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Firm innovation in policy-driven parks and spontaneous clusters: the smaller firm the better?

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Abstract Mixed evidence has been found regarding how locating in a cluster or a park affects firms' performance. This paper investigates how locating in different types of clusters and parks interacted by firm size or in-house R&D capability affects a firm's innovation. Empirically testing the research hypotheses by the data of 165 Taiwan's manufacturing firms in the information and communication technology sector and taking policy-driven parks (e.g., science parks and industrial parks) and spontaneously clusters as examples, we find that in emerging economies, firms with inferior in-house R&D capability gain more innovation benefits by locating in a science park or a spontaneous cluster while smaller firms gain more innovation benefits by locating in an industry park or a spontaneous cluster. Moreover, our findings also suggest that locating in a science park, smaller firms benefit more than larger firms in terms of innovation performance whereas larger firms benefit more than smaller firms in terms of market performance. The findings suggest that in emerging economies, compared to larger firms, smaller firms are less influenced by negative spillover effect when locating in clusters or parks.

Keywords Agglomeration effect · SMEs · In-house R&D · Science-based parks

JEL Classification O32 · R1 · R12

1 Introduction

Prior research has identified different types of clusters which may contribute different effects to firms. Chiesa and Chiaroni (2005) also suggest two major forms of clusters:

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(1) spontaneous clusters, that are the result of the spontaneous co-presence of key factors; and (2) policy-driven clusters, that are triggered by the strong commitment of the government whose objective is to establish the cluster either as a response to an industrial crisis or as a deliberate decision to foster a sector. Policy-driven clusters include industrial parks and science parks (Westhead 1997; Tan 2006). Link and Scott (2003) also summarize several types of parks in their study. For instance, research parks are characterized by tenants which are heavily engaged in basic and applied research, such as university research parks (Link and Scott 2006, 2007), while science parks including technology parks are characterized by tenants which are heavily engaged in applied research and development. Moreover, technology or innovation parks house new start-up firms and incubators, while commercial or industrial parks have tenants which carry out value-added activities through assembly or packaging rather than conduct R&D. It is widely regarded that policy-driven parks are more sponsored in emerging economies but are less in more developed economies. For instance, Tan (2006) regards China's Zhongguanchun Science Park as a successful policy-driven park for semiconductor firms. However, there are exceptions in some prior evidences. For instance, Humphrey and Schmitz (1996) note that an increasing number of developing countries have started to take lessons from the experience of European countries on running government-sponsored industrial districts. Link and Link (2003) also conclude the important role of science parks in the US. Although the prior research has suggested that different types of parks or clusters may contribute to firms differently (Chiesa and Chiaroni 2005), few studies explore how these different types of parks or clusters, such as spontaneous clusters and policy-driven parks, affect a firm's innovative and market performance differently. Thus, we would like to investigate how different types of parks or clusters affect firms innovation performance in this research.

Serving as a platform for acquiring external complementary resources or knowledge supporting firm innovative activities is one benefit of a cluster or a park (Baptista and Swann 1998). Particularly, for firms with smaller size or insufficient resources, spillover effect or knowledge diffusion facilitated by clusters or science parks has become increasingly important in strategy studies. Early studies regarding spillover effect mainly focus on knowledge transfer or diffusion among firms in a cluster or on how clusters help firms to accumulate their capability for new product development (Audretsch and Feldman 1996; Westhead 1997; Audretsch 1998; Keeble and Wilkinson 1999). However, the competition among players in clusters or parks may lessen the benefits due to the high risk of knowledge diffusion. For example, firms in Silicon Valley act together to foster innovation whereas firms in Route 128 act as independent silos to impede the information flow among them (Saxenian 1994). Alsleben (2005) finds that competitors within a small geographical distance may lure a firm's engineers away. These findings leave some puzzles to be explored, such as: can a firm's innovation be improved if the firm locates in a cluster and what kind of firms can benefit more from clusters?

Firm size is observed as another important determinant of a firm's innovativeness (Acs and Audretsch 1990). Based on the resource-based view (RBV), larger firms may have more resources or absorptive capacity (Penrose 1959; Cohen and Levinthal 1990) to conduct advanced technology research or to develop new products. Prior research suggests that larger firms can be the engine and glue for the development of local innovation and industry system, so called anchor effect (Felderman 2003). However, this does not guarantee that larger firms can benefit more from locating in a cluster. Although larger firms may have the advantage of technological economies of scale and learning curve effect, smaller firms may outweigh larger firms due to organizational diseconomies of scale

(Zenger 1994), entrepreneurial dynamism, flexibility, efficiency, and proximity to the market (Rothwell and Dodgson 1994). Some prior studies suggest that larger firms have less motivation to locate in a cluster due to the risk of knowledge leakage (Audretsch and Feldman 1996). In contrast, smaller firms may gain more in innovation by locating in a cluster since the external partnerships in a cluster can help them to accelerate innovation activities (Hewitt-Dundas 2006), to reduce the risk of innovation (Das and Teng 1998), and to provide access to complementary assets and resources (Ireland and Hitt 1999; Gulati et al. 2000). However, little empirical evidence has been offered on how firms with different size enjoy the cluster effect. This study intends to contribute to the understanding of this issue.

