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R&D Collaborations in a Cluster: An Empirical Study for the Taiwan's Hsinchu Science Park

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摘要

以群聚經濟理論為基礎，本研究試圖探討不同的研發合作類型如何影響聚落內廠商的績效。以新竹科學園區為研究範疇，透過問卷調查台灣 165 家資訊通訊科技廠商，本研究發現，位於科學園區內的廠商，其績效比位於科學園區外的廠商高。其次，園區內廠商與研究機構的研發合作對廠商績效有正向影響；園區外廠商與大學的研發合作或接受政府部門的技術移轉對廠商績效有正向影響。本研究結果對於業界與政策制定者在科學園區相關議題上有啟發與貢獻。

【關鍵字】聚落經濟、科學園區、研發合作

Abstract

This paper, based on the agglomeration economic theory, attempts to examine what types of R&D collaborations can contribute to firm performance in a cluster. Results from the industrial data together with a questionnaire survey of 165 Taiwan's ICT firms indicate that firms inside the cluster (a science park) outperformed firms outside the cluster in terms of seven-year averaged gross profit rates. Moreover, R&D collaborations with research institutions enhances a firm's profits as firms locate inside the cluster whereas R&D collaborations with universities and receiving licensed technologies from the government improves a firm's profits as firms locate outside the science park. This paper also provides implications for both practitioners and policy makers regarding science parks.

【Keywords】agglomeration economics, R&D collaboration, science parks

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1. Introduction

Agglomeration phenomenon and cluster effect studies have been widely conducted by various scholars for decades (Appold, 1995; Chung & Kalnins, 2001; Engelstoft, Jensen-Butler, Smith, & Winther, 2006; Ganesan, Malter, & Rindfleisch, 2005; Keeble & Wilkinson, 1999; Krugman, 1991; Lai, Chiu, & Leu, 2005; Marshall, 1920; Panne, 2004; Shaver & Flyer, 2000). The enduring competitive advantage in a global economy lies increasingly in local knowledge and relationships that distant competitors can not match. Theoretically, with an increase of more open global markets and faster transportation and communication, the role of location in competition will diminish. Anything, such as capital, goods, information, and technologies, can be efficiently sourced from a distance through global markets and corporate networks and therefore it is essentially nullified as a source of competitive advantage (Porter, 1998). However, if location matters less, why is it true that the odds of finding the world-class semiconductor companies in Silicon Valley are much higher than in other places? Why do firms seek for the opportunity of locating in science parks, a type of clusters, in Taiwan?

In the field of geographic economics, Marshall (1920) identifies a number of agglomeration effect, such as specialized skills, well-developed downstream and upstream networks with specialized firms, non-trade complementary input transactions, and knowledge spillover effect. Firms connected by the geographically proximate group are expected to take advantages of economies of scale or scope, which in turn enhance their market position and then increase the profitability compared to those firms without such interconnections (Porter, 1990, 1998). While agglomeration emphasizes more of the economic scope and spillover effect of a specific industry in a geographic region, cluster, though geographic-related, mainly focuses on inter-connections among firms in multiple industries. Porter (1990) and Anderson (1994) suggest that industrial cluster can be classified into resources sharing cluster, co-option cluster, and supplier-buyer cluster. A science park, which has a specific boundary of the region, has both the characteristics of geographic agglomeration and industrial cluster. Therefore, in this study, a science park is regarded as a cluster with interconnections among industries in a specific geographic region.

Rothaermel (2001) suggests that a firm can be benefited from innovation through exploitation of existing complementary assets and external resources via alliances. Particularly, when lacking sufficient internal resources, firms can improve innovation capability via external R&D collaborations or alliances (Lin, 2003). Thus, a cluster or a science park becomes a possible vehicle to access the needed external resources or

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knowledge. Prior studies regarding the knowledge spillover effect in clusters mainly focus on knowledge transfer or diffusion among firms in a cluster or on how clusters help firms to accumulate their capabilities for new product development (Audretsch, 1998; Audretsch & Feldman, 1996; Best, 1999; Enright, 1998; Foss, 1999; Ganesan et al., 2005; Keeble & Wilkinson, 1999; Teece, Pisano, & Shuen, 1997; Westhead, 1997). However, how do firms utilize the spillover effect in a cluster? What do firms benefit by conducting different types of R&D collaborations in a cluster? Moreover, though the query of what clusters provide firms has been investigated in prior studies (Ganesan et al., 2005; Quintana-Garcia & Benavides-Velasco, 2005; Lai et al., 2005; Engelstoft et al., 2006), a limited number of them explores how firm performance differs on and off a cluster (Westhead, 1997). In order to fulfill this research gap, one objective of this paper is to compare performance between firms on and off the cluster.

To answer the our research questions, an industrial panel data together with a questionnaire survey of 165 Taiwan's information and communication technology (ICT) firms were collected. Then analysis of variance (ANOVA) and the regression models were conducted to examine the developed hypotheses for this study. The empirical results partially supported the hypotheses of this research, suggesting that firms inside a science park may attain superior financial performance than firms outside a science park as well as types of R&D collaborations have different impacts on firms inside or outside a cluster. The results contribute to our knowledge on the geographic economics in the context of science parks.

2. Theoretical Background and Hypothesis Development

2.1 Cluster Effect, Geographic Economics, and Competitive Advantage

Researchers in economic geography, resource-based view and industrial organization economics have addressed the impact of agglomeration. In economic geography, Marshall (1920) first attempts to point out a number of sources of agglomeration effect, such as an abundant market for specialized skills, well-developed downstream and upstream connections with specialized firms, non-trade complementary input transactions, and knowledge spillover effect. Following his study, researchers have been investigating different issues related to agglomeration. For example, some researchers examine how social, cultural, or environmental dimensions influence geographic clusters (Engelstoft et al., 2006; Keeble & Wilkinson, 1999; Krugman, 1991; Martin & Sunley, 1996). Scholars with the resource-based perspective also highlight how agglomeration phenomenon stimulates a

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firm's technology competence and innovation (Audretsch, 1998; Audretsch & Feldman, 1996; Best, 1999; Enright, 1998; Foss, 1999; Ganesan et al., 2005; Teece et al., 1997). Finally, industrial organization economics scholars suggest that cluster effect may provide potential competitive advantage of innovation and productivity growth via industry-specific knowledge, well-designed downstream and upstream networks, and opportunities to explore and exploit new technologies (Porter, 1990, 1998). Porter (1998) asserts that a cluster may increase productivity vis-a-vis outsourcing or vertical integration, which in turn increases access to specific inputs or information, facilitates complementarities among cluster participants, and improves incentives and performance. Furthermore, Porter's (1990) diamond model re-emphasizes the cluster effect on competitiveness at a national level.

Although a larger number of cluster-related studies have been conducted, apart from econometric studies of spillover effects (Audretsch, 1998; Audretsch & Feldman, 1996), an increasing number of empirical studies attempts to evaluate how clusters affect performance (Ganesan et al., 2005; Engelstoft et al., 2006; Lai et al., 2005; Quintana-Garcia & Benavides-Velasco, 2005). However, a limited number of empirical studies have explored how a firm's competitive advantage differs on and off a cluster (Westhead, 1997). Thus, this paper attempts to fulfill this research gap by comparing competitive advantage between firms located inside and outside a cluster.

2.2 Cluster, Science Park, and Firm Performance

A science park has been regarded as a sort of clusters in a number of prior empirical studies (Hsu, 1997; Hu, Lin, & Chang, 2005; Lai et al., 2005; Rosiello, 2007; Westhead, 1997). Science parks have three fundamental characteristics, including fostering the formation and growth of innovative firms, providing an environment which enables large companies to develop relationships with small, innovative firms, and promoting formal and operational links with universities, higher education institutes and research institutions (Siegel, Westhead, & Wright, 2003). Storey and Tether (1998) identify science parks as one of five policy tools adopted by local governments to stimulate the development of high technology industry. A well-developed science park enables firms not only to take advantage of legitimate benefits such as tax holidays, but also to benefit all kinds of complementary resources at lower costs.

