Asian Economic and Financial Review, 2016, 6(9): 499-509

Asian Economic and Financial Review
ISSN(e): 2222-6737/ISSN(p): 2305-2147

URL: www.aessweb.com

OVERSEAS R&D AND TAIWAN-BASED FIRM'S PRODUCTIVITY - DOES INTERNAL TECHNOLOGICAL CAPABILITY MATTER?

To-Han Chang[1] --- **Wen-Bin Chuang**[2]†

[1]*Department of Culture and Creative Enterprise Management, Nanhua University, 55, Section 1, Nanhua Road, Darlin, Chiayi 622, Taiwan*
[2]*Department of International Business Studies, National Chi-Nan University, 1, University Rd., Puli, Nantou 545, Taiwan*

ABSTRACT

The purpose of this study is to examine the influence of overseas R&D on firm productivity. In particular, we further consider the moderating effect of internal technological capability. To provide more empirical evidence, this analysis takes advantage of a longitudinal dataset covering the 2009-2013 period and the system-GMM approach is employed in the empirical analysis to control for the problem of endogeneity. The empirical results show that overseas R&D has a significant influence on their firm productivity. Moreover, internal technological capability is found to play a significant moderating role in strengthening the influence of overseas R&D on firm productivity.

Keywords: Overseas R&D, Firm productivity, Technological capability, Taiwan MNEs, Emerging economies, Internal technology capability.

Received: 14 January 2016/ **Revised:** 8 February 2016/ **Accepted:** 18 May 2016/ **Published:** 1 June 2016

Contribution/ Originality

The primary contribution is finding internal technological capability play a significant moderating role when firms develop offshore R&D to enhance performance. These findings imply that lacking such technological capability will limit the potential not only to identify, search and assimilate information on the local market but also to acquire for new learning opportunities.

1. INTRODUCTION

With increasing technical complexity and market uncertainties, the firm capability not only depends on the exploitation of current capabilities which involves the refinement of resources and capabilities that are currently available, but also requires the exploration of new capability which involves the acquisition of new knowledge and the improvement of future performance (Ding and Huang, 2010; Choi and Ko, 2012). Moreover, firms have tried to obtain collaborative advantages by utilizing the interorganizational relationships that synergistic benefits could not be achieved by acting independently, which in turn will significantly affect their technological capabilities and productivity (Hallin *et al.*, 2011; D'Agostino and Santangelo, 2012). From a dynamic capability perspective, a firm's ability to reconfigure its asset structure plays a significant role in its sustainable capability (Sanders, 2008). That is to say, firms have to renovate and enhance their technological capability in order to compete with others in the future (Cantwell *et al.*, 2010; Hallin *et al.*, 2011).

† Corresponding author
DOI: 10.18488/journal.aefr/2016.6.9/102.9.499.509
ISSN(e): 2222-6737/ISSN(p): 2305-2147

Recent studies have found firms' overseas R&D activities to have rapidly increased (Belderbos *et al.*, 2006; Chuang and Lin, 2010). With firms' manufacturing facilities and marketing activities located abroad, the role of overseas R&D activities is increasing. On the one hand, firms can take advantage of overseas R&D activities to promote the use of their technological capability in conjunction with local sales, manufacturing activities, and market conditions in order to exploit existing assets in the host countries (Kuemmerle, 1997; Iwasa and Odagiri, 2004). On the other hand, overseas R&D activities give rise to a channel of technology sourcing. Firms can raise or create new technological capabilities and resources that are unavailable at home (Florida, 1997; Kuemmerle, 1999). Therefore, whether overseas R&D has a significant effect on firm productivity is a question that is examined in this article. Thus, it is critical to understand the influences of overseas R&D activities in the local environment so as to respond to local needs quickly and to establish stronger strategic positions in the host country (Im and Rai, 2008; Chuang and Lin, 2010; Choi and Ko, 2012).

Along with the overseas R&D activities, internal technological capability also has been regarded as an important strategic resource that enables firms to achieve a sustainable capability when they face a changing environment (Lokshin *et al.*, 2008; Athreye *et al.*, 2013). Firms with more internal technological capabilities can perform better in more turbulent environments, since superior technological capability can help firms achieve greater efficiency gains by pioneering process innovations, as well as higher differentiation by innovating products in response to the changing market environment (Song *et al.*, 2006; D'Agostino and Santangelo, 2012). Moreover, superior technological capability can accelerate the development of new products in order to reap the pioneer's advantages (D'Agostino and Santangelo, 2012; Athreye *et al.*, 2013). In other words, internal technological capability can challenge the effects of strategy patterns based on the collaborative relationships in the local environment (Hagedoorn and Wang, 2012). Therefore, there is a need to develop a comprehensive framework with empirical studies to characterize the interrelationships among the aforementioned factors.