There is a consensus that in-house research and development (R&D) is positively associated with firm innovation performance (Gambardella 1992; Lundvall and Nielsen 1999; Caloghirou et al. 2004). Given high investment costs of R&D activities, not every firm has sufficient resources to conduct in-house R&D. Thus, firms may seek critical resources from external entities to supplement the shortage of internal resources (Pfeffer and Salancik 1978). However, how the level of in-house R&D capability interacted with the external cluster effect affects a firm's innovative performance has not been fully investigated. Therefore, another objective of this study is to examine how a firm's level of in-house R&D capability affects its gains in innovation when it locates in a cluster.

Taking the Hsinchu Science Park (HSP), Tao-Yuan Industrial Park and a spontaneous cluster in Taipei County as our sample clusters and the data of 165 manufacturing firms in the information and communication technology (ICT) sector, we empirically tested the research hypotheses. The findings suggest that in emerging economies, firms with lower levels of in-house R&D capability gain more innovation benefits by locating in a science park or a spontaneous cluster while smaller firms gain more innovation benefits by locating in an industry park or a spontaneous cluster. Moreover, our findings also suggest that locating in a science park, smaller firms benefit more than larger firms in terms of innovation performance whereas larger firms benefit more than smaller firms in terms of market performance.

2 Theoretical background and hypothesis development

Complexity and variability of technologies increase the need for external collaboration for complementary resources (Nooteboom 1999). Firms not only need external sources of competence to complement their own capability but also need inter-organizational linkages to advance existing knowledge into new types of knowledge or to develop new products, processes, and services (Nonaka and Takeushi 1995). Particularly for small and medium-sized firms which have limited resources to conduct in-house R&D activities or for firms with inferior in-house R&D capability, a cluster or a park provides an interactive place for nurturing innovation and improving competitive advantage.

2.1 Spontaneous clusters and policy-driven parks in emerging economies

It is widely regarded that clusters are formed spontaneously in developed countries in prior research (Saxenian 1994). External economies of a cluster arise from the emergence of suppliers who provide materials or components as well as from the emergence of a pool of skilful workers. However, there are exceptions that clusters may be developed for the purpose of industrial development. For instance, Humphrey and Schmitz (1996) summarize a number of successful policy-supported industrial districts in European countries (such as in Italy) and note that an increasing number of developing countries start to learn these successful lessons from the developed countries. These industrial districts are developed for the purpose of enhancing local production and innovation capability (Rabellotti 1995). As a result, this type of policy-driven parks becomes a popular tool for industrial development in emerging economies.

Like an industrial district, a science park, which is normally developed by the government, can be also regarded as another type of policy-driven parks (Cooke 2002; Westhead 1997; Sofouli and Vonortas 2007; Tan 2006), though a science park consists of firms from a variety of industries. Particularly, governments normally have a policy intention of fostering a science park where firms are closely-related to each other. For instance, the first science park in Taiwan, Hsinchu Science Park (HSP), was constructed to facilitate a competitive environment for high technology firms. A well-developed science park enables firms not only to take advantage of legitimate benefits such as tax holidays but also to benefit from economies of scope. Science parks also provide a platform to induce knowledge exchange or information sharing among firms (Dierdonck et al. 1991; Squicciarini 2007).

While most studies assume that clusters or parks foster salient benefits for co-located firms, these studies generally neglect the constraints co-existing with the benefits. Several recent studies suggest that the competitive costs entailed by the cluster effect may lessen firm competitiveness (Chung and Kalnins 2001; Shaver and Flyer 2000). Saxenian (1994) also suggests that the firms in Route 128 act like silos to impede the flow of information among them. Thus, a firm's innovation is likely to be discouraged as it comes to knowledge diffusion to competitors located in the same geographic area, particularly because these competing firms have a similar knowledge base or similar industrial experiences (Audretsch and Feldman 1996). Moreover, imitation by competitors also discourages a firm's effort to innovate if the firms co-locate in a cluster or a park. As a result, innovative ideas may be discouraged (Chang and Park 2005).

