Industrial Cluster Involvement and Product Innovation: An Empirical Study in International Industrial Clusters

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Abstract

Researchers in strategy and organization theory are increasingly investigating the relationship between industrial clusters and organizational competitiveness. Many industrial clusters in the world play vital roles in the development of advanced technologies and innovations. By applying cluster and network related theoretical foundations, this study examines critical elements of a firm's cluster involvement and its expected product innovation performance. An empirical study of four high technology industrial clusters in U.S. China, Taiwan and Sweden reveals the relationships between a firm's cluster involvement and innovation. Based on the results, this study concludes that greater involvement in an industrial cluster can promote a firm's product innovation outcomes, but the nature of the innovation benefits depend, to a large degree, on the type of cluster involvement.

Keywords: industrial cluster, industry agglomeration, product innovation

Introduction

The research of industrial clusters has attracted much attention in regards to organizational competitive advantage as well as global competitiveness. There is an increasing agreement that industrial clusters facilitate firms to compete in distant markets as a synergistic whole. Such phenomenon can be observed from small and medium enterprises (SMEs) in many developing countries that may lack the domestic market necessary for growth and with weaker infrastructures and limited supporting industries. As a result, authorities have devoted in promoting the development of industrial clusters where firms can develop their competitiveness against the world's best competitors by sharing resources, innovative capabilities, and knowledge (Antonelli, 2000).

Although industrial clusters have received attention in the literature, much of the research has focused on the exogenous factors that may facilitate the development and growth of industrial clusters. Attention has been directed towards the resources, local endowments, pools of labor, and infrastructure that support the cluster as a whole. However, the success of such clusters, and of particular firms within a cluster, might have as much to do with endogenous factors such as networking with other firms or information flow as it does with exogenous factors. From a competitive advantage perspective, the spillover of technological know-how, strong network ties, and relational capital can also be applied to help explain the performance of firms within industrial clusters. A number of researchers (e.g., Boschma, 2005; Krugman, 1995; Starkey & Barnatt, 1997) suggest that effective and continuous innovation attempt is the key to sustaining competitive advantage for a firm.

Although much were discussed in theory, there are not much empirical evidence to support the argument that industrial cluster leads to greater amount of product innovation. In this regard, this paper focuses on answering the following research question: "Does industrial cluster or industrial agglomeration induce and promote product innovation?" Both industrial cluster and product innovation have received much attention in the past and it is a general believe that if a firm is involved in a industrial cluster, the firm's innovation performance can be improved, however, the combination of the two in a research to produce comprehensive empirical support has not done enough in the past, especially at firm level.

Therefore, in the pages that follow, the relationship between a firm's involvements within an industrial cluster and its ability to innovate were examined. The author used Ever's (2003) and Storper's (1997) research on cluster as the key theoretical foundation to generate and operationalize constructs due to the lack of existing ones while Hoonsopon and Ruenrom's (2010) research to elaborate product innovation. The operationalization of industrial cluster is deemed extremely difficult and it is also the reason that we've not seen any measures in any research related to industrial clusters at macro level. The major contribution of this paper is the initial attempt of the operationalization of firm industrial cluster involvement that allows researchers to, at least in a way, measure industrial cluster and hope the understanding of industrial clusters can be advance to a next level. This study begins with an overview of existing literature in industrial cluster and innovation capability. Specific hypotheses were generated for empirical testing. Field researches with linear regression on survey responses from 4 international industrial clusters were employed. Based on the analysis, the results were presented and their implications for both researchers and practitioners were discussed.