Despite the increasing number of studies that have been conducted to examine the determinants and effect of overseas R&D, our study makes several contributions to the debates on international business and theory of fragmentation. In particular, few studies have examined the moderating effect of internal technological capability on the overseas R&D-productivity relationship. We provide significantly different significant contributions on global outsourcing, with particular emphasis on the effects of overseas R&D based on their local collaborative relationships. We found that overseas R&D has a significant positive influence on their firm productivity. Moreover, internal technological capability is found to play a significant moderating role in strengthening the influence of overseas R&D on firm productivity. Moreover, our analysis is based on detailed Taiwan firm-level data, combined with data for countries over the 2009-2013 period. The detailed micro data include information on oversea R&D at the firm-country level. Taiwan is a significant emerging economy in the world and its overseas exploitative and explorative activities have recently grown (Chen and Chen, 2002; 2003; Chuang and Lin, 2011). The fast growth and success of Taiwan's manufacturing industry has been the existence of a well-articulated subcontracting-based production system. Moreover, Taiwan-based firms have become preferred original equipment manufacturing (OEM) and original design manufacturing (ODM) suppliers of Western brand name MNEs. Finally, we apply system GMM econometric approaches to capture the advantage of panel data, thereby reducing the risk that our results are driven by the methodological approach.

Following on from this Introduction, the remainder of this paper is organized as follows. Section 2 proposes the theoretical framework and hypotheses used in this study. This is followed by Section 3, which provides an introduction to the research methodology adopted in this study, including both the model and the data sources employed in the estimations. The empirical results of the estimations are presented and interpreted in the penultimate section, Section 4, before the paper concludes with some remarks on the findings in Section 5.

2. BACKGROUND AND HYPOTHESES

The firm's technical capability has been found to depend not only on the exploitation of existing technological and knowledge assets, but also on the exploration of new capabilities from the external environment (Teece *et al.*, 1997). Moreover, the interorganizational collaboration has been considered to consist of not only pure transactions, but also of leveraging dispersed core resources and knowledge creation for sustainable capability development (Im and Rai, 2008; Sanders, 2008; Ding and Huang, 2010; Choi and Ko, 2012). Im and Rai (2008) also show that sharing knowledge in interorganizational relationships enables firms to benefit from exploiting existing competencies and exploring new learning opportunities. Sanders (2008) also argued that engaging in long-term strategic and operational relationships among firms could obtain operational and strategic benefits. Similarly, it is claimed that the external network plays a crucial role in their strategic resources and specific capability building when firms develop their collaborative relationships in local market to respond to local needs quickly and establish stronger strategic positions in host countries (Chuang and Lin, 2010; Hallin *et al.*, 2011).[1]

At the same time, the increasing number of studies has found that overseas R&D allows firms to challenge the technology strategies, to accelerate innovation speed and to specialize the capabilities and complementary assets, which in turn has a positive impact on firm productivity. Through the overseas R&D strategy based on local collaborative relationships, firms not only can identify, and assimilate some information on the local market to improve the efficiency of existing technology capabilities in the local market but also can search and acquire for new technology learning opportunities from local environment with abundant technological capacity to augment their technological knowledge or capabilities, thereby obtaining a leading position in the technology field and enhancing their firm productivity (Cantwell *et al.*, 2010; Chuang and Lin, 2010; Hallin *et al.*, 2011). Therefore, the first hypothesis is as follows:

Hypothesis 1 (H1): The utilization of overseas R&D strategy plays a significant and positive role in terms of enhancing the firm productivity.

Given that overseas R&D strategy in the local environment enhances the firm productivity, does the technological capability challenge this effect? The ability to learn and continually improve the firm's technological capability is path dependent in the sense that the development of future technological capability is constrained by the firm's current capabilities, as well as its learning routines (Teece *et al.*, 1997). In particular, the extant studies are more ambiguous and inconclusive in terms of the relationships between internal technological capability and external technology strategy (Hagedoorn and Wang, 2012; Athreye *et al.*, 2013). Some studies showed internal technological capability and external technology sourcing strategy as substitutes.)[2] However, the increasing number of studies has found that the interrelatedness of internal technological capability and external technology strategy in improving a firm's innovation performance (Lokshin *et al.*, 2008; Schmiedeberg, 2008). To identify, acquire, and assimilate valuable external technological assets, especially tacit technology, to some extent a firm has to possess considerable internal technological capability (Cohen and Levinthal, 1990; Song *et al.*, 2006) in related technological areas. Moreover, from open innovation views, the utilization of the inflows and outflows of knowledge and technological assets will accelerate innovation pace and expand the markets growth for external use of innovation (Chesbrough, 2003).