Taking the aforementioned propositions, we expect that the impact of locating in a cluster or a park on firm innovation performance may not be clearly assessed due to the mixed results of cluster-affiliation. However, the positive and negative impacts may be associated with the types of clusters involved (i.e., spontaneous clusters and policy-driven parks).

In spontaneous clusters, it is the communication between individuals which facilitates the transmission of knowledge across agents, firms, and even industries, and that is conducive to innovative activity. Technical and market information is exchanged and the decentralized and fluid environment in the spontaneous cluster also promotes the diffusion of intangible technological capabilities and understandings (Saxenian 1994). Similarly, in policy-driven parks, the exchanged technical and market information via movement of individuals among firms enhances innovation activities (Dierdonck et al. 1991). However, the main difference between spontaneous clusters and policy-driven parks is the government's commitment on the development of the cluster. Policy-driven parks are well organized by governments which can provide more financial supports as well as abundant high-skill labours by establishing research institutions in these parks while spontaneous clusters emerge with historical development of the regions which may benefit less financial supports from the government and planned sources of high-skill labours, which lead to less innovation for firms in the spontaneous clusters. Therefore, we can expect that, comparing with spontaneous clusters, policy-driven parks can contribute more to a firm's innovativeness.

Hypothesis 1 Comparing with spontaneous clusters, firms locating in policy-driven parks are expected to have better firm innovation performance.

2.2 Firm size, spontaneous clusters or policy-driven parks, and firm innovation

Empirically, firm size is observed as having a positive impact on a firm's innovation performance, such as patents (Scherer 1965). Freeman (1987) suggests that larger firms are more effective in conducting industrial research. Prior agglomeration studies investigate how size of firm affects the choice of establishment location (Arauzo Carod and Manjón Antolín 2004; Brush et al. 2008; Galbraith et al. 2008; Nicolini 2001). There is some evidence that science parks are more attractive for smaller firms. For instance, in their study in UK, Siegel et al. (2003) suggest that 80% of firms in science-based parks are small and medium sized. However, compared with larger firms, do small and medium-sized enterprises (SMEs) locating in spontaneous clusters or policy-driven parks enjoy better innovation performance?

Larger firms have more resources or absorptive capacity (Penrose 1959; Cohen and Levinthal 1990), and therefore have advantages to conduct advanced technology research or to develop new products on their own. However, facing the high possibility of knowledge diffusion to competitors (Audretsch and Feldman 1996) and imitation by competitors located in the same geographic area, larger firms are discouraged to innovate if they locate in clusters or parks (Chang and Park 2005). Thus, we expect that compared to larger firms, smaller firms can improve their innovation better through obtaining needed resources or knowledge when locating in spontaneous clusters and policy-driven parks.

Hypothesis 2 The interaction of firm size by the cluster types is negatively correlated to firm innovation performance.[1]

2.3 In-house R&D capability, cluster effect, and firm innovation

In addition to firm size, in-house R&D capability may also have an impact on firm innovation performance. Although in-house R&D capability is regarded to be influenced by firm size, Cohen et al. (1987) find that overall firm size has statistically insignificant effect on R&D intensity. This implies that in-house R&D and firm size represent different characteristics of a firm. Thus, it is necessarily to investigate these two factors separately in this study.

In-house R&D efforts, such as intense interactions among individuals or organizations, can amplify knowledge exploration and exploitation (Caloghirou et al. 2004). Previous empirical studies confirm that a higher level of in-house R&D capacity improves a firm's ability to exploit sources of knowledge (Gambardella 1992). Thus, we expect that a firm's internal R&D capability has a positive correlation with its innovation performance.

However, the resource dependence theory suggests that complementary resources are extremely beneficial to reduce costs and risks especially in an uncertain environment (Pfeffer and Salancik 1978). Shaver and Flyer (2000) suggest that firms with limited resources, such as technologies, human capital, training programs, suppliers, or distributors, are motivated to join geographical clusters to access complementary resources. Kalnins and Chung (2004) assert that firms will co-locate with other firms possessing resources that can spill over. However, a firm has to consider another side of the spillover effect: it acts as a receiver as well as a giver of technological resources. Alsleben (2005) asserts that the flow of skilled employees more likely emerges in a cluster due to small geographical distance. Since the resource-rich firms possess more highly-trained expertises

[1] This can be interpreted as larger firms gain less in innovation in a cluster than smaller firms.

in R&D, they are more vulnerable to losing their existing internal resources. Thus, when locating in a cluster or a park, resource-rich firms may suffer more outflows of spillover than resource-shortage firms. As a result, compared to R&D capability-rich firms, firms with inferior in-house R&D capability will experience less negative consequences (i.e., less risk of losing existing knowledge) in innovation as they locate in both spontaneous clusters and policy-driven parks.