2. Theoretical Background

2.1 Industrial Cluster

The initial success of industrial clusters such as Silicon Valley and Route 128 in Boston has set examples for policy makers to follow and lead to efforts on the part of both firms and governments to promote similar clusters in many different locations. The research on industrial clusters is usually associated with their close boundedness in a geographical location which may induce a location based comparative advantage (Evers, 2003). A cluster, also sometimes termed an industrial district, can be defined as a geographical, shared-focused, and sectoral concentration and combination of firms. Clustering of firms is likely to facilitate efficient and effective collaboration and the leveraging of different resources and competences possessed by each firm (Giuliani, 2007). As the sum of the components is of greater value than each individual company or institution, clusters create synergies. Industrial clusters affect competitiveness in several ways (Porter, 1998). First, industrial clusters can enhance competitiveness by increasing the productivity of constituent firms. Cluster members are encouraged to specialize in technology, information, and resources and thereby develop unique capabilities that can lead to profitability. As well, the differentiation that evolves within firms in the cluster is likely to increase variety, which has been proven to enhance profitability, learning, and innovation (Iammarino & McCann, 2006). Tallman, Jenkins, Henry and Pinch (2004) distinguish between two types of competitive characteristics which can be further developed into competitive advantage for a cluster: those based on traded interdependencies and those based on non-traded interdependencies. Traded interdependencies exist in the economic sphere and involve formal exchanges of value for value. They include licensing, alliances, acquisitions, or technological know-how in which formal exchanges take place (Tallman, Jenkins, Henry & Pinch, 2004).

Existence within the economic sphere infers that traded interdependencies reflect the rational actor principle in efforts to maximize the efficient allocation and effective utilization of resources. Storper (1997) observed that traded interdependences are readily dispersed as industries mature. This can be attributed to a greater understanding of the processes surrounding economic transactions in an industrial cluster. On the other hand, non-traded interdependencies are "based on shared knowledge for which no or limited market mechanisms exist" (Storper 1993). They exist outside the economic sphere. Non-traded interdependencies include customs, cultures, beliefs, and institutions that lead to the creation of "worlds of production" which present action trajectories for firms within an uncertain world (Storper and Salais, 1997). Non-traded interdependencies reflect the "knowledge in the air" associated with what Marshall (1890) called "industrial atmosphere." These particular competitive characteristics run parallel to the economic system in an industrial cluster and can also help reduce transaction costs related to traded interdependencies (Tallman et al., 2004).The importance of traded and non-traded interdependencies has changed over time. Traditional agglomeration economics identified advantages related to trade interdependencies such as lower production cost, development of pooled suppliers, specialized labor pools, and spillovers of technological know-how (James, 2005). The emergence of globalization, however, was expected to reduce the importance of proximity in attaining these advantages. As clusters continue to be able to sustain competitive advantage, the research focus has gradually shifted to non-traded interdependencies. These competitive advantages have been attributed to interaction and the resulting trust that enabled industrial clusters to develop what Mathews (2003) refers to as "learned patterns of innovation".

As such, the importance of "industrial atmosphere" or "knowledge in the air" is growing in explaining both individual firm and collective competitive advantage.

2.2 Product Innovation

There are many definitions of product innovation. The popular terms used to classify the degree of new product innovation are radical and incremental product innovation (Atuahene-Gima, 2005). However, these terms have diverse definitions. For example, Gatignon and Xuereb (1997) and Kristina and Dean (2005) consider product innovation in terms of technology; Cooper (2000) define product innovation in terms of customer's opinion.
Kristina and Dean (2005) propose that product innovation may be evaluated in terms of the differentiated technological characteristics of the product. The two criteria for the evaluation are: 1) novelty, which is the need to be dissimilar from prior technologies; 2) uniqueness, which is the need to be dissimilar from current technology. Anderson and Tushman (1991) define product innovation only in terms of radical innovation. They define product innovation as "technological discontinuities that advance by an order of magnitude the technological state-of-the art which characterizes an industry" (Anderson & Tushman, 1991). They further explain product discontinuities as technological breakthroughs which produce fundamentally different product forms that possessed a decisive cost, performance, or quality advantage over prior product forms.