---

[1] For example, Song and Shin (2008). also found that the local collaborative relationships significantly influence the technology sourcing of overseas R&D labs from the host locations.

[2] Transaction cost theory has suggested that acquisition of external knowledge and technological assets may substitute internal technological capability Williamson (1985). Blonigen and Taylor (2000). Also found a negative relationship between R&D intensity and acquisition activity in high-tech industries.

Similarly, the interaction of internal technological capability and overseas R&D strategy helps explain why certain firms are more efficient and better productivity than others in using external technology resources in local environment (D'Agostino and Santangelo, 2012; Athreye *et al.*, 2013). For example, Athreye *et al.* (2013) found that the firms with abundant internal R&D are superior in assimilating and extending knowledge sourced from the host locations. D'Agostino and Santangelo (2012) showed that R&D labs of OECD-based firms tend to complement the host country R&D with home region knowledge creation. Hervas-Oliver and Albors-Garrigos (2009) also found that the interaction between the internal resources and their external resources enhances innovation performances. Given the above discussion, the second hypothesis is as following.

Hypothesis 2 (H2): Internal technological capability plays a positive moderating role in strengthen the effects of overseas R&D strategy on firm productivity.

3. METHODOLOGY

Based on the discussion regarding the influence of oversea R&D on firm performance and the moderating effect of internal technological capability, the Cobb-Douglas production form with degree one can be parameterized as:

$$\mathrm{Q_i} = (\mathrm{K_i})^{\alpha}(\mathrm{L_i})^{1-\alpha}\mathrm{e}^{\mathrm{Z_i}}, \qquad (1)$$

Where i denotes firm i, $\mathrm{Q_i}$ is output, $\mathrm{K_i}$ and $\mathrm{L_i}$ are respectively capital and labor for firm i, Z_i are corresponding control variables that will be explained specifically later, and α is a parameter. We assume further that productivity will gradually adjust to an equilibrium level, which is assumed to be entirely determined by exogenous variables that can change over time and hence alter the steady-state level continuously.

Letting Y_{it} denote the productivity of firm i at time t and Y_{it}^* being the corresponding equilibrium level, then:

$$\Delta lnY_{it} = \xi(lnY_{it}^* - lnY)\ , i = 1,2, \dots, N;\ t = 1,2, \dots, T, \qquad (2)$$

where ξ, such that $0 < \xi < 1$, is known as the coefficient of adjustment. Equation (2) shows that the actual change in productivity at time t is some fraction ξ of the gap between the equilibrium level and the actual level. Since it is assumed that Y_{it}^* is not a function of Y_{it} (i.e. the equilibrium level is determined exogenously only), equation (2) assures stability in the model by diminishing the effects of agglomeration when the actual level approximates its equilibrium level. Hence, the observed productivity will gradually adjust to the optimal level via the self-reinforcing effect.

Collecting terms and rearranging them results in:

$$y_{it} = (1 - \xi)y_{i,t-1} + \xi y_{it}^*, \qquad (3)$$

Where lower case letters denote natural logarithms. Equation (3) says that the observed productivity at time t is a weighted average of the productivity in the previous period and the desired level at that time. It implies that current productivity attracts further productivity, while the steady-state level is determined by a vector of independent variables, which will be discussed below. In other words, we have:

$$y_{it}^* = \vartheta x_{it}' + \lambda_i + \nu_{it}, \qquad (4)$$

Where ϑ is a $K \times 1$ vector and x_{it}' is the ith observation on K explanatory variables. Here, λ_i is a standard unobserved time-invariant subsidiary-specific fixed effect, and ν_{it} is an uncorrelated stochastic error term over all i and t.

Substituting (4) into (3) yields:

$$y_{it} = \Theta y_{i,t-1} + \beta x_{it} + \varepsilon_{it}\ \ , \varepsilon_{it} = \eta_i + \mu_{it}, \qquad (5)$$

Where $\theta = (1 - \xi)$, $\beta = \xi\vartheta$, $\eta_i = \xi\lambda_i$, and $\mu_{it} = \xi\nu_{it}$, and $\varepsilon\varepsilon_{it}$ is an error term absorbing all other technology factors influencing productivity and measurement error. Equation (5) is a dynamic regression model with a lagged dependent variable, which explains the actual productivity at period t with the productivity in the previous period and a set of other explanatory variables. To get rid of the possible endogeneity problem, the system-GMM approach apart from the random effects model provides asymptotically efficient estimators in the case of a dynamic model for a small number of time periods even under a weak assumption regarding the disturbance term and it is robust in the presence of heteroskedasticity across countries and shows a correlation of disturbances within countries over time (Blundell and Bond, 1998; Blundell *et al.*, 2000). In particular, the panel model allows us to account for the influence of overseas R&D on firm productivity after controlling the overall business cycle, while disentangling the time invariance firm-specific effects and unmeasured firm heterogeneity.