Hypothesis 3 The interaction of the cluster types by in-house R&D capability is negatively correlated to firm innovation performance.[2]

3 Research methodology

3.1 Sample, data collection, and statistic analysis

The sample firms of this research were 415 Taiwanese manufacturing firms in the information and communication technology sector. The firms were selected on the basis of the stock code compiled by the Taiwan Stock Exchange Corporation (TSEC) and the Over-The-Counter (OTC). The codes starting with 23, 24, and 30, in the TSEC and 53, 54, 61, and 80 in the OTC were selected as the sample firms in this study.

For those measurable variables, such as the number of Taiwan's patent stock and firm performance, secondary data were collected via government publications or government-maintained databases. A questionnaire survey was conducted to gather the information for other variables, such as the number of employees, industry difference, in-house R&D capability, external resources from universities and research institutions, public supports. The recipients of the survey package were CEOs or senior executives. The number of responses for the survey was 169. Excluding five invalid responses, the total responses were 165, representing a response rate of 40%. The one-way ANOVA was taken to test the three sub-samples in terms of firm size and the result shows no significant difference between them ($F = 1.230$, $p > 0.1$). This suggests that non-response bias might not be a problem.

Since our dependent variable, firm innovation performance (measured by patents), is a count variable and has a non-negative integer value, the negative binomial regression is suggested by prior studies (Keil et al. 2008; Huang and Yu 2011). To test the research hypotheses, we first established a base model for control variables and then established the second model for direct impact and the third and fourth models for interaction effects.

4 Measurements

4.1 Dependent variable—innovation performance

Firm innovation performance was measured by a firm's applications for patents to the Taiwan's government from 2003 to 2008. Patent data are generally accepted as an appropriate measure for a firm's innovative performance in a range of studies (Acs et al. 2002; Hagedoorn and Cloodt 2003). Particularly, in some high-technology industries such as electronic industries, an increasing number of firms patent their innovation (Mansfield

[2] This hypothesis can be interpreted reversely, i.e., the less the in-house R&D, the less losses in innovation due to negative spillover effect.

1984). Thus, in this study, patent stock between 2003 and 2008 was appropriately employed as a measure of innovation performance of the ICT firms. Since firms usually have already developed and used such technologies or products as they apply for patents, such un-issued but applied patents should be regarded as the outcomes of innovation. Almeida and Phene (2004) also use patent application date to measure innovation performance.

4.2 Independent variables

4.2.1 Firms in or off a spontaneous cluster or a policy-driven park

Westhead (1997) examines R&D input and output performance of technology-based firms in and off science parks. In this research, since we would like to investigate the impact of different cluster types on firm innovation, we included sample firms both in the spontaneous cluster and policy-driven park in our models. In order to meet this study's objective, we selected our sample firms from one spontaneous cluster and two policy-driven parks. The policy-driven parks were further divided into two types: (1) industry parks organized by the local government at the county level and (2) science parks organized by the central government at the national level. Although both industry parks and science parks are organized and supervised by the government, the mechanisms and governance are different because of the objectives and commitment. Science parks with specific objectives and tasks for the development of the national strategic industry (e.g., the semiconductor sector in Taiwan) receive better benefits (e.g., tax holidays) or supports (e.g., universities and research institutions nearby), whereas industry parks with the objective of developing local economies receive less benefits or supports from the government, particularly at the national level. As a result, a firm's performance may be affected differently due to differences in mechanisms and governance. Thus, there is a need to distinguish the effect of two different policy-driven parks on firm performance.

This study selected the Hsinchu Science Park (HSP), a noted successful example of industry clusters, as the focused policy-driven park. Although the HSP has selection criteria for admitting firms to locate in the park, the requirements are basically the same for all firms regardless of firm size. This implies that the HSP does not intend to select larger or better-performed firms. Thus, the concern of selection bias, which good-quality firms are more likely to be located in the science-based park, can be eased. A dummy variable was employed to distinguish whether firms located in the HSP, with 1 indicating YES and 0 indicating NO (Ferguson and Olofsson 2004; Squicciarini 2007). In total 28 firms were located in the HSP.

As for the industry park, we selected Tao-Yuan Industrial Park (TYIP) as our sample park. The TYIP was established in 1969 and has been under the supervision of the Tao-Yuan county government and is mainly composed of firms manufacturing printed circuit boards. In this research, we used the postcode and the address to identify whether a firm was located in or off the TYIP. A dummy variable was employed to distinguish whether a firm was located in the TYIP, with 1 indicating YES and 0 indicating NO. In total 27 firms were located inside the HSP.