Product discontinuities also represent a new way of making something (i.e., novel product architecture). Radical products are the result of technological discontinuities. From the customer's perspective, Christensen (1997) classifies disruptive product innovation as involving the creation of new products that bring a very different value proposition in a market than product created using previously available technologies. Cooper (2000) suggests that radical product innovation and disruptive product innovation, created a new dimension to the customer's perspective. Ziamou and Ratneshwar (2003) define product innovation as creating a novel set of benefits available to customers, although the physical shape of the product offered might not be new to the market. Olshavsky and Spreng (1996), however, note that it is difficult for customers to form evaluations or make expectations regarding product innovation. Moreover, customers may reject new products if they are still satisfied with present products or if new products do not meet expectations. Hence, it is very important for firms to know the expectations of customers so that firms can gain competitive advantage from their new products.

Each firm has different objectives for developing new products because resource heterogeneity (e.g., staff, capital, and organizational capabilities) and external pressures (e.g., demand uncertainty, competition, and technological change) (Barney, 1991). For example, some firms may want to promote themselves as innovator or they want to offer new features and benefits to customers in the market. So, these firms develop radical products to meet their objective. However, other firms may develop incremental products to serve the additional needs of their customers. Also, in the case of a shortage and immaturity of technology and capability, firms may develop incremental products based on existing products by marginally improving the performance.

Based on the prior definitions of product innovation, this paper focuses on product innovation from the customer's perspective. The reason is that new products would succeed if new products are developed to satisfy a perceived need of customers, rather than being developed to take advantage of new technologies (Voss and Voss, 2000). Thus, this study applies the definition of radical and incremental product innovation from Hoonsopon and Ruenrom (2010). Radical product innovation is defined as "the development of products that have a different set of features and performance attributes that create a set of benefits different from that of existing products from the customer's perspective" (Hoonsopon & Ruenrom, 2010). Incremental product innovation is defined as "the development of products that have minor changes in attributes, and the benefits from these changes are minimal from the customer's perspective" (Hoonsopon & Ruenrom, 2010).

3. Theory Developments and Hypothesis

Knowing the importance of adapting to changing environments, research has begun to search for the means of successful innovation by trying to answer the question of *how*. As highlighted in the previous discussion, potential benefits from involvement in an industrial cluster and efforts geared toward sharing resources and knowledge spillover seem to be the primary benefits that firms intend to reach. While the literature has argued for the value of cluster membership in enhancing organizational performance and innovation (e.g., Miles, Snow & Miles, 2000; Niu, 2010), it is our contention that a firm's successful innovation may be the result of involvement with other firms in the cluster (see Fig. 1).

Figure 1: Model of the Influence of Cluster Involvement on Product Innovation

Industrial clusters are recognized as a network-based system containing a variety of closely bound firms (James, 2005). This type of network formation is also characterized by linkages between actors that are created in a temporal or semi-temporal fashion, commonly centering on a problem or issue (Schmitz, 1999). Actors in network-based system have more access to learn from each other and integrate each other's knowledge until the problem is solved or the goal is achieved. In a cluster such as Silicon Valley, the entire region is organized to innovate and adapt continuously to fast-changing markets and technologies by frequent and synergistic information flow within the cluster. The network structure of the cluster encourages the pursuit of multiple technical opportunities through the spontaneous exchanging and regrouping of technology, capital investment and know-how for quick enhancement of a firm's existing capability and competence (Sexenian, 1994). As well, an atmosphere resides within an industrial cluster in which related technological breakthroughs and know-how are "contagiously floating in the air", and eventually may affect all the participating firms in this particular industrial cluster (Schmitz, 1999).