A longitudinal dataset was compiled by the Department of Statistics of the Ministry of Economic Affairs, Taiwan over the 2009-2013 period in performing this empirical analysis. First, the Report on the Foreign Investment Strategies of the Manufacturers provides the information on the basic characteristics of Taiwan-based firms in the manufacturing industry. 3 Second, the Report on the Factory's Correction & Operation Investigation provides information on human capability. In addition, to capture the technological capacity in the host country, the number of patents granted by each host country is obtained from the U.S. Patent and Trademark Office (USPTO). This longitudinal dataset included 327 manufacturing firms completely balanced for 2009-2013 (a total of 1,635 observations). Table 1 shows the trend of overseas R&D engaged in by firms. A total of 137 of 327 firms (41.89%), on average, have engaged in R&D activities abroad. Interestingly, the number of firms engaging in overseas R&D has been decreasing over the period, while the share of overseas R&D to total R&D has been increasing over the same period. We can thus see the important role that overseas R&D activities play in the firm's innovation strategy.

Table 2 summarizes the average basic statistics of the main variables from the longitudinal dataset for 2009-2013. Some interesting points are worth mentioning. First of all, firms engaging in overseas R&D are found on average to exhibit superior firm productivity and higher technological capability than those without overseas R&D activities at the same time. Secondly, firms are found on average to have similar firm size, capital-labor ratios, and human capability regardless of whether they engage in overseas R&D or not. On the contrary, firms with overseas R&D have more overseas experience than those without overseas R&D. The statistics lead us to conclude that firms with overseas R&D are significantly different from those firms without overseas R&D.

Table-1. Trend of Overseas R&D Activities (n=327, 2009-2013)

	2009	2010	2011	2012	2013
Firms doing Overseas R&D (Number and %)	181 (55.35)	138 (42.20)	116 (35.47)	126 (38.53)	124 (37.92)
Overseas R&D Share per firm with R&D, %	17.031	29.829	34.711	37.479	36.114

Notes: 1.The shares are in parentheses.

2. Source: Statistical Dept. of the Ministry of Economic Affairs, 2009-2013.

The dependent variable is firm performance which is defined as total factor productivity (TFP).[4] As for the explanatory variables, three types of explanatory variables are employed in this empirical analysis. The first one comprises firm's basic characteristics which are employed to indicate the attribute and the corresponding level of competitiveness. The firm-specific factors include firm size, the capital-labor ratio, human capability, experience of overseas operations, overseas R&D activities, and technological capability. The second one is related to the overseas

[3] Firms were asked to indicate their most representative location of overseas activities based on the amount of investment from a list of 18 countries and regions.

[4] Many empirical studies adopt firm productivity such as total factor productivity (TFP) and labor productivity to assess the contributions of technological knowledge Cantwell, Dunning and Lundan (2010). In particular, TFP is a better index to examine firm's productivity than labor productivity. The TFP is calculated as the difference in logs between the value added and the sum of labor and physical capital weighted by the productivity elasticity of labor and capital, which are estimated from Cobb-Douglas production function. The details for computing TFP in this study are provided in Appendix.

operation characteristics, which account for the host country environment facing a firm. The factors include local demand growth and local technological capacity. Finally, industry dummies are included that control for the difference in technological opportunity in different kinds of industry.[5]

Lagged productivity is added to capture the effect of the path-dependence process on dynamic capability. In term of the firm-specific factors, firm size, which is defined in terms of the number of employees, is used to capture the concept of ownership advantage. We expect that, as in the case of FDI theory, firm size will have a positive impact on firm performance. The capital-labor ratio is measured by the ratio of the book value of fixed capital stock to total labor expenditure. Ramstetter (1999) found that firms engaging in overseas operations generally adopt relatively higher capital-intensive production technologies that reflect firm-specific assets. On the other hand, higher capital-intensive production represents highly homogeneous products with lower product differentiation. As a result, the influence of the capital-labor ratio is uncertain. Being defined as the wage rate per capita, human capability captures the concept of absorptive capability, which is the core resource of competitive advantage. Hence, human capability is expected to have a positive impact on firm performance.