A number of empirical studies suggest that firms located inside science parks can benefit from cluster effect. Deriving from the geographic economics perspective, firms inside a cluster can benefit from the spillover effect (Audretsch, 1998; Audretsch &

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Feldman, 1996; Marshall, 1920; Westhead, 1997) or learning effect (Hsu, 1997; Keeble & Wilkinson, 1999) more than firms outside the cluster. These studies assert that knowledge transfer or diffusion among firms in a cluster helps firms to learn and accumulate their capabilities for new product development (Audretsch & Feldman, 1996; Best, 1999; Enright, 1998; Foss, 1999). Rowen (1998) also asserts that a science park provides an opportunity for technology diffusion among firms and attracts abundant highly qualified and experienced engineers and researchers. Hsu (1997) asserts that due to the close relationships among firms inside a science park, such firms can access all kinds of components and materials at lower costs, which in turn enhances their competitive advantage over firms outside the science park.

Viewing from the industrial organization economics, Porter (1998) asserts that clusters increase productivity vis-a-vis close outsourcing or vertical integration, which in turn reduces costs and improves profits. Porter (1998) posits that a cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. As firms are connected in a geographically proximate group, they are expected to take advantages of economies of scale or scope, which in turn increase their market position compared to those firms without such interconnections. Thus, we hypothesize that firms inside a cluster will have better performance than firms outside the cluster.

Hypothesis 1: Firms inside a cluster tend to have better performance than those outside the cluster.

2.3 R&D Collaborations

In emphasizing the importance of complementary assets and strategic alliances, Rothaermel (2001) suggests that a firm can be benefited from innovation through exploitation of existing complementary assets and external resources via alliances. The importance of technology innovation as a source of competitive advantage of a firm has been discussed by many researchers (Barney, 1991; Dedrick & Kraemer, 1998; Hamel & Prahalad, 1994; Kogut & Zander, 1992). Firms with abundant research resources are possible to accumulate their innovation capability internally whereas firms lacking sufficient internal resources can improve innovation capability via external R&D collaborations or alliances (Lin, 2003).

There are several types of R&D collaborations identified in prior research. A number of studies have focused on the collaborative projects between universities and firms (Liu &

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Jiang, 2001; Shane, 2002; Steffensen, Rogers, & Speakman, 2000; Pérez & Sanchez, 2003). In addition to the university-industry collaboration, external R&D collaborations can be also conducted via collaboration with public-supported research institutions (Kassicieh, Kirchhoff, Walsh, & McWhorter, 2002; Sakakibara & Dodgson, 2003). The difference between collaborations with universities and research institutions, all public-funded, in Taiwan is that the later focuses more on applied technologies or product development while the former emphasizes basic research more (Dedrick & Kraemer, 1998).

Moreover, R&D collaborations can be formed with competitors or other firms (Yeheskel, Shenkar, Fiegenbaum, Cohen, & Geffen, 2001). An inter-firm R&D collaboration is formed because none of the firms has sufficient resources necessary to achieve the target specification within a limited schedule. It is made possible if heterogeneous and complimentary resources possessed by different firms are combined in supplemental manners (Mothe & Quelin, 2001). In addition to the various type of R&D collaboration, firms can acquire needed resources from public sectors. For example, firms can obtain technology licensing (Parker & Zilberman, 1993) or receive financial subsidies (Klette, Moen, & Griliches, 2000; Lee & Park, 2006) from governments or government-funded agencies. Technology licensing and financial subsidies from governments are suggested to strengthen a firm's innovativeness (Lee & Park, 2006), which in turn enhance competitive advantage.

2.4 R&D Collaborations on Clusters

R&D collaborations are important sources of innovation, which affects a firm's competitive advantage. However, the query of how these R&D collaborations influence a firm's performance, particularly in a cluster, has not been fully investigated. One important cluster effect suggested by earlier researchers is the knowledge spillover effect (Marshall, 1920). Jaffe, Trajtenberg, and Henderson (1993) also compare the geographical location of patent citations to investigate the extent to which knowledge spillovers are geographically localized. They find that patent citations often come from the same region, suggesting that knowledge spillovers are localized. Malmberg, Solvell, and Zander (1996) further identify three factors influencing localized knowledge spillovers: the nature of the innovation process, the extent of knowledge diffusion, and the attraction of outside resources.

The innovation process is fundamentally incremental and trial-and-error problem-solving, which enhances the need for continuous interaction, both formal and informal, with other organizations such as related companies, customers, universities, and public research

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institutes. Thus, face-to-face contacts smooth continuous interactions and then accelerate the accumulation and exchange of knowledge. If knowledge can diffuse rapidly and at a low cost, agglomeration becomes less necessary. However, knowledge embedded in human capital or social capital is much less diffusible and bounded to local circumstances. This tacit knowledge is embedded in the local milieu and generates competitive advantage for firms in a region. Finally, Acs, Fitzroy, and Smith (1999) suggest that spillover effects mainly rely on a pool of trained employees as well as scientific graduates. As the local milieu evolves, it will then attract more new people, firms, and supporting institutions (Fujita, 2007), making firms in the cluster more competitive.

As for the field of technology and innovation management, previous cluster-related studies mainly focus on knowledge transfer or diffusion among firms in a cluster or how clusters help firms to accumulate their capabilities of new product development (Audretsch & Feldman, 1996; Keeble & Wilkinson, 1999; Westhead, 1997). Nevertheless, the question of what types of R&D collaborations can help firms to benefit from spillover effect most in a cluster remains unclear. Thus, this study attempts to fill this research gap by differentiating the effect of types of R&D collaborations on firm performance in a cluster.

Five types of R&D collaborations are discussed in this research, including collaborative R&D projects with universities, with research institutions, with other firms, by receiving licensed technologies from governments or receiving financial subsidies from governments. When firms conduct R&D collaboration with universities and research institutions, the spillover effect helps firms inside a cluster to attract outstanding scientists and engineers which are conductive to the execution of R&D collaborations. As a result, firms inside a cluster can exert the spillover effect associated with a cluster positively on firm performance as they simultaneously conduct R&D collaborations with universities or research institutions. Thus, we can derive the Hypothesis 2 and 3:

Hypothesis 2: Compared to firms outside a cluster, firms in the cluster conducting R&D collaborations with universities tend to have better performance.

Hypothesis 3: Compared to firms outside a cluster, firms in the cluster conducting R&D collaborations with research institutions tend to have better performance.

In addition to collaborations with universities and research institutions, inter-firm R&D collaborations with suppliers, customers, and competitors can also provide an important external source of acquiring technology and knowledge. Particularly, supplier and customer relationships play a vital role in knowledge transfer (Hakansson, 1987; Takeishi, 2001). Moreover, relationships with industry members, including competitors, are helpful in the

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exchange of knowledge related to effective methods for improving innovation (Luo, 2007). Thus, R&D collaborations with suppliers, customers, and competitors are important sources of external knowledge transfer. From the perspective of agglomeration economics, prior studies suggest that firms inside a cluster seek for complementary resources from the upstream suppliers or downstream customers (Marshall, 1920; Porter, 1998). However, the network theorists suggest that a competitive-oriented network is more appropriate for innovation diffusion than the upstream-downstream network (Burt, 1987; Galaskiewicz & Burt, 1991; Harkola & Greve, 1995).

The results of previous studies suggest that firms with inter-firm R&D collaborations can have better financial performance (Branzei, 2005; Hemmert, 2003; Walker, 1995; Yeheskel et al., 2001) and market performance (Branzei, 2005). Nevertheless, evidences also suggest that cooperations with direct competitors are more difficult to manage (Hamel, Doz, & Prahalad, 1989) and more likely to spark learning races (Hamel, 1991). As a result, inter-firm collaborations with competitors raise the greatest suspicions for the potential of opportunism (Hagedoorn, 1993; Hagedoorn, Link, & Vonortas, 2000; Powell, Kogut, & Smith-Doerr, 1996). Particularly, firms locating inside a cluster, the science park in this study, are more technologically advanced due to the screen process of the science park administration, and then they become more conservative and will take measures to guard their technologies and innovative resources against competitors. The safeguard for opportunism hinders the potential benefits of inter-firm collaborations with competitors, which may lead to lower profits. In contrast, firms outside the science park are relatively technological followers and in short of innovative resources, which incur less safeguard behaviors. These firms are more willing to collaborate with technology-leading competitors so that they can learn from their partners. This learning enables them to develop new products or improve production process and results in higher profits. Therefore, we argue that collaborations with competitors befit more for tend to generate more benefits for firms outside a cluster than inside a cluster. We then hypothesize:

Hypothesis 4: Compared to firms inside a cluster, firms outside the cluster conducting R&D collaborations with competitors tend to have better performance.