Network-based clusters support a decentralized process of innovation and knowledge exchange that fosters positive interaction between organizations because of the easy access to other proprietary knowledge and other type of resources. Through both traded and non-traded interdependences, clustered firms form a complex network structure within a cluster which further develops and even strengthens inter-organizational relationships that offer firms multiple portals to access other's resources and technological know-how. Such benefits, however, are likely to depend upon the degree of involvement that the firm maintains within the cluster. While some benefits are likely to accrue to a firm simply from being part of a cluster, higher levels of both competitive specialization and next round of innovation are more likely to occur as a firm increases both its traded and non-traded relationships. The more involved a firm becomes with other members of the cluster, the more opportunities are created for keeping existing competence up-to-date and for maintaining at least an awareness of a broader range of understanding regarding the competitive market. Therefore, it is possible that different aspects of industrial cluster involvement (i.e., traded and non-traded interdependence) are associated with different aspects of innovation (i.e., incremental and radical). As such, we offer two hypotheses of the relationship between industrial cluster involvement and product innovation. Said formally:

H1: A firm's involvement in an industrial cluster is positively related to its incremental product innovation and,
H2: A firm's involvement in an industrial cluster is positively related to its radical product innovation.

4. Methods

4.1 Sample

The sampling population of this study consists of firms in four international industrial clusters that represent the U.S. (*CU*), China (*CC*), Taiwan (*CT*), and Sweden (*CS*). By sampling from clusters in Europe, North America, and Asia any factors that might be unique to a particular cluster could be controlled for. *CU* is the naturally occurring high technology cluster based in the Silicon Valley in California. The targeting subjects were chosen from Fortune 1000 (2012) and Forbes Global 2000 (2012) and included 194 companies. *CT* is one of the larger and well known high technology industrial clusters in the Asia Pacific region which is known for its well-developed semiconductor industry and original equipment manufacturers. *CC* is another well-known high technology industrial cluster in Asia.

Although it is not as well developed as others, it still catches significant foreign attentions due to the market opportunities and above average rate of growth in China. In total, 173 companies from the industrial cluster in *CT* and 361 from *CC* targeted. *CS* is a well-established cluster in information technology and is also recognized worldwide for its leading position in biotechnology. The targeted companies were identified and included 215 individual firms.

The questionnaires were sent out to all the 943 companies with the assistance of several key individuals who had good contacts within each industrial cluster in hope of increasing the response rate. In this study, with the help from the individuals who have access to each sampling cluster, 242 questionnaires were returned from the respondents after three months. Of the 242 questionnaires, 213 respondents completed the survey. Of the 213 respondents who completed the survey, 188 were useable, resulting in a 19.8% response rate. Non-response bias was checked by comparing early to late respondents (Thompson & Daniel, 1996) and does not appear to be an issue in the analysis. Table 1 and 2 shows the descriptive statistics of the sample.

TABLE 1: Position of Respondent

Position	*Frequency*	*Percentage*
Managing Director	59	31%
Vice Managing Director	18	9.5%
Factory Manager	12	6.5%
R&D Manager	29	15%
QA/OC Manager	16	9%
Marketing Manager	31	17%
Finance Manager	7	4%
Other	16	8%
Total	*188*	*100%*

TABLE 2: Type of Industry

Industry	*Frequency*	*Percentage*
Semiconductor	37	20%
PC Industry	29	15%
Telecommunication	33	18%
IC Design	13	7%
Biotechnology	27	14%
Pharmaceutical	17	9%
Financial/Banking	14	8%
OEM	11	6%
Others	7	3%
Total	*188*	*100%*

4.2 Measures

For all measures included in the hypotheses, respondents were asked to respond to statements by indicating the degree to which the statement characterized their firm using a Likert scale ranging from 1, indicating highly disagree, to 5, indicating highly agree. All items measuring each construct were considered during the first run using principal components and varimax rotation at eigenvalue greater than one level. In each case this resulted in items that did not load on the intended factors. Hence, minor modifications of the instrument were made and the remaining items were subjected to another factor analysis which, in each case, resulted in a model with a better fit. As was expected, the results suggested two factors for firm involvement in industrial clusters and two factors for product innovation. The results of factor analyses considered in the final measures for each construct are shown in Table 3 and 4, and each is discussed in turn below.