The more experience of overseas operations the firm has, the more she will know the local conditions (Iwasa and Odagiri, 2004). The experience of overseas operations is thus expected to have a positive impact on firm performance. The experience of overseas operations is measured in terms of the years of foreign operations. Overseas R&D is a dummy variable that has a value of one if the firm engages in overseas R&D investment in the host country and a value of zero otherwise. As mentioned in the previous section, we expect there to be a positive relationship between overseas R&D and firm performance.

Table-2. Descriptive Statistics

Variable	All Sample	With Overseas R&D	Without Overseas R&D
Firm productivity Total factor productivity	3.054 (5.48)	3.577 (3.95)	2.468 (6.55)
Overseas R&D (ORD) 1 for ORD and 0 otherwise	0.431 (0.49)	–	–
Technological capability (TC) Log(R&D stock)[6]	8.453 (4.07)	10.218 (2.12)	7.538 (4.81)
Firm Size Log(Number of employees)	5.655 (1.55)	5.897 (2.11)	5.440 (1.14)
Capital-Labor Ratio Log(Physical capital/number of employees)	7.367 (1.62)	7.338 (2.79)	7.393 (1.46)
Human Capability Log(wage rate)	6.143 (0.45)	6.147 (0.36)	6.140 (0.43)
Experience of Overseas Operations (Years of foreign operation)	8.792 (4.11)	8.647 (6.07)	8.921 (4.14)
Local Demand Growth Log(Foreign subsidiaries' sales growth)	12.088 (2.05)	12.376 (4.03)	11.833 (2.04)
Local Technology Capacity Log(Average number of patents applied)[7]	7.045 (1.63)	7.022 (1.94)	7.066 (1.61)
Observations (# of firms)	1,635(327)	710(142)	925(185)

Notes: 1. Means and standard errors in parentheses are calculated from longitudinal data for the 2009-2013 period.

2. All variables are deflated by the corresponding price deflator.

3. The data source for human capability and local technology capacity are Report on the Factory's Correction & Operation Investigation, Taiwan and U.S. Patent and Trademark Office, respectively.

[5] The industry dummy includes the following industries: electrical and electronic machinery and machinery; chemicals and chemical products; rubber and plastic products; primary metal and metal products; textile, apparel, leather and related products; food and beverages; pulp, paper, and paper products; lumber, wood products, and furniture; and miscellaneous.

[6] The R&D stock is constructed from the past R&D flows with a depreciation rate of 15% per year.

[7] Technology capacity in the host country is defined as the average number of patents applied for by host country to U.S. patents in the past three years

Following Tsai (2004) technological capability is defined as the ratio of firm sale to R&D stock with a constant depreciation rate of 15% per year, indicating that the influence of technological capability is not only affected by current R&D expenditure but also by previous efforts. Technological capability is expected to bring a superior technological capability.

As for the host environment, the local demand growth is defined in terms of the sales growth of the prominent subsidiary. A larger local demand growth reflects a greater opportunity for a firm to exploit its resources and capability. The local demand growth is thus expected to have a positive influence. If firms operate in host countries with abundant capacity for learning technology and/or knowledge, firms will boost their own competitive advantage. Local technological capacity is thus expected to have a positive impact on firm productivity. Such capacity is measured in terms of the average number of patents granted in the past three years by each host country, according to the U.S. Patent and Trademark Office (USPTO). Finally, the interaction term is employed to capture the moderating effect of technological capability in this empirical analysis.

4. EMPIRICAL RESULTS

Given the above methodology, dataset and variable selection, Table 3 lists the empirical results using the system GMM approach and random effect model. The estimates in columns (1) and (2) are obtained using the random effects model. It is particularly worth noting that the estimates in the random effects model might be inconsistent when the explanatory variables are assumed to be exogenous rather than endogenous variables. To solve this problem, the system-GMM estimates using the differentiated lagged explanatory variables as instrumental variables are displayed in columns (3) and (4). The Hansen J tests at the bottom of Table 3 are larger than the 5% critical value, indicating that we do not reject the null hypothesis of overidentifying restrictions and show that a proper specification of instruments is valid. Moreover, the results of the Arellano-Bond tests present no second-order serial correlation in the first-differenced residuals. It can thus be clearly seen that our setting for system GMM estimates is suitable.[8]

The results are as anticipated and are quite similar to those of previous studies. The estimated coefficient of firm size is positive and significant at the 10% significance level, implying that larger firms have better resources and capability, thus enabling the firms to gain a competitive advantage, and in turn further enhancing their productivity. The positive coefficient at the 1% statistical level for the capital-labor ratio indicates that the adoption of technology with higher capital intensity often leads to higher technological knowledge. As for human capability, focusing on human capability can often enhance the ability to identify and absorb new information, thereby helps firms better appraise the host environment and the current resources and capability although the effect is not significant here.

