forced these SMEs to scale back operations, seek diversification, or simply close down their businesses. The SMEs Clusters Innovative Integrated Service Project, as established in 2008 in Taiwan, is an initiative to establish cluster advantages for both vertical and horizontal divisions of labour in order to compete with emerging economies.

In the context of changing times and international competition, this paper samples 282 SME mould & die manufacturers in northern Taiwan in order to explore whether different cluster relationships affect knowledge flows, and hence, technical innovations. The empirical findings suggest the following:

(1) There is no significant correlation between vertical cooperation and technical innovations. Horizontal competition and technical innovation are significantly and negatively correlated, while resource sharing and technical innovations are significantly and positively correlated;
(2) Knowledge flows and technical innovations are significantly and positively correlated;
(3) The greater the horizontal competition, the weaker the knowledge flows and the fewer the technical innovations;
(4) The greater the resource sharing, the more frequent the knowledge flows and the stronger the technical innovations.

This paper believes that the above findings convey three theoretical implications:

. Industry clusters are conducive to knowledge flows between companies. Literature focuses on the effects on knowledge absorption. This paper, however, argues that knowledge flows encompass two-way communication, i.e. knowledge absorption and knowledge transfer. Technical innovations should be based on the interactions of knowledge sharing in order to create multiplier effects within a cluster;

. How do cluster relationships affect knowledge flows, and thus, technical innovations? This paper posits that the industry positioning and roles, as assumed by manufacturers as partners or competitors, inherently affect the intensity of knowledge flows. Literature indicates that cluster relationships are beneficial to technical innovations; however, this answer seems overly simplistic. This paper assumes that a black box exists in the process of how cluster relationships affect technical innovations, and knowledge flows are the key;

. Manufacturers are either in vertical cooperation or horizontal competition in the context of value chains within a cluster; however, this is by no means constant. The relative positioning determines the nature of the relationship (to be collaborative or competitive). Hence, regarding cooperative/competitive relationships in a cluster, it is a relative issue and not a binary issue.

B. Managerial Implications

This paper summarizes the managerial implications based on the above findings.

The clusters of mould & die manufacturers in northern Taiwan with a higher degree of resource partitioning often report greater success in technical innovations

Geographic proximity is one of the contributors to the formation of industry clusters. Given the limited resource capacities, the sharing or concentration of resources can help to ensure evenly dispersed opportunities regarding access to resources and thus, minimize the likelihood of wasted resources. The sharing of experience by manufacturers on a common platform is beneficial to industry innovations. The government should encourage strategic alliances between companies via incentives or subsidies to facilitate the collective efforts of gathering and sharing information, as this would allow rapid flows of knowledge within clusters and promote innovative activities in the industry.

Knowledge flows are critical to technical innovations by the mould & die manufacturers in northern Taiwan

Knowledge flows encompass two-way traffic, knowledge absorption (to take) and knowledge transfer (to give). While knowledge transfer occurs before knowledge absorption, the two are essentially two sides of the same coin. According to the Social Exchange Theory, the mould & die manufacturers happy to share know-how are often more likely to receive knowledge willingly transferred to them by others. Such a friendly and open atmosphere encourages collaboration and division of labour between companies, and hence, facilitates technical innovations. It is worth noting that the mould & die manufacturers in Sanchong, Xinzhuang, and Shulin are mostly part of a contact network comprised of friends, former colleagues, mentors, apprentices, and shareholders. This social network helps to promote the flows of explicit and implicit knowledge, and hence, technical innovations (Storper and Venables, 2004).

The degree of resource sharing is an antecedent variable to the influence of knowledge flows on technical innovations

The degree of industry clustering has a positive influence on the intensity of knowledge flows, and hence, the success of technical innovations (Porter,1998; Breschi and Malerba, 2001). This paper finds that the greater the resource sharing, the better the knowledge flows and the stronger the technical innovations, which is possible because the sharing of infrastructure and resources and the closeness of geographic locations contribute to the network of collaborations from upper and mid to downstream and among affiliated sectors. As a result, the knowledge flows regarding products and technologies are intensified, and industrial innovations are created (McEvily and Zaheer, 1999; Dyer and Nobeoka, 2000). The landscape of the mould & die manufacturers scattered throughout Sanchong, Xinzhuang, and Shulin of northern Taiwan is consistent with the concentration and centrality described in the theory of resource sharing. It is worth noting that an increase in outsourcing demand prompts small suppliers to acquire technical competencies by learning from leading companies, which encourages the innovations of the mould & die industry. The cooperation between turnkey contractors and subcontractors also creates opportunities for interactions, knowledge sharing, and essential industry innovations. The turnkey mechanism in the mould & die industry is comprised of subcontractors and outsourcing partners, which are all part of an ecosystem with a high degree of resources sharing. This is consistent with the research findings of this paper. The degree of resource sharing is the antecedent variable to the influence of knowledge flows on technical innovations.

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