A number of empirical studies suggest that governments should play an important role in supporting basic research as well as applied research (Cutler, 1990; Merchant, 1997; Moon & Bretschneider, 1997; Tung, 2001). Moreover, government subsidies have been increasingly seen as enabling firms to produce and regain international competitiveness (Ahmad, 1992; Glick & Moreno, 1997; Wint, 1998). Although government subsidies can

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enhance a firm's performance (Grupp, 1997; Lackman, 2005; Lerner, 1999), the benefits of government subsidies are available for firms either located inside or outside a cluster. As long as firms meet the criteria for the application of subsidies, they all can obtain subsidies from governments. In addition to the subsidies received from governments, the firms locating inside a science park may receive additional subsidies granted by the park's administration. However, the total subsidies received by these firms in a science park relative to their firm size are still very small in Taiwan. This is because generally the size of the firms locating inside the science park is larger than that of the firms locating outside the science park due to the park's screening process. Because the financial subsidies are relative small to firms either locating inside or outside the park, we feel that governmental subsides on firm performance is the same for them. Thus, we argue in this study that no significant difference between firms inside a cluster and firms outside the cluster for the effect or governmental subsides on firm performance.

Hypothesis 5: There is no difference between the impact of financial subsidies from the government on performance for firms outside or inside a cluster.

The acquisition of licensed technologies can help firms to accelerate the innovation process and then more quickly achieve competitive advantage. Previous studies suggest that firms with collaborative R&D projects with the government, including technology transfer, may have better financial performance (Mowery, 1998). However, due to the spillover effect of cluster, firms inside a cluster can easily access information regarding the development of advanced technologies. As a result, acquisition of licensed technologies from governments brings no differentiation to firms locating in a cluster. In contrast, due to relatively information asymmetry regarding the development of the up-to-date technologies, firms locating outside a cluster can benefit more from licensed technologies from governments if their counterparts are unaware of their acquisition of new technologies. Thus, we can derive the following hypothesis:

Hypothesis 6: Receiving licensed technologies from the government exerts no significant impact on performance for firms inside a cluster. Firms outside a cluster receiving licensed technologies from the government tend to have better performance than those without.

3. Research Method

Since this study attempted to provide an empirical examination for the cluster effect, a range of industrial data was collected as well as a questionnaire survey of 165 Taiwan's

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information and communication technology (ICT) firms was conducted. Regression analyses were employed for hypotheses testing.

3.1 Sample and Data

The firms sampled in this study had to satisfy the following criteria: (a) information and communication technology (ICT) firms; (b) manufacturing firms; (c) firms listed on the Taiwan Stock Exchange Corporation (TSEC), the Over-The-Counter Exchange (OTC), the Emerging Stock Board (ESB), or publicly-held corporations in Taiwan between 1996 and 2002; (d) firms with headquarters in Taiwan. Based on the above criteria, 415 firms were selected which accounted for 80% of the sales of all ICT firms in Taiwan in 2002 and 165 of them responded to the questionnaire, representing a 40% response rate. A t-test showed that the firm size between the first-half and second-half of the responses is not significantly different ($F = 2.564$, $p > 0.1$). This suggests that non-response bias is not an issue (Armstrong & Overton, 1977).

In this study, objective and subjective data were used. Objective data, such as gross profit rates, were gathered via corporate financial statements provided by the Securities & Futures Institute (SFI). Subjective data, such as the assessment for a firm's choice of collaborations by senior managers, were gathered through a mail questionnaire survey.

3.2 Measures

The measurements for a firm's performance, clusters, and the types of network relationship are discussed in this section.

3.2.1 Dependent Variable: Firm Performance

Indictors, such as gross profits are widely adopted to measure a firm's profitability in various economic and management studies (Murphy, Trailer, & Hill, 1996). Therefore, we measured firm performance by gross profit rates in this research. The data were collected through the SFI databases and corporate financial statements.

3.2.2 Independent Variable: Cluster Representing a Firm on or off the Hsinchu Science Park

Following Westhead (1997), which examines R&D input and output performance of technology-based firms on and off science parks, this study selected the Hsinchu Science Park in Taiwan as the focused cluster because of its characteristics. Among the three established science parks in Taiwan, the Hsinchu Science Park (HSP), established in 1980, was Taiwan's first science park. The HSP provides not only tax deductions for start-ups but also facilities at lower rates. Two top ranking universities near the HSP provide talented

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engineers and scientists to firms locating in the HSP. By 2002, 334 high-tech firms located in HSIP, representing 20.2 billion US dollars in revenues (SIPA, 2008). The primary reason for choosing the HSP instead of Southern Taiwan Science Park (STSP) or Central Taiwan Science Park (CTSP) as our focused cluster is that the HSP had been a well-established science park during our research period between 1996 and 2002 whereas STSP established in 1996 and CTSP established in 2003 had not been well developed during this period. Moreover, the HSP accounted for 27.3% of the Taiwan's ICT production value in 2002 as well as successfully helps developing Taiwan's ICT industry. In addition, firms in the HSP engage in more R&D activities while firms in the STSP or CTSP focus more on manufacturing activities.

This research divided sample firms into two groups, firms inside the HSP and firms outside the HSP. The classification was based on whether their headquarters and main operation activities were located in the HSP or not. Based on the above criteria, 34 firms were located inside the HSP while remaining 131 firms were located outside the HSP.

3.2.3 Independent Variables: Types of R&D Collaborations

Since this study attempted to investigate how R&D collaborations affect firm performance in a cluster, based on previous literature, we identified the following five types of collaborations: collaborations with universities, collaborations with research institutions, collaborations with competitors, receiving government subsidies and receiving licensed technologies from the government. A questionnaire was used to ask the respondents to indicate whether their firms had engaged in these five types of R&D collaborations between 1996 and 2002. A dummy variable was employed for each type of collaborations, with 1 indicating yes and 0 indicating no.

3.2.4 Control Variable: Firm Size and Internal Innovation Capability

Empirically, firm size is observed as having an impact on a firm's innovation performance (Freeman, 1982; Scherer, 1965; Symth, Boyes, & Pessau, 1975) as well as market performance (Said, HassabElnaby, & Wier, 2003; Scherer, 1965; Symth et al., 1975). Thus, firm size was added as a control variable and was measured by the logarithm of a firm's 7-year total assets between 1996 and 2002. These data were collected through the SFI database. Moreover, a firm's internal innovation capability is also observed having impact on a firm's leadership in the market (Fan, 2006), and then it should be controlled. A firm's internal innovation capability was measured by seven-year average R&D intensity (R&D expenditures as a percentage of sales) between 1996 and 2002. We standardized this indicator when we ran the regression models.

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3.3 Research Approach

An analysis of variance (ANOVA) was first employed to examine whether firms inside the science park had better firm performance than firms outside the science park. To test the rest of the research hypotheses, we used OLS regression models via two regression equations. This is because our sample size is unequal for the group of firms inside (34 firms) and outside (131 firms) the cluster. If we pool the sample as one regression equations, it may induce estimation bias for the dependent variable. Thus, in this study, we separately tested two different groups of sample firms and examined the relationships between the dependent variable and the independent variables respectively. By doing this, we could explore the different behaviors of R&D collaborations between firms inside and outside the cluster. After running the regression separately, we then compared the parameter estimates for the explanatory variables between the two groups of firms with a cross-functional t-test (Cohen, 1983).