Turning to the overseas operations, the positive and significant estimated coefficient at the 5% statistical level indicates that more overseas experience in terms of knowledge of local markets can help firms to achieve better productivity. As for the host country environment, the positive and significant coefficient of local demand growth at the 10% statistical level implies that a larger local demand growth in the host countries will provide opportunities for firms to exploit their current capability and resources, thereby enhancing their performance. Alternatively, the negative coefficient of local technological capacity implies that there is a negative effect on performance, although the negative effect is not significant here.

Our main concern in this empirical analysis is to assess the effects of the overseas R&D activities on firm productivity and to examine whether the effects are sensitive to firms' technological capability. First, the significant

[8] The empirical model includes one-year lagged dependent variable and all independent variables, are treated as endogenous variables to control endogeneity problem in system GMM. One and more year lagged variables (up to two or three lags depending on the length of time periods in model specification) of the endogenous variables are used as instruments in the difference equation, while the current and one-year lagged differences are used in the level equations.

and positive coefficient supports the first hypothesis that higher overseas R&D activities not only raises the efficiency of resources and capability, but also speeds up the pace of new product development, thereby bringing higher firm productivity.

Table-3. Results of the Panel Data Model over the 2009-2012 Period

	Random Effects Model			System GMM Model	
Variables	**(1)**	**(2)**		**(3)**	**(4)**
Firm Size	0.509* (1.70)	1.821** (1.99)		1.416** (2.44)	1.298*** (3.03)
Capital-labor ratio	-0.668 (-1.52)	0.8145 (-1.17)		1.427*** (-2.84)	0.957*** (-3.98)
Human capability	2.179 (0.57)	1.949 (0.51)		1.629*** (5.46)	1.098 (0.89)
Overseas operating experience	0.147** (2.32)	0.152** (2.33)		0.915** (2.45)	1.113*** (2.78)
Local demand growth	1.780* (1.83)	1.739* (1.92)		0.535*** (3.97)	0.654*** (2.63)
Local technology capacity	-0.180 (-0.14)	-0.108 (-0.08)		-1.864 (-1.17)	-5.994 (-1.01)
Technological capability (TC)	0.435*** (5.89)	0.406*** (4.49)		0.832*** (5.63)	0.659*** (4.02)
Overseas R&D (ORD)	2.338*** (7.58)	1.548*** (8.97)		1.708*** (3.00)	2.049** (2.03)
TC*ORD	_	1.926*** (7.41)		_	1.915** (2.02)
Firm Productivity (-1)				0.436*** (8.92)	0.573*** (4.23)
Constant	21.368*** (7.87)	26.800*** (19.53)		_	_
Industry Effect	Yes	Yes		Yes	Yes
R-squared	0.724	0.745		-	-
Hansen J test	_	_		0.067	0.084
Arellano-Bond test for AR(1)				0.000	0.001
Arellano-Bond test for AR(2)				0.102	0.078
Number of firms (Observations)	327 (1,635)				

Notes: 1. The dependent variable is firm productivity.

2. The numbers in the parentheses are the t statistics.

3. ***, **,* denote significance at the 1%, 5% and 10% levels, respectively.

This result is consistent with the results in previous studies such as Tsai (2004). Next, the significant and positive coefficient for technological capability suggests that firms with more technological capability will have better productivity. In sum, the empirical indicating that both technological capability and overseas R&D are important determinants for firms to accelerate the pace of new product development, which will increase competitive advantage and lead to better productivity.

As for the moderating effect of technological capability, the positive and significant coefficients at the 1% statistical level imply that technological capability plays a crucial moderating role for the second hypothesis that when firms engage in overseas R&D activities in the host country to raise their firm productivity. These empirical results provide helpful issues that the managers should raise firstly their technological capability and then develop their overseas R&D strategy in the local collaborative environment, because higher technological capability will enable them not only to improve the efficiency of existing capabilities, but also to enhance the effectiveness of new capabilities and resources, which in turn will raise their productivity to a greater extent than for firm without enough technological capability.

5. CONCLUSION

This study has presented an empirical framework to explain how a firm's overseas R&D activities determines its firm productivity and how internal technological capability play a significant moderating effect. To provide more empirical evidence, two corresponding hypotheses are postulated and are empirically tested in this study. Moreover, the analysis takes advantage of the longitudinal dataset compiled by the Ministry of Economic Affairs, Taiwan for 2009-2013. In addition, the system-GMM for panel data model is employed in this empirical analysis due to the problem of endogeneity, for this technique can enable us to provide insightful results regarding the influence of overseas R&D activities on firm productivity over time.