As for the spontaneous cluster, we selected firms locating in the Taipei County, which is a well developed industrial region in Northern Taiwan. In early days, firms located in this region in order to receive better institutional and financial supports from regulatory and supporting organizations (such as tax bureaus, state banks, commercial administration agencies), due to its closeness to Taipei City. As the time goes by, it has become a spontaneous cluster and the firms operating in this region have also transformed from manufacturers of consumer electronics to ICT manufacturers. In this research, with verification by three industrial experts, we used the postcode and the address to identify whether the firms locate in or off the Taipei County cluster. Again, a dummy variable was employed to distinguish whether a firm was located in the Taipei County cluster or not. In total 51 firms were located inside the Taipei County cluster. As a result, our sample included 28 firms in the Hsinchu Science Park, 27 firms in the Tao-Yuan Industrial Park, 51 firms in the Taipei County cluster, and remaining 59 firms were not located in clusters or parks.

4.2.2 Firm size

Prior studies suggest that firm size has a positive impact on a firm's innovation performance (Scherer 1965; Freeman 1987). Following prior studies (Bates and Nucci 1989; Mitton 2002), firm size was measured by the logarithm of total number of employees in 2002.

4.2.3 In-house R&D capability

In-house R&D capability can be regarded as a firm's ability to respond to technological opportunities. Firms responding to technological opportunities are believed to attain competitive advantage (Tushman and Anderson 1988; Miyazaki 1995). We used three five-point Likert scale items developed by Zahra (1996) to measure a firm's in house R&D capability, including: (1) my firm is usually among the first to introduce new products to the market; (2) my firm leads in introducing new products in the industry; and (3) my firm is noted for introducing breakthrough-type products.

4.3 Control variable

4.3.1 Industry difference

Industry difference is related to innovation outcomes since the competitive intensity and R&D activities may vary across industries (Lichtenthaler 2007). Industry difference was measured by types of core business instead of the SIC code. Five sub-sectors of the ICT industry were identified, including semiconductors (13.4%), computers and peripherals (46.3%), optical electronics (12.8%), communications (6.1%), and others (21.4%). Four dummy variables were created (i.e., Industry-Semiconductors, Industry-Computers, Industry-Optical, and Industry-Communications) and the sub-sector "others" was the base industry.

4.3.2 Supports from universities and research institutions

The results of previous empirical research suggest that firms with collaborative research projects with universities outperform firms without such projects in terms of number of patents (Lockett et al. 2003; Zucker et al. 2002). In addition to university-industry collaborations, existing empirical studies suggest that firms conducting collaborative R&D projects with research institutions have better innovation performance (Blau 1999; Kennedy and Holmfeld 1989). Therefore, this study controlled both factors and measured it with two five-point Likert scale items: ‘joint projects with universities help improve my firm’s core technology’ and “joint projects with research institutions help improve my firm’s core technology”.

4.3.3 Public subsidies and supports

Governmental subsidies can help to improve a firm’s innovation (Lackman 2005). Lee and Park (2006) also conclude that financial support from the government in the early stage of R&D activities can improve the success of a firm’s innovativeness. Moreover, previous studies also suggest that firms with collaborative R&D projects with the government, including technology transfer, may have better innovation performance (Cohen et al. 2002). Therefore, this study controlled both factors and measured it with two five-point Likert scale items: ‘the percentage of total R&D budgets is funded by the government or public sector’ and ‘how much of the core technology has been transferred from the government or government-funded research institutions?’

5 Analysis and results

5.1 Descriptive statistics and correlations

Table 1 summarizes the descriptive statistics for the 165 firms of this study. The firm size in Table 1 is the logarithm of the number of employees. The mean for the number of employees is 1,017, while firm innovation performance measured by the 6-year accumulated patent stock in this research is 91.09. Table 1 also presents the correlation matrix among the variables. The results show that correlations among our primary explanatory variables (e.g., in-house R&D capability, firm size, and cluster; coefficient were less than 0.3) are moderate, suggesting that multicollinearity should not be a concern for estimation.

5.2 The fitness of the model

All models were estimated through Poisson regressions due to the count nature of the dependent variable. Table 2 presents the estimation results for three models. In negative binomial regression, the goodness of fit for a model is evaluated by deviance and the Akaike’s Information Criterion (AIC). The above information criteria are in smaller-is-better form (Bozdogan 1987). For instance, the AICs are 1,635.467, 1,613.422, and 1,595.241 in Model 1, Model 2, and Model 3, respectively. It shows that the goodness of model fit increases as the variables are added into the models.