4. Results

4.1 Descriptive Results

Table 1 summarizes the descriptive statistics and correlations for 165 firms of this study[1]. The mean of 7-year gross profit rate was 23.29%. The average firm size (in terms of the logarithm of 7-year total assets) was 14.02. The 7-year average R&D intensity was 5.33%. For the industry types, 13.41% of firms were semiconductor firms while 46.34% of firms were computer-related firms. Optical firms and communication firms accounted for 12.80% and 6.10% respectively while the rest of firms accounted for 21.34%. One fifth of firms (34 out of 165 firms) were located in Hsinchu Science Park. Furthermore, more than 60% of Taiwanese ICT firms had collaborative R&D projects with universities, research institutions, and competitors in the ICT industry. In contrast, more than 60% of firms did not receive subsidies or licensed technologies from the government during the investigated period.

Table 1 also presents the correlation matrix among the variables. Although the results show that there were some correlations between dependent variable and independent variables or control variables, we further used Variance Inflation Factor (VIF) to examine

[1] Please see the descriptive statistics and correlations for firms inside and outside the HSP in Appendices 1 and 2.

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this multicollinearity problem. Myers and Montgomery (1995), Bowerman and O'Connell (1990) suggest that if the largest VIF is greater than 10 then there is cause for concern. In the models of this research, the VIF scores for all variables were less than 2, suggesting that the model in this study has no serious multicollinearity problem among independent variables.

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Table 1 Descriptive statistics and correlations

	Mean	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Firm performance	23.29	1.00													
(2) Firm size	14.02	-0.29**	1.00												
(3) Internal innovation capability	5.33	0.20**	-0.26**	1.00											
(4) Semiconductor	0.13	0.14	0.04	0.35**	1.00										
(5) Computer	0.46	-0.03	0.11	-0.35**	-0.37**	1.00									
(6) Optical	0.13	-0.16*	-0.11	0.03	-0.15	-0.36**	1.00								
(7) Communication	0.06	-0.05	-0.02	0.12	-0.10	-0.24**	-0.10	1.00							
(8) Other	0.21	0.08	-0.14	0.05	-0.21*	-0.48**	-0.20*	-0.13	1.00						
(9) Cluster	0.21	0.16*	0.01	0. 34**	0.42**	-0.36**	0.16*	0.06	-0.08	1.00					
(10) Universities	0.72	0.10	-0.04	0.18*	0.05	-0.25**	0.16*	-0.06	0.17*	0.12	1.00				
(11) Research institutions	0.63	0.11	0.03	0.14	0.08	-0.15	0.07	-0.02	0.06	-0.01	0.60**	1.00			
(12) Competitors	0.64	-0.05	0.09	0.07	0.15	-0.14	0.02	-0.02	0.05	0.07	0.37**	0.45**	1.00		
(13) Financial subsidies	0.38	0.14	-0.12	0.21**	-0.04	-0.21**	0.16*	-0.04	0.18*	0.07	0.38**	0.26**	0.16*	1.00	
(14) Technology licensing	0.26	0.06	0.05	0.11	-0.03	-0.15	0.03	-0.09	0.24**	0.11	0.38**	0.31**	0.16*	0.48**	1.00

N=165; ** $p < 0.01$; * $p < 0.05$.

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4.2 ANOVA Results

Table 2 shows the result of ANOVA in terms of firm size and firm performance. The mean of firm size (4,147,424) for firms locating inside the cluster is greater than the mean (3,207,847) of firms outside the cluster but the difference is not significant (F=0.034, p>0.1). The mean of 7-year gross profit rate (30.23%) for firms locating inside the cluster is greater than the mean (21.49%) of firms outside the cluster and the difference is significant (F=4.281, p<0.05). This suggests that firms locating inside the cluster have better performance than those outside the cluster, which supports the Hypothesis 1.

Table 2 ANOVA results for firm performance

	Cluster	
	Means	
	Yes	No
	N=34	N=131
7-year firm size	4,147,424	3,207,847
(F Value)	0.347	
7-year gross profit	30.23	21.49
(F Value)	4.281*	

** p<0.01; * p<0.05

4.3 Regression Results

Before conducting regression models, there are some concerns regarding whether we should use a dummy variable to run one regression model with a combined dataset or we should run two regression models separately with two sub-sample sets. Chow (1960) has discussed this issue and suggests that two sample groups should be run by two separate regression models if the interceptions and slopes of both regression models are unequal. A Chow test provides such a test of whether the set of linear regression parameters (i.e., the intercepts and slopes) is equal across groups. In this research, we also used the Chow test to verify whether we should run two regression models separately or not. The results showed that only R&D collaborations with research institutions passed the Chow test (F=6.444, p<0.05) and the other four types of R&D collaborations failed to pass the test. This result suggests that the sets of linear regression parameters (i.e., the intercepts and slopes) are not equal between these two groups (i.e., inside or outside the cluster). Thus, it is more

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appropriate to run two separate regression models with two groups of sample firms[2].

4.3.1 Inside the Cluster

Table 3 presents the estimation results for firms inside the cluster from Model 1 to Model 7. Model 1 explained 11.8% of the variance (Adjusted R Square = 0.118) in firm performance. The result shows that only firms in the computer sector have a positive association with firm performance. The rest of control variables are not significant (F value=1.736, $p > 0.1$). We then entered the five types of R&D collaborations into the regression model one by one to examine the effect of individual type of R&D collaboration on performance. Model 2 explains 11.9% of the variance (Adjusted R-Square = 0.119) in firm performance but the change of adjusted R-Square between Model 1 and Model 2 and the Chi-Square of F-values are not significant (Δ Adjusted R-Square = 0.001, $p > 0.1$). This suggests that the added independent variable, R&D collaboration with universities, is not significant for explaining the regression model.

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[2] As shown in Appendix 3, the attributes of two groups of sample firms are somewhat different.

Table 3 Results of regression models inside the cluster - 7-year gross profits

Exogenous Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
(Control Variable)							
Firm Size	-0.008	-0.032	-0.014	0.066	-0.018	-0.039	0.077
Internal Innovation Capability	0.093	0.065	-0.010	0.156	0.063	0.068	0.063
Semiconductor Industry	0.060	0.102	-0.001	0.045	0.196	0.124	0.049
Computer Industry	0.524**	0.591**	0.524**	0.508**	0.609**	0.575**	0.574**
Optical Industry	-0.058	-0.032	-0.034	-0.118	-0.020	-0.013	-0.103
Communication Industry	-0.024	0.018	0.014	-0.037	0.042	0.029	0.029
(Independent Variable)							
Universities		0.181					0.178
Research Institution			0.319*				0.269
Competitors				-0.204			-0.268
Financial Subsidies					0.260		0.112
Technology Licensing						0.115	-0.072
F-Value	1.736	1.637	2.091*	1.668	1.859	1.498	1.534
Adjusted R-Square	0.118	0.119	0.188	0.124	0.154	0.096	0.151
Adjusted R-Square Change (against Model 1)		△0.001	△0.070*	△0.006	△0.036	- △0.024	△0.033

*** p < 0.01;** p < 0.05; * p < 0.1; Dependent Variable: Firm Performance (7-year Gross Profit)

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Model 3 explains 18.8% of the variance (Adjusted R-Square = 0.188) in firm performance. We further examined the change of adjusted R-Square between Model 1 and Model 3 and the result shows that the change of Chi-Square of F-value is significant (Δ Adjusted R-Square = 0.070, $p < 0.1$). As shown in Model 3, R&D collaborations with research institutions have a positive effect on firm performance ($b = 0.319$, $p < 0.1$), suggesting that firms inside the cluster can further increase profits by conducting R&D collaborations with research institutions. Models 4, 5, and 6 explain 12.4%, 15.4%, and 9.6% of the variance in firm performance respectively (Adjusted R-Square = 0.124, 0.154, and 0.096). However, none of the change of adjusted R-Square for these three models is significantly improved. This suggests that inside the cluster, collaborations with competitors, governmental subsidies, and technology licensing do not increase a firm's profits. Our results suggest that as firms locate inside the cluster, only conducting collaborative projects with research institutions can further enhance firm performance.