The findings of this study are twofold. First of all, this study has identified our first hypothesis that the utilization of overseas R&D activities has a significantly positive contribution to the firm productivity. It should be borne in mind that such an outcome implies that managers should underscore the importance of developing more overseas R&D to achieve higher productivity. Next, we also found that internal technological capability plays a significant moderating role in strengthening the influence of overseas R&D on firm productivity. In particular, lacking such technological capability will limit the potential for firms not only to identify, search and assimilate some information on the local market but also to acquire for new technology learning opportunities when firms develop the overseas R&D to enhance their productivity. These findings from this research have broadened and deepened our understanding of how firms enhance their competitive advantage and improve their performance.

Although this article provides some interesting results, there are some limitations in this study. First of all, although the sample used in this study is large in size, the time series encompasses only five years (2009-2013). This result cannot fully explain the time-dimensional difference across firms since the time period is not long enough. Secondly, to simplify our discussion, this study does not distinguish overseas R&D between market-oriented and technology-oriented activities in the host country, which constitutes an important step in future research. Thirdly, this study is confined to firms in the manufacturing industry that are suitable for testing our framework. However, this approach also restricts the generalization of our results to some extent. Comparative studies involving firms in other industries such as the services industry would be useful to test the framework. Finally, there is still a long way to go to establish a well-developed and complex construct of technological capability to improve our understanding of the moderating effect of technological capability. Although there are some limitations, this study does still provide some interesting results for managers in the enhancement of their productivity captured by a firm's overseas R&D.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study.

REFERENCES

Athreye, S., G. Batsakis and S. Singh, 2013. Subsidiary embeddedness is a strategic choice: Complementarity and the factors associated with different types of embeddedness. DRUID Working Paper No. 13-05.

Aw, B.Y., X. Chen and M. Roberts, 2001. Firm-level evidence on productivity differentials and turnover in Taiwanese manufacturing. Journal of Development Economics, 66(1): 51-86.

Belderbos, R., K. Fukao and T. Iwasa, 2006. Domestic and foreign R&D investment: Evidence from Japanese multinationals. Working Paper, No. 2006-1, Hitotsubashi University.

Blonigen, B. and C. Taylor, 2000. R&D intensity and acquisitions in high-technology industries: Evidence from the US electronic and electrical equipment industries. Journal of Industrial Economics, 48(1): 47-70.

Blundell, R. and S. Bond, 1998. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics, 87(1): 115–143.

Blundell, R., S. Bond and F. Windmeijer, 2000. Estimation in dynamic panel data models: Improving on the performance of the standard GMM estimator. In nonstationary panels, panel cointegration, and dynamic panels. Advances in Econometrics 15, edited by B. Baltagi. New York: Elsevier. pp: 53–92.

Cantwell, J., J. Dunning and S. Lundan, 2010. An evolutionary approach to understanding international business activity: The co-evolution of MNEs and the institutional environment. Journal of International Business Studies, 41(4): 567-586.

Chen, H. and T. Chen, 2002. Asymmetric strategic alliances: A network view. Journal of Business Research, 55(12): 1007-1013.

Chen, H. and T. Chen, 2003. Governance structures in strategic alliances: Transaction cost versus resource-based perspective. Journal of World Business, 38(1): 1-14.

Chesbrough, H.W., 2003. Open innovation: The new imperative for creating and profiting from technology. Boston: Harvard Business School Press.

Choi, S. and l. Ko, 2012. Leveraging electronic collaboration to promote interorganizational learning. International Journal of Information Management, 32(6): 550-559.

Chuang, W.B. and H. Lin, 2010. Interdependence between overseas and domestic R&D activities: Evidence from Taiwan-based multinationals model. Asian Economic Journal, 24(4): 305-332.

Chuang, W.B. and H. Lin, 2011. Overseas R&D activities and intellectual property rights: A longitudinal study of MNEs in emerging economies. Technology Analysis & Strategic Management, 23(2): 175-189.

Cohen, W.M. and D.A. Levinthal, 1990. Absorptive capacity: A new perspective on learning and innovation. Administrative Science Quarterly, 35(1): 128-152.

D'Agostino, L.M. and G.D. Santangelo, 2012. Do overseas R&D laboratories in emerging markets contribute to home knowledge creation? Management International Review, 52(2): 251 -273.

Ding, X. and R. Huang, 2010. Effects of knowledge spillover on inter-organizational resource sharing decision in collaborative knowledge creation. European Journal of Operational Research, 201(3): 949–959.

Florida, R., 1997. The globalization of R&D: Results of a survey of foreign-affiliated R&D laboratories in the USA. Research Policy, 26(1): 85-103.