TABLE 3: Factor Analysis of Industrial Cluster Involvement

Variable	*Factor 1*	*Factor 2*
Industrial Cluster Involvement	Traded	Non-Traded
Engagement in subcontracting	.682	
Inter-firm collaboration	.832	
Widespread product imitation	.812	
Development of core capability	.536	
Technical competence of cluster members	.606	
Joint social history		.757
Geographic proximity		.688
Social network and ties		.804
Supportive institution and infrastructure		.760
Cultural background		.762
Government support		.560
Total Variance Explained	*.27*	*.30*
Cronbach's Alpha	*.86*	*.85*

TABLE 4: Factor Analysis of Product Innovation

Variable	*Factor 1*	*Factor 2*
Product Innovation	Incremental Innovation	Radical Innovation
Refined product design	.752	
Improved engineering function	.750	
Improved product reliability	.871	
Adding product features	.791	
Enhanced product quality	.822	
Improved customer service	.560	
New patents		.635
Product has not been seen in the market		.718
New market entry/creation		.727
Large sales from new services/product		.709
New supply chain function		.797
Introduction of new technology		.612
Total Variance Explained	*.28*	*.31*
Cronbach's Alpha	*.81*	*.79*

Industrial cluster involvement represents the degree of involvement by a firm in a unique environmental setting. Adopted from Niu (2010), two distinct factors were expected to emerge. Fourteen items, 7 for each expected factor, were initially included in the survey but after the first run of the factor analysis three items were dropped due to cross loading. The second run of factor analysis showed the remaining items loading as expected onto two factors and they were labeled *traded* and *non-traded interdependence* respectively. Traded interdependence has five items while non-traded interdependence has six, and the total variance explained by these two factors is 57%. The alpha for traded and non-traded interdependence is .86 and .85, respectively.

Product innovation is the dependent variable in this study and based on Garcia and Calantone (2002) and Hoonsopon and Ruenrom (2010), it was also expected to have two factors. Sixteen items were initially included in the survey but 4items was dropped due to cross loading found in the first factor analysis. The result of the second factor analysis had clean loadings for two factors: *incremental innovation and radical innovation*. A total of six items were related to incremental innovation and six items were related to radical innovation. The variances explained by both incremental and radical innovation are 59%. Cronbach's alpha of the two measures is .81 and .79, respectively.

Convergent and discriminant validity were assessed primarily by using factor analysis. Convergent validity is demonstrated if the items load strongly (> .50) on their associated factors (Grandon & Pearson, 2003). Discriminant validity was achieved when each item loads stronger on its associated factor than on any other factor (Hair, Anderson, Tatham & Black, 1998). Table 3and 4 illustrate that all items loaded stronger on their associated factors than on other factors. Thus, there is evidence to support convergent and discriminant validity for the measures in this study. Internal consistency was assessed by using Cronbach's alpha (1951). Table 3and 4 illustrate the alpha values ranged from .79 to .86, which indicates construct reliability is sufficient for all factors.

5. Findings

Before turning to the hypotheses testing, the data were examined for any potential issues. Respondents appeared to be appropriate, covering mostly upper and middle management positions appropriate for judging the variables of interest. From a statistical perspective, the data were judged to be appropriate for analysis and multi-collinearity diagnostics suggested multi-collinearity is not likely to be a problem in this study. Table 5 presents means, standard deviations, and correlations of the variables in this study.

TABLE 5: Means, Standard Deviations, and Correlations

	Mean	**s.d.**	**1**	**2**	**3**
1. Traded	3.67	0.64	1.00		
2. NonTraded	3.73	0.69	.41**	1.00	
3. Incremental	3.57	0.69	.28**	.31**	1.00
4. Radical	3.89	0.64	.20**	.30**	.32**
n= 188					
***p*<.01					
**p*<.05					

Of particular interest was a comparison of responses by cluster. As noted, we collected data from multiple clusters so that we could control for any influence that might be unique to a given cluster. This was examined initially through an ANOVA analysis that revealed minor but statistically significant differences between clusters on some variables. Accordingly, dummy variables for clusters were included in the initial testing of the hypotheses. In all cases, however, the dummy variables were non-significant and so have been excluded from the analysis that follows in order to improve power and reporting clarity.