4.3.2 Outside the Cluster

Table 4 presents the estimation results for firms outside the cluster from Model 8 to Model 14. Model 8 explains 38.9% of the variance (Adjusted R-Square = 0.389) in firm performance. The result shows that, except for the semiconductor sector, all other control variables are significant correlated to firm performance. Firm size is negatively correlated to firm performance ($b = -0.336$, $p < 0.01$) whereas internal innovation capability is positively correlated to firm performance ($b = 0.232$, $p < 0.01$). As shown in Table 4, the rest of models also have the same results of the relationship between firm performance and firm size or internal innovation capability.

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Table 4 Results of regression models outside the cluster - 7-year gross profits

Exogenous Variable	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
(Control Variable)							
Firm Size	-0.336***	-0.365***	-0.370***	-0.369***	-0.364***	-0.373***	-0.365***
Internal Innovation Capability	0.232***	0.206**	0.229***	0.235***	0.210**	0.219***	0.205**
Semiconductor Industry	0.068	0.090	0.070	0.065	0.080	0.103	0.115
Computer Industry	-0.195**	-0.171*	-0.188**	-0.190**	-0.184**	-0.163	*-0.153*
Optical Industry	-0.281***	-0.291***	-0.285***	-0.283***	-0.285***	-0.265**	-0.270***
Communication Industry	-0.165**	-0.145*	-0.165**	-0.164**	-0.154**	-0.143*	-0.126
(Independent Variable)							
Universities		0.121*					0.134
Research Institution			0.046				-0.085
Competitors				0.040			0.020
Financial Subsidies					0.069		-0.020
Technology Licensing						0.140**	0.127
F-Value	14.706***	13.185***	12.608***	12.584***	12.717***	13.475***	8.585***
Adjusted R-Square	0.389	0.398	0.386	0.386	0.389	0.404	0.393
Adjusted R-Square Change (against Model 7)		△0.009*	-△0.003	-△0.003	△0.000	△0.015**	△0.004

*** p < 0.01;** p < 0.05; * p < 0.1; Dependent Variable: Firm Performance (7-year Gross Profit)

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We also enter the five types of R&D collaborations in the regression models individually from Model 9 to Model 13. Model 8 explains 38.9% of the variance (Adjusted R-Square = 0.389) in firm performance. We further examined the change of adjusted R-Square between Model 8 and Model 9 and the result shows that the change of Chi-Square of F-value is significant (ΔAdjusted R-Square = 0.009, $p < 0.1$). As shown in Model 9, R&D collaborations with universities have a positive effect on firm performance ($b = 0.121$, $p < 0.1$), suggesting that firms outside the cluster can further increase profits by conducting R&D collaborations with universities.

In addition to R&D collaborations with universities, receiving licensed technologies from the government can also enhance a firm's performance outside the cluster. As shown in Table 4, Model 13 explains 40.4% of the variance (Adjusted R-Square = 0.404) in firm performance and the change of adjusted R-Square between Model 8 and Model 13 is significant (ΔAdjusted R-Square = 0.015, $p < 0.05$). Receiving licensed technologies from the government is positively associated with firm performance ($b = 0.140$, $p < 0.05$). Other types of R&D collaboration are not significantly correlated to firm performance. Therefore, our results suggest that for firms locating outside the cluster, only conducting collaborative projects with universities or receiving licensed technologies from the government can improve firm performance.

5. Discussion

5.1 Cluster Effect on Firm Performance

The results show that firms locating inside a cluster have better firm performance, which supports our Hypothesis 1. This result is consistent with the findings of previous cluster-related studies (Krugman, 1991; Keeble & Wilkinson, 1999; Martin & Sunley, 1996; Porter, 1990, 1998), suggesting that cluster effect helps firms to reduce costs, including procurement costs, transportation costs, coordination and administration costs, and so on, which in turn leads to higher profits. The findings in this research suggest that cluster effect may enhance firm performances as firms locate inside a cluster. Compared to firms located outside a cluster, firms located inside a cluster might also be perceived as offering higher valued products due to their reputation of the specialization in specific products and lower procurement costs due to price competition among suppliers, which lead to higher products prices as well as gross profits. Hsu (1997) asserts that due to the close relationships among firms in a science park, these firms can access all kinds of components and materials at lower costs, which in turn enhance their competitive advantage over firms off the science

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park.

Our findings also provide some empirical evidence that the cluster effect of science parks may affect a firm's performance for different industries. As shown in Table 3 and Table 4, computer firms inside a science park have better performance whereas computer, communication and optical firms outside a science park have worse performance. This implies that the firms inside the HSP, particularly computer firms, can benefit more from the cluster effect than firms in other industries in the HSP, suggesting that the science park policy does help the development of the Taiwan's computer firms during the late 1990s.

5.2 The R&D Collaborations Inside and Outside the Cluster

As suggested by prior studies, locating in a cluster with close geographical distance can help firms to reduce costs, such as procurement costs, transportation costs, and coordination and administration costs, which in turn to improve their profits. Our study attempts to examine which types of R&D collaborations lead to better performance in a cluster. Table 5 lists the result of hypothesis testing for firms locating inside and outside a cluster. As mentioned earlier, after running the regression models separately, we planned to run a cross-functional t-test (Cohen, 1983) to examine the difference of parameter estimates. As shown in Table 5, since none of the same parameter estimates in two samples is significant at the same time, there is no need for further examination. Therefore, Hypotheses 3, 5 and 6 are supported and Hypotheses 2 and 4 are not supported.

5.2.1 R&D Collaborations with Universities

As shown in Table 5, while there is no significant effect of R&D collaborations with universities on performance for firms inside a science park, the impact is positive for firms outside a science park. These results, while do not support Hypothesis 2, may be attributed to information asymmetry. Though information diffuses quickly in a cluster, information diffusion among firms outside a cluster may not be that efficient. When a firm inside a cluster works with a university on an R & D project, other firms in the cluster learn the news quickly. This is not the case for firms outside a cluster. A firm outside a cluster works with a university on an R & D project may reap the benefits of innovation longer because their competitors may not be aware of the collaboration or it takes longer time for them to retrieve the news.

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Table 5 Results of hypothesis testing

Types of R&D Collaboration	Inside a cluster	Outside a cluster	Hypothesis (better performance)	Result
Universities	No impact	Positive	H2: Inside a cluster	Not Supported
Research institutions	Positive	No impact	H3: Inside a cluster	Supported
Competitors	No impact	No impact	H4: Outside a cluster	Not Supported
Financial subsidies	No impact	No impact	H5: No difference	Supported
Technology licensing	No impact	Positive	H6: Outside a cluster*	Supported

* Performance is indifference among firms inside a cluster

5.2.2 R&D Collaborations with Research Institutions

Table 5 shows that as firms locate inside a science park, R&D collaborations with research institutions are positively associated with firm performance. However, as firms located outside a science park, there is no significant effect of R&D collaborations with research institutions on firm performance. This result supports our Hypothesis 3. The reason why R&D collaborations with research institutions can further enhance firm performance is because firms located in a science park are easier to access right information regarding applied technology development via homogeneous firms in the same cluster. As a result, the firms inside a science park can make more accurate decisions to use more advanced technologies either to increase production efficiency or to add product value, leading to higher profitability.

5.2.3 R&D Collaborations with Competitors

There is no significant effect of R&D collaborations with competitors on firm performance for both firms locating inside and outside a science park, which is not consistent with our Hypothesis 4. As prior studies suggest that collaborations with competitors raise the greatest suspicions for the potential of opportunism (Hagedoorn, 1993; Hagedoorn et al., 2000; Powell et al., 1996), our study implies that such negative impact of inter-firm R&D collaborations on firm performance does not take place no matter where firms locate.

5.2.4 Financial Subsidies

Similarly, as shown in Table 5, no significant relationship between financial subsidies and firm performance has been found for both groups of firms locating inside and outside a science park. The result supports our Hypothesis 5. This suggests that locating in a cluster

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can not help firms to increase innovation performance via receiving financial subsidies.

5.2.5 Technology Licensing from the Government

As shown in Table 5, as firms locate inside a science park, there is no significant effect of technology licensing from the government on firm performance. However, as firms located outside a science park, technology licensing from the government is positively associated with firm performance. These results support our Hypothesis 6, which is consistent with previous studies (Mowery, 1998). Particularly, due to information asymmetry regarding the development of the up-to-date technologies, firms locating outside a cluster can benefit more from technology licensing from the government than those with no such acquisitions.