5.3 Regression results

As shown in Models 1, 2, 3, and 4 (Table 2), in-house R&D capability is positively associated with firm innovation performance ($B = 0.528$, $p < 0.01$; $B = 0.609$, $p < 0.01$; $B = 1.026$, $p < 0.01$; $B = 0.571$, $p < 0.01$), consistent with prior studies (Sakakibara and Dodgson 2003; Caloghirou et al. 2004), suggesting that a higher level of in-house R&D capability improves a firm’s innovation performance. Similarly, in Models 1, 2, 3, and 4, firm size is positively associated with firm innovation performance ($B = 0.748$, $p < 0.01$;

Table 1 Descriptive statistics and correlations

Pearson correlation	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Innovation performance	91.09	306.49	1.00									
(2) Industry-semiconductors	0.13	0.34	0.06	1.00								
(3) Industry-computers	0.46	0.50	−0.00	−0.37**	1.00							
(4) Industry-optical	0.13	0.34	0.10	−0.15	−0.36**	1.00						
(5) Industry-communications	0.06	0.24	−0.07	−0.10	−0.24**	−0.10	1.00					
(6) University and research institution	2.38	1.51	0.10	0.11	−0.23**	0.10	−0.05	1.00				
(7) Public subsidies and supports	1.91	0.55	0.02	−0.04	−0.13	−0.01	−0.02	0.23**	1.00			
(8) In-house R&D capability	2.77	0.99	0.10	−0.28**	0.31**	−0.19*	−0.00	−0.05	−0.00	1.00		
(9) Firm size[a]	14.82	1.26	0.36**	−0.03	0.03	0.10	−0.10	0.17*	0.12	0.11	1.00	
(10) Science park	0.17	0.38	0.16*	0.49**	−0.39**	0.07	0.09	0.12	0.21**	−0.24**	0.02	1.00
(11) Industry park	0.16	0.37	−0.09	−0.18*	0.28**	−0.17*	0.09	−0.13	−0.06	0.22**	−0.04	−0.20*
(12) Spontaneous cluster	0.31	0.46	−0.13	−0.03	−0.02	−0.02	−0.01	−0.04	0.08	0.02	−0.07	−0.30**

N = 164; ** $p < 0.01$; * $p < 0.05$

[a] The figure in the table is the logarithm figure. The mean of firm size measured by the number of employees is 1,017 and the SD is 1,687

Table 2 Negative binomial regression results (beta coefficients)

Exogenous variables	Model 1	Model 2	Model 3	Model 4
Control variable				
Firm size	0.748*** (18.573)[a]	0.568*** (14.738)	0.581*** (19.406)	1.045*** (8.730)
In-house R&D capability	0.528*** (8.616)	0.609*** (12.828)	1.026*** (17.899)	0.571*** (12.929)
Industry 1-semiconductors	1.115** (6.720)	0.525 (1.155)	0.449 (0.703)	0.409 (0.691)
Industry 2-computers	−0.257 (0.382)	−0.116 (0.113)	−0.372 (1.088)	−0.169 (0.221)
Industry 3-optical	0.509 (1.299)	0.567 (1.733)	0.336 (0.757)	0.526 (1.420)
Industry 4-communications	−1.923*** (7.952)	−2.271*** (16.186)	−2.271*** (16.422)	−2.349*** (17.749)
Universities and research institutions	0.003 (0.001)	0.044 (0.221)	−0.005 (0.003)	0.045 (0.250)
Public subsidies and supports	0.378 (2.409)	0.155 (0.425)	0.000 (0.000)	0.168 (0.511)
Predictor variables				
Science park (Hsin Chu)		0.849* (2.738)	3.301*** (8.729)	0.947* (3.176)
Industry park (Tao Yuan)		−0.621 (1.062)	0.386 (0.103)	−0.691 (1.707)
Spontaneous cluster (Taipei)		−0.469 (2.098)	2.183*** (7.261)	−0.466 (2.133)
Interaction				
Science park × in-house R&D capability			−1.024** (4.716)	
Industry park × in-house R&D capability			−0.352 (0.588)	
Spontaneous cluster × in-house R&D capability			−0.964*** (11.412)	
Science park × firm size				−0.480 (1.496)
Industry park × firm size				−1.245*** (10.649)
Spontaneous cluster × firm size				−0.923** (4.542)
Goodness of fit[b]				
Deviance	538.628	510.583	486.402	493.252
Akaike's Information Criterion (AIC)	1,635.467	1,613.422	1,595.241	1,602.092

Wald Chi-Square significance: *** $p < 0.01$;** $p < 0.05$; * $p < 0.1$

Dependent variable: Taiwan patent stocks between 2003 and 2008

[a] Wald Chi-Square

[b] Information criteria are in small-is-better form

$B = 0.568$, $p < 0.01$; $B = 0.581$, $p < 0.01$; $B = 1.045$, $p < 0.01$). The findings are also consistent with prior studies (Scherer 1965; Freeman 1987).