To test hypotheses 1 multiple regression analysis was conducted. The two measures of industrial cluster involvement, the independent variable, are traded and non-traded interdependence, while the dependent variable, product innovation, is measured by using incremental innovation. The results, shown in Table 6, provide support for the hypothesis, though the influence of traded and non-traded interdependence on incremental product innovation varies. As indicated in the table, traded interdependence predicts incremental innovation, explaining about 26% of the variance while non-traded interdependence explains 17%. Both traded and non-traded interdependence are significant at $p< .05$ level. For testing hypothesis 2, radical innovation was used as the dependent variable and the two measures of industrial cluster involvement (i.e., traded and non-traded interdependence) as independent variables. As predicated, industrial cluster involvement was positively related to radical innovation. Interestingly, only non-traded interdependence is the significant predictor of radical innovation, explaining 24% of the variance for radical innovation.

TABLE 6: Test of Hypothesis 1 and 2

Independent Variable	Dependent Variable: Incremental	Dependent Variable: Radical
Intercept	1.96	.26
Traded	.26**	.13
Non-Traded	.17*	.24**
F	14.45**	10.57**
R2	.14	.11
***p< .01*		
**p< .05*		

To gain further insight, a post hoc path analysis using SEM was produced to investigate the effect brought by industrial cluster involvement on product innovation as whole. As shown in Fig. 2, the path coefficients are all significant at $p < .01$ level which can be regarded as the initial evidence of a strong relationship. To better understand the model, however, model fit indices need to be reviewed as well. The chi-square value is 12.81 and it is not significant at $p < .05$ level, indicating that path analysis model fits data well. The NFI of the revised model is .954, CFI is .982, and RMSEA is .037 can all be regarded as evidence of an overall acceptance of the fit for the path analysis model.

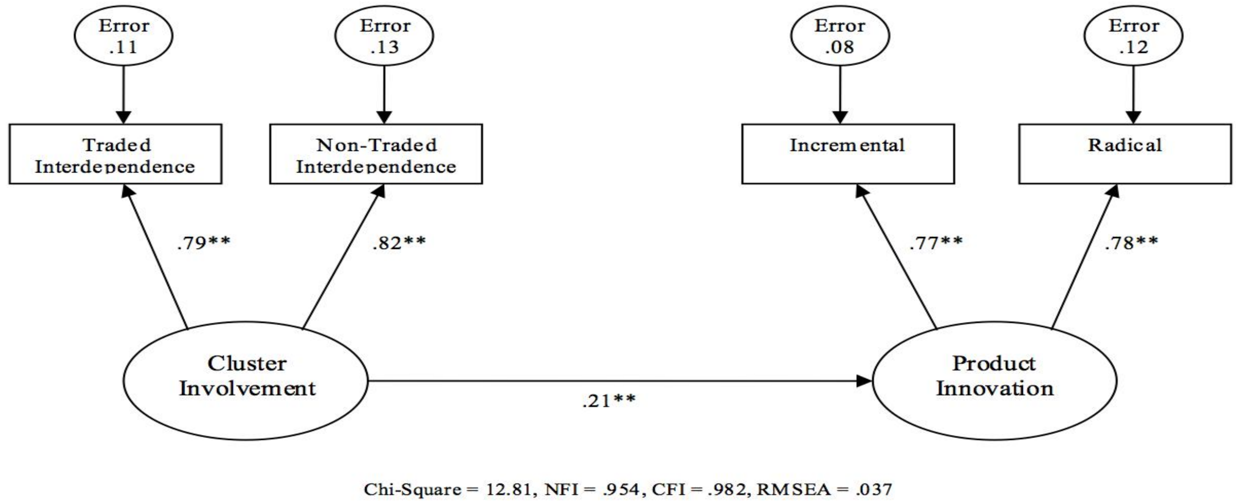

FIGURE 2: Path Analysis of the Relationship between Industrial Cluster Involvement and Product Innovation

6. Discussion

The results of this study provide empirical support for theories of industrial clusters and product innovation, suggesting that industrial cluster involvement and product innovation are significantly associated. At the same time, the differences in results for the different aspects of each variable provide additional insights regarding how cluster involvement works to help an organization innovate.