Based on the above discussion, our study provides a comprehensive research regarding how R&D collaborations affect firm performance in a cluster. Our findings suggest that as firms locating inside a science park, R&D collaborations with research institutions can help firms further to enhance profits. On the other hand, as firms locating outside a science park, R&D collaborations with universities and acquiring licensed technologies from the government can increase a firm's profits.

5.3 The Moderation Effect of Multiple-source R&D Collaborations on Firms Inside a Cluster

To further explore whether multiple-source R&D collaborations have impact on firm performance in a cluster, this research used the regression models with the interaction term to test the moderation effect. As shown in Table 3, since only R&D collaborations with research institutions could improve a firm's performance for firms locating in the science park, we used R&D collaborations with research institutions interacted by the other four types of R&D collaborations as the interaction terms in the regression models.

Table 6 shows the results of the regression models. As can be seen in Model 18, the interaction effect of R&D collaborations with research institutions by R&D collaborations with universities improves a firm's performance. However, the change of adjusted-R Square for Model 18 is not statistically significant (Adjusted R-Square = 0.198, $p > 0.1$). This suggests that the moderation effect of multiple-source R&D collaborations is not found from firms inside the science park in this research. A plausible explanation is that because the number of the sample firms inside the science park is small (i.e., 34 firms). The small number of sample firms may jeopardize the examination of the regression models with a large number of variables including interaction terms.

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Table 6 The moderation effect of multiple-source R&D collaborations on firms inside a cluster

Exogenous Variable	Model 15	Model 16	Model 17	Model 18
(Control Variable)				
Firm Size	-0.008	-0.014	0.077	0.009
Internal Innovation Capability	0.093	-0.010	0.063	0.102
Semiconductor Industry	0.060	-0.001	0.049	-0.020
Computer Industry	0.524**	0.524**	0.574**	0.345
Optical Industry	-0.058	-0.034	-0.103	-0.307
Communication Industry	-0.024	0.014	0.029	-0.062
(Independent Variable)				
Research Institution		0.319*	0.269	0.273
(Moderators)				
Universities			0.178	0.545*
Competitors			-0.268	-0.551**
Financial Subsidies			0.112	-0.023
Technology Licensing			-0.072	-0.090
(Interaction)				
Research Institution × Universities				0.483*
Research Institution × Competitors				-0.410*
Research Institution × Financial Subsidies				0.007
Research Institution × Technology Licensing				-0.222
F-Value	1.736	2.091*	1.534	1.545
Adjusted R-Square	0.118	0.188 0	.151	0.198
Adjusted R-Square Change (against Model 15)		△0.070*	△0.033	△0.080

*** p < 0.01;** p < 0.05; * p < 0.1; Dependent Variable: Firm Performance (7-year Gross Profits)

6. Conclusion

As suggested by previous agglomeration economic studies, an abundant market for specialized skills, well-developed downstream and upstream connections with specialized firms, non-trade complementary input transactions, and knowledge spillover are important cluster effects. This study, based on the agglomeration economic theory, investigated the

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cluster effects on firm performance in the context of R&D collaborations.

One major finding of this study suggests that firms inside a science park (e.g., Hsinchu Science Park) have better gross profits than firms outside a park, implying that the cluster effect indeed helps firms to gain competitive advantage, which is consistent with precious research. Another important contribution of our findings is that as firms locate inside a science park, R&D collaborations with research institutions can enhance a firm's profitability. This implies that the cluster effect on firm performance can be further improved by conducting R&D collaborations with research institutions. In contrast, as firms locate outside a science park, R&D collaborations with universities and receiving licensed technologies from the government can improve a firm's profitability.

In this research, we found that firms inside a science park have better performance than firms outside the science park. In addition, inside a science park, only R&D collaborations with research institutions is found to improve firm performance. This suggests that the cluster effect does enhance a firm's performance but that the spillover effect of knowledge on firm profitability only takes place in R&D collaborations with research institutions inside a science park.

Empirical results from this study contribute to our understanding of the interaction effect of cluster effect by R&D collaborations on a firm's performance. The results have implications for both practitioners and policy makers regarding science parks. First, the higher profitability of firms inside a science park than those of firms outside the science park implies that the establishment of the HSP has become a successful model due to the cluster effect. Firms inside a science park can coordinate the upstream suppliers and downstream customers at lower costs, which enhance their profitability. Policy makers can replicate this successful experience of the development of the HSP, including the selection process of firms as well as the administration of the science park. Moreover, among various types of R&D collaborations, collaborations with research institutions seem most significant for the firms inside a science park since these collaborations can improve their profitability. The research and development taken place inside a science park is more applied research-oriented. Thus, R&D collaborations with research institutions which emphasize more on applied research can more appropriately meet the demand of firms inside a science park, which in turn helps these firms to develop profitable products. Most importantly, the collaborations between firms and research institutions incur less moral hazard, making spillover effect more effectively. Future industrial policies are suggested to encourage firms inside a science park to conduct R&D collaborations with research institutions.

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Although this study attempts to examine what cluster effect has impacts on firm performance, there are some limitations in this research. First, the size of the sample firms inside and outside the science park is unequal. Particularly, only 34 firms were located inside the science park, leading to a possible representative issue in the research. Since this research employed the questionnaire survey, the relatively fewer responding number of the science park firms led to the unequal sample size between groups. Therefore, future studies are encouraged to conduct a survey to with larger sample size. Second, this research has a limitation of controlling time lag between independent variables and the dependent variable. A possible remedy for this limitation is using the seven-year averaged data which can explain the on-going relationships between the dependent variable and independent variables. As for the measurements of the types of R&D collaboration, this study used dummy variables for simplicity because the nature of collaborations for each type may differ. Future studies may use multiple-item survey to measure a firm's commitment to each type of R&D collaborations. Moreover, this study only uses gross profit rates as the measurement for firm performance. Future studies can use different indicators for firm performance, such as innovation outputs. Finally, there are also limitations regarding the measure for R&D collaborations with competitors. We only investigated how inter-firm R&D collaborations with competitors affect firms' innovation inside or outside a science park. Future studies are suggested to investigate the impact of inter-firm R&D collaborations with suppliers and customers on firm performance.

臺灣大學學術期刊資料庫

References

Acs, Z. J., Fitzroy, F. R., & Smith, I. 1999. High technology employment, wages and university R&D spillovers: Evidences from US cities. ***Economics of Innovation and New Technology***, 8 (1/2): 57-78.

Ahmad, J. 1992. Import competition, government subsidies, and trade with developing countries. ***Journal of Economic Studies***, 19 (2): 48-57.

Anderson, G. 1994. Industry clustering for economic development. ***Economic Development Review***, 12 (2): 26-33.

Appold, S. J. 1995. Agglomeration, interorganizational networks, and competitive performance in the U.S. metalworking sector. ***Economic Geography***, 71(1): 27-54.

Armstrong, J. S., & Overton, T. S. 1977. Estimating nonresponse bias in mail surveys. ***Journal of Marketing Research***, 14 (3): 396-402.

Audretsch, D. B. 1998. Agglomeration and the location of innovative activity. ***Oxford Review of Economic Policy***, 14 (2): 18-29.

Audretsch, D. B., & Feldman, M. P. 1996. R&D spillovers and the geography of innovation and production. ***American Economic Review***, 86 (3): 630-645.

Barney, J. B. 1991. Firm resources and sustained competitive advantage. ***Journal of Management***, 17 (1): 99-120.

Best, M. H. 1999. Regional growth dynamics: A capabilities perspective. ***Contribution of Political Economics***, 18(1): 105-119.

Bowerman, B. L., & O'Connell, R. T. 1990. ***Linear statistical models: An applied approach*** (2nd ed.). Belmont, CA: Duxbury.

Branzei, O. 2005. ***Product innovation in heterogeneous R&D networks: Pathways to exploration and exploitation***. Paper presented at INFORMS annual conference, New Orleans.

Burt, R. S. 1987. Social contagion and innovation: Cohesion versus structural equivalence. ***American Journal of Sociology***, 92 (6): 1287-1335.