Model 2 indicates that locating in the science park is significantly positive associated with firm innovation performance ($B = 0.849$, $p < 0.1$). However, locating in the industry park and spontaneous cluster is not significantly associated with firm innovation performance. The above results partially support our Hypothesis 1 that firms locating in policy-driven parks, such as science parks, have better innovation performance than those locating in spontaneous clusters. More importantly, our study further provides the evidence that firm innovation is better achieved in science parks organized by the central government than in industry parks organized by the local government.

We used Model 3 to examine the interaction effects of the cluster by in-house R&D capability. As shown in Table 2, the interaction effect of in-house R&D capability by the cluster types (i.e., a science park and spontaneous cluster) is negatively significant ($B = -1.024$, $p < 0.05$ and $B = -0.964$, $p < 0.01$ respectively), which supports our Hypothesis 3. This could be interpreted as that a firm with lower in-house R&D capability benefits more if located in clusters, both policy-driven parks and spontaneous clusters. Moreover, as shown in Model 4, the interaction effect of firm size by the cluster types is negatively significant ($B = -1.245$, $p < 0.01$ and $B = -0.923$, $p < 0.05$ respectively), which also supports our Hypothesis 2. This suggests that smaller firms located in both policy-driven parks and spontaneous clusters benefit more in innovation than larger ones.

6 Discussion

The result shows that the interaction effect of the cluster types by in-house R&D capability on innovation is negative. This suggests that firms with less in-house R&D capability can gain more benefits in innovation than those with more in-house R&D capability by locating in a science park or a spontaneous cluster. This finding not only supports previous studies that firms seeking potential complementary resources may benefit from locating in a cluster (Porter 1998a, b) but also further advances our understanding that firms with limited in-house R&D capability can benefit more or incur less loss on innovative performance if they locate in a policy-driven park or a spontaneous cluster. Compared to resource-rich firms, firms with inferior in-house R&D can better improve their innovativeness by locating in a cluster (i.e., positive spillover effect). Meanwhile, firms with limited in-house R&D experience less leakage or loss of technological resources to other firms in a cluster (i.e., negative spillover effect).

Our results also show that the interaction effect of the cluster by firm size on innovation is negative. This implies that smaller firms can better improve their innovation by locating in both policy-driven parks (industry parks) and spontaneous clusters than can larger firms. Although a cluster can provide an environment for knowledge sharing and spillovers, the co-location of firms in the same geographic area may have the risk of knowledge diffusion (Audretsch and Feldman 1996), which in turn prevents firms from locating in the cluster or park. Even though larger firms decide to locate in clusters, they are less likely to acquire knowledge or technologies from their smaller counterparts in the same clusters. As a result, larger firms enjoy less benefit from firm innovation in science parks, while smaller firms gain more firm innovation by locating in spontaneous clusters and industry parks.

If larger firms are less likely to be benefited in innovation when locating in policy-driven parks, why do these firms still prefer to locate in policy-driven parks? To answer this question, we further investigated whether larger and smaller firms in the HSP have different performance other than innovation. We used a firm's 6-year average market share between 2003 and 2008 as a measure of market performance and re-ran the regression models (see Table 3). As shown in Model 8, the result shows that larger firms enjoy a higher level of market performance than that of smaller firms in the HSP ($B = 0.688$, $p < 0.01$). This suggests that although smaller firms in the HSP have better innovation performance, larger firms in the HSP still can gain some other benefits such as increased market share. Therefore, firms may have different purposes to locate in science parks. In our study, it seems smaller firms seek better innovation via accessing spillover effects in science parks while lager firms seek better market performance via networks in science parks.

The findings in this research suggest that in-house R&D capability and firm size are two important moderating determinants of firm innovation in clusters. Firms with higher in-house R&D capability and larger size have better innovation performance in Taiwan's ICT industry. However, if the on-or-off cluster is taken into account, the results show different stories. Firms with inferior in-house R&D capability as well as smaller size can better improve their innovation performance when they locate in a cluster. This result confirms prior arguments that smaller firms and resource-short firms can benefit more from the cluster effect due to benefits from external partnerships which accelerate innovation activity (Hewitt-Dundas 2006), reduce or share the risk of innovation (Das and Teng 1998), and provide access to complementary assets and resources (Ireland and Hitt 1999; Gulati et al. 2000). Particularly, our study extends the existing cluster study by examining policy-driven parks and spontaneous clusters separately. Our findings suggest that locating in science parks helps improve firm innovation performance. Moreover, firms with inferior in-house R&D capability do benefit more when locating in science parks and spontaneous clusters whereas smaller firms benefit more if located in industry parks and spontaneous clusters.