Hagedoorn, J. and N. Wang, 2012. Is there complementarity or substitutability between internal and external R&D strategies? Research Policy, 41(6): 1072-1083.

Hallin, C., U. Holm and D.D. Sharma, 2011. Embeddedness of innovation receivers in the multinational corporation: Effects on business performance. International Business Review, 20(3): 362-373.

Hervas-Oliver, J.L. and J. Albors-Garrigos, 2009. The role of the firm's internal and relational capabilities in clusters: When distance and embeddedness are not enough to explain innovation. Journal of Economic Geography, 9(2): 263-283.

Im, G. and A. Rai, 2008. Knowledge sharing ambidexterity in long-term interorganizational relationship. Management Science, 54(7): 1281–1296.

Iwasa, T. and H. Odagiri, 2004. Overseas R&D, knowledge sourcing, and patenting: An empirical study of Japanese R&D investment in the US. Research Policy, 33(5): 807-829.

Kuemmerle, W., 1997. Building effective R&D capabilities abroad. Harvard Business Review, 75(2): 61-69.

Kuemmerle, W., 1999. Foreign direct investment in industrial research in the pharmaceutical and electronics industries – results from a survey of multinational firms. Research Policy, 28(2-3): 179-193.

Lokshin, B., R. Belderbos and M. Carree, 2008. The productivity effects of internal and external R&D: Evidence from a dynamic panel data model. Oxford Bulletin of Economics and Statistics, 70(3): 399-413.

Ramstetter, E., 1999. Comparisons of foreign multinationals and local firms in Asian manufacturing over time. Asian Economic Journal, 13(2): 163-203.

Sanders, N.R., 2008. Pattern of information technology use: The impact on buyer–suppler coordination and performance. Journal of Operations Management, 26(3): 349–367.

Schmiedeberg, C., 2008. Complementarities of innovation activities: An empirical analysis of the German manufacturing sector. Research Policy, 37(9): 1492–1503.

Song, J. and J. Shin, 2008. The paradox of technological capabilities: What determines knowledge sourcing from overseas R&D operations? Journal of International Business Studies, 39(2): 291-303.

Song, M., H. Van Der Bij and M. Weggeman, 2006. Factors for improving the level of knowledge generation in new product development. R&D Management, 36(2): 173–187.

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

Tsai, K.H., 2004. The impact of technological capability on firm performance in Taiwan's electronics industry. Journal of High Technology Management Research, 15(2): 183-195.

Williamson, O.E., 1985. The economic institutions of capitalism. New York: Free Press.

APPENDIX

The firm productivity index is calculated separately for each firm of the four-digit industries in the manufacturing sector. The multilateral TFP index has been adopted by Aw *et al.* (2001) and is constructed by the industry mean level of log output, log input, and input cost shares in this study. The TFP index for firm i in year t is thus calculated as follows:

$$\ln TFP_{it} = \begin{array}{l} \left(lnVA_{it} - \overline{lnQ_t}\right) + \sum_{s=2}^{t}\left(\overline{lnVA_s} - \overline{lnVA_{s-1}}\right) \\ \quad - \left[\sum_{j}\frac{1}{2}\left(\alpha_{ijt} + \overline{\alpha_{Jt}}\right)\left(lnX_{ijt} - \overline{lnX_{Jt}}\right)\right] \\ + \left[\sum_{s=2}^{t}\sum_{j}\frac{1}{2}\left(\overline{\alpha_{Js}} + \overline{\alpha_{J(s-1)}}\right)\left(\overline{lnX_{Js}} - \overline{lnX_{J(s-1)}}\right)\right] \end{array}$$

where □□ VA_{it}, lnX_{ijt}, and αijt are the log value added, input j, and the cost share of input j for firm i in year t. $\overline{\text{lnVAt}}$, $\overline{\text{lnXJt}}$, and $\overline{\alpha\text{Jt}}$ are the mean of the corresponding variable for all firms in the industry in year t. The first term is the deviation of firm i's value added from the industry mean level in year t, and the second term captures the growth of industry value added relative to the initial year. The last two terms are the same operations for the deviation of input usage weighted by the corresponding cost shares of inputs. Firm value added is defined as the production value deflated by a wholesale price index defined at the four-digit industry level. We use two inputs in the production to construct the TFP: labor and capital. The labor input is measured by the number of employees. Labor expenditures are measured as total salaries paid by the firm. We use the sum of the interest and depreciation of fixed assets as the measure of capital input. In addition, we deflate the change in each firm's book value by a price index for new capital goods. The cost shares for labor and capital are measured as the input expenses divided by the value of firm output.