Chow, G. C. 1960. Tests of equality between sets of coefficients in two linear regressions. ***Econometrica***, 28 (3): 591-605.

Chung, W., & Kalnins, A. 2001. Agglomeration effects and performance: A test of the Texas lodging industry. ***Strategic Management Journal***, 22 (10): 969-988.

Cohen, A. 1983. Comparing regression coefficients across subsamples. ***Sociological Methods and Research***, 12 (1): 77-94.

臺灣大學學術期刊資料庫

Cutler, R. A. 1990. A survey of the high-technology practices in Japan and the US. ***Interfaces***, 19 (6): 67-77.

Dedrick, J., & Kraemer, K. L. 1998. ***Asia's computer challenge***. New York, NY: Oxford University Press.

Engelstoft, S., Jensen-Butler, C., Smith, I., & Winther, L. 2006. Industrial clusters in Denmark: Theory and empirical evidence. ***Regional Science***, 85 (1): 73-98.

Enright, M. 1998. Regional clusters and firm strategy. In A. D. Chandler, P. Hagstrom, & O. Solvell (Eds.), ***The dynamic firm: The role of technology, strategy, organization, and region***: 315-342. Oxford, UK: Oxford University Press.

Fan, P. 2006. Catching up through developing innovation capability: Evidence from China's telecom-equipment industry. ***Technovation***, 26 (3): 359-368.

Foss, N. J. 1999. Network, capabilities, and competitive advantage. ***Scandinavian Journal of Management***, 15 (1): 1-15.

Freeman, C. 1982. ***The economics of industrial innovation*** (2nd ed.). Cambridge, MA: MIT Press.

Fujita, M. 2007. The development of regional integration in East Asia: From the viewpoint of spatial economics. ***Review of Urban and Regional Development Studies***, 19 (1): 2-20.

Galaskiewicz, J., & Burt, R. S. 1991. Interorganization contagion in corporate philanthropy. ***Administrative Science Quarterly***, 36 (1): 88-105.

Ganesan, S., Malter, A. J., & Rindfleisch, A. 2005. Does distance still matter? Geographic proximity and new product development. ***Journal of Marketing***, 69 (4): 44-60.

Glick, R., & Moreno, R. 1997. The East Asian miracle: Growth because of government intervention and protectionism of in spite of it? ***Business Economics***, 32 (2): 20-25.

Grupp, H. 1997. The links between competitiveness, firm's innovative activities and public R&D support in Germany: An empirical analysis. ***Technology Analysis & Strategic Management***, 9 (1): 19-34.

Hagedoorn, J. 1993. Understanding the rationale of strategic technology partnering: Interorganizational modes of cooperation and sectoral differences. ***Strategic Management Journal***, 14 (5): 371-385.

Hagedoorn, J., Link, A., & Vonortas, N. 2000. Research partnerships. ***Research Policy***, 29 (4/5): 567-586.

Hakansson, H. 1987. ***Industrial technological development: A network approach***. London,

臺灣大學學術期刊資料庫

UK: Croom Helm.

Hamel, G. 1991. Competition for competence and inter-partner learning within international strategic alliances. ***Strategic Management Journal***, 12 (Special Issue): 83-103.

Hamel, G., Doz, Y. L., & Prahalad, C. K. 1989. Collaborate with your competitors and win. ***Harvard Business Review***, 67 (1): 133-139.

Hamel, G., & Prahalad, C. K. 1994. ***Compete for the future***. Boston, MA: Harvard Business School Press.

Harkola, J., & Greve, A. 1995. ***Diffusion of technology: Cohesion or structural equivalence***? Paper presented at the annual meeting of the Academy of Management, Vancouver.

Hemmert, M. 2003. International organization of R&D and technology acquisition performance of high-tech business units. ***Management International Review***, 43 (4): 361-382.

Hsu, J. 1997. ***A late-industrial district? Learning network in the Hsinchu Science-based Industrial Park, Taiwan***. Unpublished doctoral dissertaion, University of California.

Hu, T., Lin, C., & Chang, S. 2005. Technology-based regional development strategies and the emergence of technological communities: A case study of HSIP, Taiwan. ***Technovation***, 25 (4): 367-380.

Jaffe, A. B., Trajtenberg, M., & Henderson, R. 1993. Geographical localization of knowledge spillovers as evidenced by patent citations. ***Quarterly Journal of Economics***, 108 (3): 577-598.

Kassicieh, S. K., Kirchhoff, B. A., Walsh, S. T., & McWhorter, P. J. 2002. The role of small firms in the transfer of disruptive technologies. ***Technovation***, 22 (11): 667-674.

Keeble, D., & Wilkinson, F. 1999. Collective learning in regionally clustered high technology SMEs in Europe. ***Regional Studies***, 33 (4): 295-303.

Klette, T. J., Moen, J., & Griliches, Z. 2000. Does subsidies to commercial R&D reduce market failure? Microeconometric evaluation studies. ***Research Policy***, 29 (4/5): 471-495.

Kogut, B., & Zander, U. 1992. Knowledge of the firm, combinative capabilities, and the replication of technology. ***Organization Science***, 3 (3): 383-397.

Krugman, P. 1991. Increasing return and economic geography. ***Journal of Political Economy***, 99 (3): 483-499.

Lackman, C. L. 2005. The comparative influence of government funding by the US

臺灣大學學術期刊資料庫

Commerce Department's advanced technology program and private funding on the marketing strategy of the high-tech firms. ***Journal of Nonprofit & Public Sector Marketing***, 13 (1/2): 179-197.

Lai, H., Chiu, Y., & Leu, H. 2005. Innovation capacity comparison of China's information technology industrial clusters: The case of Shanghai, Kunshan, Shenzhen, and Dongguan. ***Technology Analysis and Strategic Management***, 17 (3): 293-315.

Lee, J., & Park, C. 2006. Research and development linkages in a national innovation system: Factors affecting success and failure in Korea. ***Technovation***, 26 (9): 1045-1054.

Lerner, J. 1999. The government as venture capitalist: The long-run impact of the SBIR program. ***The Journal of Business***, 72 (3): 285-318.

Lin, B. W. 2003. Technology transfer as technological learning: A source of competitive advantage of firms with limited R&D resources. ***R&D Management***, 33 (3): 327-341.

Liu, H., & Jiang, Y. 2001. Technology transfer from higher education institutions to industry in China: Nature and implications. ***Technovation***, 21 (3): 175-188.

Luo, Y. 2007. A coopetition perspective of global competition. ***Journal of World Business***, 42 (2): 129-144.

Malmberg, A., Solvell, O., & Zander, I. 1996. Spatial clustering, local accumulation of knowledge and firm competitiveness. ***Geografiska Annaler: Series B, Human Geography***, 78 (2): 85-97.

Marshall, A. 1920. ***Principles of economics***. London, UK: Macmillan.

Martin, R., & Sunley, P. 1996. Paul Krugman's geographical economics and its implications for regional development theory: A critical assessment. ***Economic Geography***, 72 (3): 259-292.

Merchant, J. E. 1997. The role of governments in a market economy: Future strategies for the high-tech industry in America. ***International Journal of Production Economics***, 52 (1/2): 117-131.

Moon, M. J., & Bretschneider, S. 1997. Can state government actions affect innovation its diffusion? An extended communication model and empirical test. ***Technological Forecasting and Social Change***, 54 (1): 57-77.

Mothe, C., & Quelin, B. V. 2001. Resource creation and partnership in R&D consortia. ***The Journal of High Technology Managemen***t, 12 (1): 113-138.

Mowery, D. C. 1998. Collaborative R&D: How effective is it? ***Issues in Science and Technology***, 15 (1): 37-46.

臺灣大學學術期刊資料庫

Murphy, G. B., Trailer, J. W., & Hill, R. C. 1996. Measuring performance in entrepreneurship research. ***Journal of Business Research***, 36 (1): 15-23.

Myers, R. H., & Montgomery, D. C. 1995. ***Response surface methodology: Process and product improvement with designed experiments***. New York, NY: Wiley.

Panne, G. 2004. Agglomeration externalities: Marshall versus Jacobs. ***Journal of Evolutionary Economics***, 14 (5): 593-604.