7 Conclusion

Our results suggest that by differentiating the positive and negative impacts in a cluster or a park, locating in a cluster or a park is conductive to firm innovation but with the following two negative consequences: (1) the positive relationship between in-house R&D capability efforts and firm innovation is negatively moderated by the cluster effect; and (2) the positive relationship between firm size and firm innovation is negatively moderated by the cluster effect. A firm's in-house R&D capability is positively associated with innovation performance but firms with inferior in-house R&D capability can better improve their innovation as the firms locate in a policy-driven park (e.g., a science-based park) or a spontaneous cluster. Our finding supports the resource dependence theory that seeking the complementary resource is one major motivation for geographically clustering (Shaver and Flyer 2000; Kalnins and Chung 2004), which implies that locating in clusters can bring firms complementary resources to enhance innovation. This provokes an important issue that locating in clusters or parks can benefit more for resource-short firms than resource-rich firms.

Another important result of our research is that firm size is positively associated with firm innovation performance but smaller firms can better improve their innovation performance when locating in a policy-driven park (e.g., an industry park) or a spontaneous cluster. This result suggests that although larger firms are more innovative in general since they possess a higher capacity of inter-organizational coordination and integration

Table 3 Regression results (beta coefficients)

Exogenous variables	Model 5	Model 6	Model 7	Model 8
Control variable				
Firm size	0.567*** (7.294)[a]	0.547*** (7.722)	0.543*** (7.762)	0.349*** (2.870)
In-house R&D capability	0.039 (0.503)	0.077 (0.999)	0.196 (1.648)	0.092 (1.346)
Industry 1-Semiconductors	0.206 (0.799)	−0.191 (−0.654)	−0.222 (−0.731)	−0.166 (−0.631)
Industry 2-Computers	0.083 (0.403)	0.128 (0.678)	0.143 (0.750)	0.164 (0.954)
Industry 3-Optical	0.340 (1.335)	0.220 (0.872)	0.241 (0.943)	0.217 (0.957)
Industry 4-Communications	0.107 (0.311)	−0.114 (−0.321)	−0.114 (−0.319)	−0.013 (−0.040)
Universities and research institutions	0.012 (0.243)	0.025 (0.508)	0.023 (0.453)	0.018 (0.395)
Public subsidies and supports	−0.045 (−0.337)	−0.158 (−1.141)	−0.164 (−1.163)	−0.038 (−0.302)
Predictor variables				
Science park (Hsin Chu)		0.700** (2.511)	0.799 (1.156)	0.515** (2.031)
Spontaneous cluster (Tao Yuan)		−0.194 (−0.885)	0.773 (1.120)	−0.258 (−1.308)
Industry park (Taipei)		0.077 (0.446)	0.600 (1.171)	0.014 (0.088)
Interaction				
Science park × in-house R&D capability			0.013 (0.043)	
Industry park × in-house R&D capability			0.313 (1.502)	
Spontaneous cluster × in-house R&D capability			−0.183 (−1.075)	
Science park × firm size				0.688*** (4.199)
Industry park × firm size				−0.290 (−1.511)
Spontaneous cluster × firm size				0.109 (0.655)
F-value	9.613***	8.056***	6.526***	10.248***
Adjusted R square	0.343	0.370	0.370	0.495
Δ Adjusted R square		0.027** (Against Model 5)	0.000 (Against Model 6)	0.125*** (Against Model 6)

Dependent variable: 6-year averaged sales between 2003 and 2008

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

[a] t-value

capability, smaller firms can better improve innovation by locating in a cluster or a park. This is because by agglomerating in a cluster or a park, smaller firms can improve their credits on raising capital to conduct innovative activities, attracting excellent workers with specialized skills, and acquiring needed technologies from external parties in the cluster. Our finding also shows that while smaller firms can benefit more from innovation from the cluster effect, larger firms still enjoy positive market performance from locating in a park. Although our empirical results suggest larger firms can not better enhance their innovation performance from the cluster effect, they may be the anchor effect for the technological development of the infant industry in emerging economies.

Business practitioners can learn lessons from our findings, especially for firms with a lower level of in-house R&D capability or smaller size, if they intend to improve their firms' innovation by locating in clusters or parks. For larger firms, our findings still illustrate the gains in market shares if they locate in clusters or parks. Policy makers in developing countries can learn from this study to understand that different types of clusters can help firms with inferior in-house R&D capability or smaller firms to innovate differently. In contrast, larger firms or firms with superior in-house R&D may not be motivated to locate in clusters which house a lot of smaller firms. As a result, a geographic platform for spillover effects can hardly be achieved if larger firms or superior R&D firms are absent in science parks. Thus, policy makers shall refine policies to provide other incentives or protection mechanisms for larger firms or firms with superior-R&D-capability to encourage them to locate in clusters.

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