Based on the results, it appears that traded dependencies are particularly important to an organization when it is trying to incrementally enhance its current product features and performance, while non-traded interdependencies are more important when a firm is trying to explore newness or to innovate radically. The logic to support these findings is straightforward. When a firm is trying to incrementally enhance its product, it usually seeks to acquire technological know-how and resources that are more explicit, transparent, and already usable, so the newly acquired technological knowledge can be put into practice without too much alteration which shortens time to market. Traded interdependence, which refers to more formal transactional exchanges such as buyer-supplier agreements or contractual relationships among participating firms, provides an additional source for such capability absorption. Because it occurs within the industrial cluster, it may also reduce or eliminate transaction and other costs that might otherwise be incurred (Niu, 2010).

When trying to innovate radically, on the other hand, firms usually want to keep the new ideas proprietary so that they can be transformed into competitive advantage. However, to create next round innovation still relies on remaining up-to-date, being exposed to a variety of different approaches, and creating an atmosphere that allows for the exchange of ideas both within the firm and across other firms. In line with this view, the results of the analysis suggest that non-traded interdependencies are more important to radical innovation. Non-traded interdependencies represent the social and cultural characteristics of a cluster and create their own pattern of non-economic exchange of ideas. The consequence is the emergence of an industrial atmosphere that can become contagious, and enable firms to become a part of idea exchanges that can ultimately spark participating firms to create their own proprietary capability for next round innovation. It is important to note, however, that it is the degree of cluster involvement, not just cluster membership that makes a difference. All of the firms in this study were members of an industrial cluster, but there were differences in their levels and ability to adapt through incremental innovation and radical innovation.

He was predicted, at least in part, by the level of involvement the firms had established within the cluster in terms of both traded and non-traded interdependencies. This suggests that cluster members desiring to improve either their ability for incremental innovation and/or radical innovation should consider how they might improve their traded and/or non-traded interdependencies with other cluster members.

7. Conclusion

The major contribution of this work is a coherent model that logically link industrial clusters and product innovation for empirical test that is important to this area of research. An underlying assumption about the role industrial cluster involvement toward innovation has been examined. This study emphasizes how involvement within an industrial cluster affects firms' product innovation.

As with any study, some caution should be used in interpreting these findings. This study relied on self-reported data which, while common within the field, has the potential for introducing common method variance. Another limitation to this study is the use of only one respondent from each organization. While there is support for using this method from previous research (e.g., Maloni & Benton, 2000), it is possible that the individual responding on behalf of the organization may not provide a true representation for the entire company. Future empirical research will need to address both these issues to enhance the thoroughness and generalizability of this study. On the positive side, the fact that the study included samples from industrial clusters in Asia, Europe, and the U.S. and found that the hypothesized relationships did not appear to be unique to any particular cluster provides at least some evidence for generalizing the findings.

All that said, the findings are still intriguing and provide implications for both researchers and practitioners. Perhaps the most important discovery is the difference found between the organizational-innovation outcomes of incremental innovation and radical innovation. Industrial clusters are often regarded as innovation systems due to the potential for resource sharing and local knowledge spillover and past research has suggested a relationship between industrial cluster and innovation. The current findings, though, highlight that it is important to consider the nature of the cluster involvement as well as whether the product innovation is directed towards incremental or radical. Future research will continue to try to break down innovation into its constituent pieces and examines the different ways that firm actions influence different aspects of each. From a practitioner standpoint, the findings suggest that firms need to consider not just the necessity of innovation but to give consideration to the nature of innovation desired and focus their cluster involvement and inter-firm relationships appropriately.

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