Parker, D. D., & Zilberman, D. 1993. University technology transfers: Impacts on local and US economies. ***Contemporary Policy Issues***, 11 (2): 87-96.

Pérez, M. P., & Sanchez, A. M. 2003. The development of university spin-offs: Early dynamics of technology transfer and networking. ***Technovation***, 23 (10): 823-831.

Porter, M. E. 1990. ***The competitive advantage of nations***. New York, NY: Free Press.

_____. 1998. The Adam Smith address: Location, clusters, and the new microeconomics of competition. ***Business Economics***, 33 (1): 7-13.

Powell, W. W., Kogut, K. W., & Smith-Doerr, L. 1996. Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. ***Administrative Science Quarterly***, 41 (1): 116-145.

Quintana-Garcia, C., & Benavides-Velasco, C. A. 2005. Agglomeration economics and vertical alliances: The route to product innovation in biotechnology firms. ***International Journal of Production Research***, 43 (22): 4853-4873.

Rosiello, A. 2007. At the interfaces of governance and competence perspectives: Discussing organizational choices in the Scottish biotechnology cluster. ***Technology Analysis and Strategic Management***, 19 (1): 45-68.

Rothaermel, F. T. 2001. Complementary assets, strategic alliances, and the incumbent's advantage: An empirical study of industry and firm effects in the biopharmaceutical industry. ***Research Policy***, 30 (8): 1235-1251.

Rowen, H. S. 1998. ***Behind East Asia growth: The political and social foundations of prosperity***. London, UK: Routledge.

Said, A. A., HassabElnaby, H. R., & Wier, B. 2003. An empirical investigation of the performance consequences of nonfinancial measures. ***Journal of Management Accounting Research***, 15 (1): 193-223.

Sakakibara, M., & Dodgson, M. 2003. Strategic research partnership: Empirical evidence from Asia. ***Technology Analysis and Strategic Management***, 15 (2): 227-245.

Scherer, F. M. 1965. Firm size, market structure, opportunity, and the output of patented inventions. ***American Economic Review***, 55 (5): 1097-1125.

臺灣大學學術期刊資料庫

Shane, S. 2002. Executive forum: University technology transfer to entrepreneurial companies. ***Journal of Business Venturing***, 17 (6): 537-552.

Shaver, J. M., & Flyer, F. 2000. Agglomeration economies, firm heterogeneity, and foreign direct investment in the United States. ***Strategic Management Journal***, 21 (12): 1175-1193.

Siegel, D. S., Westhead, P., & Wright, M. 2003. Science parks and the performance of new technology-based firms: A review of recent U.K. evidence and an agenda for future research. ***Small Business Economics***, 20 (2): 177-184.

SIPA. 2008. ***Science-based Industrial Park Administration (SIPA) brochure***. Taipei, TW: SIPA.

Steffensen, M., Rogers, E. M., & Speakman, K. 2000. Spin-offs from research centers at a research university. ***Journal of Business Venturing***, 15 (1): 93-111.

Storey, D. J., & Tether, B. S. 1998. Public policy measures to support new technology-based firms in the European Union. ***Research Policy***, 26 (9): 1037-1057.

Symth, D. J., Boyes, W. J., & Pessau, D. E. 1975. The measurement of firm size: Theory and evidence for the United States and United Kingdom. ***Review of Economics and Statistics***, 57 (1): 111-114.

Takeishi, A. 2001. Bridging inter- and intra-firm boundaries: Management of supplier involvement in automobile product development. ***Strategic Management Journal***, 22 (5): 403-433.

Teece, D. J., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. ***Strategic Management Journal***, 18 (7): 509-533.

Tung, A. 2001. Taiwan's semiconductor industry: What the state did or did not. ***Review of Development Economics***, 5 (2): 266-288.

Walker, W. E. 1995. ***Technological innovation, corporate R&D alliances and organizational learning***. Unpubished doctoral dissertation, Frederick S. Pardee RAND Graduate School.

Westhead, P. 1997. R&D inputs and outputs of technology-based firms located on and off Science Parks. ***R&D Management***, 27 (1): 45-62.

Wint, A. G. 1998. The role of government in enhancing the competitiveness of developing economies. ***International Journal of Public Sector Management***, 11 (4): 281-299.

Yeheskel, O., Shenkar, O., Fiegenbaum, A., Cohen, E., & Geffen, I. 2001. Cooperative wealth creation: Strategic alliances in Israeli medical-technology ventures. ***The Academy of Management Executive***, 15 (1): 16-25.

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APPENDIX

Appendix 1. Descriptive statistics and correlations (inside the science park)

	Mean	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Firm performance	30.23	1.00												
(2) Firm size	14.04	-0.18	1.00											
(3) Internal innovation capability	10.68	0.02	-0.27	1.00										
(4) Semiconductor	0.41	-0.06	0.41*	0.08	1.00									
(5) Computer	0.12	0.51**	-0.35*	-0.16	-0.31	1.00								
(6) Optical	0.24	-0.18	-0.07	0.03	-0.46**	-0.20	1.00							
(7) Communication	0.09	-0.10	-0.05	-0.07	-0.26	-0.14	-0.17	1.00						
(8) Other	0.15	-0.08	-0.13	0.06	-0.35*	-0.15	-0.23	-0.13	1.00					
(9) Universities	0.21	0.01	0.14	0.17	0.07	-0.31	0.08	-0.13	0.19	1.00				
(10) Research institutions	0.82	0.27	0.02	0.34*	0.29	-0.09	-0.13	-0.18	-0.02	0.27	1.00			
(11) Competitors	0.62	-0.19	0.30	0.21	0.28	-0.17	-0.25	-0.03	0.09	0.38*	0.16	1.00		
(12) Financial subsidies	0.71	0.13	-0.07	0.13	-0.26	-0.14	0.21	-0.07	0.30	0.41*	0.21	-0.08	1.00	
(13) Technology licensing	0.44	-0.04	0.19	0.20	0.01	-0.27	0.03	-0.23	0.39*	0.34*	0.33	0.07	0.34	1.00

N=34; ** $p < 0.01$; * $p < 0.05$.

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Appendix 2. Descriptive statistics and correlations (outside the science park)

	Mean	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Firm performance	21.49	1.00												
(2) Firm size	14.01	-0.48**	1.00											
(3) Internal innovation capability	3.94	0.43**	-0.31**	1.00										
(4) Semiconductor	0.06	0.33**	-0.20**	0.43**	1.00									
(5) Computer	0.55	-0.23**	0.21**	-0.35**	-0.29**	1.00								
(6) Optical	0.10	-0.22**	0.02	-0.08	-0.09	-0.37**	1.00							
(7) Communication	0.05	-0.04	-0.00	0.24**	-0.06	-0.27**	-0.08	1.00						
(8) Other	0.23	0.26**	-0.15	0.10	-0.14	-0.61**	-0.18*	-0.13	1.00					
(9) Universities	0.69	0.17	-0.09	0.16	-0.03	-0.21*	0.17	-0.06	0.18	1.00				
(10) Research institutions	0.63	0.02	0.04	0. 06	-0.00	-0.17*	0.15	0.04	0.08	0.68**	1.00			
(11) Competitors	0.63	0.02	0.03	-0.02	0.07	-0.12	0.10	-0.03	0.05	0.36**	0.53**	1.00		
(12) Financial subsidies	0.36	0.16	-0.14	0.26**	0.01	-0.21**	0.13	-0.03	0.17	0.37**	0.27**	0.22*	1.00	
(13) Technology licensing	0.24	0.13	-0.00	0.02	-0.14	-0.10	0.00	-0.05	0.22*	0.38**	0.31**	0.17	0.52**	1.00

N=131; ** p < 0.01; * p < 0.05

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Appendix 3. Comparison between firms inside and outside the science park

	Inside the Since Park	Outside the Science Park
Semiconductor Industry	41%	6%
Computer Industry	12%	55%
Optical Industry	24%	10%
Communication Industry	9%	5%
Other Industry	15%	23%
Total	**100%**	**100%**
Universities	21%	69%
Research institutions	82%	63%
Competitors	62%	63%
Financial subsidies	71%	36%
Technology licensing	44%	24%

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