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THE GOVERNANCE DECISIONS FOR A R&D OFFSHORING FIRM

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Abstract

The purpose of this study is to verify the potential difference in different governance decisions (captive and outsourcing mode) for a R&D offshoring firm. Due to the specific feature of technological assets, we particularly pay attention to the relationships between governance decisions and the motivations to offshore R&D. This analysis takes advantage of the longitudinal dataset on Taiwan-based manufacturing firms for the period 2009-2012 and employs a propensity score of multinomial choice method to correct the bias from the potential outcomes in observational data. We show that outsourcing mode bring a larger firm productivity for exploitation-orientation firms, while captive mode is observed for exploration-orientation cases. With the transform of network integration from OEM arrangements to ODM arrangements in global value chain activities, a R&D offshoring firm will change its governance mode for the local environment to raise productivity. The results offer useful implication for academia and policy makers.

Keywords: Offshore R&D, Governance Decision, Network Transform, Global Value Chain and Taiwan-Based Firms.

Introduction

Offshoring strategy has received considerable attention in recent years. Such strategy plays an important role in terms of reducing production cost, leveraging activities worldwide, and responding to global market change, thereby enhancing sustainable competitive advantages (Fabio et al., 2021; Jensen and Pedersen, 2012). Meanwhile, more and more firms start to offshore higher added value activities such as research and development (R&D) to another country (Jaana, 2021; Almahendra and Ambos, 2015). R&D offshoring in essence has been considered to be an external technology sourcing strategy for competence exploiting and competence exploring motivations (Shotaro et al., 2021), the former (exploitation-orientation) focuses on the exploitation of existing technological assets such as refinement, implementation and execution in their environment; the latter (exploration-orientation) focuses on the exploration of new capabilities from the external environment by engaging in fundamental research, experimentation, and search (Ambos and Ambos, 2009; Nieto and Rodriguez, 2013; Im and Rai, 2008).

R&D offshoring firms can choose different governance modes in the host country. They can establish its own R&D operation (captive mode) or outsource them to other firms in the host country (outsourcing mode). In particular, captive mode can be associated with internalization advantages such as lower coordination cost, few leaks of technical assets and lower transaction costs. Outsourcing mode by contrast eliminate bureaucracy costs and the higher fixed costs of establishing a foreign subsidiary (Nieto and Rodriguez, 2013).

Most importantly, we pay attention to the interesting linkage between the governance modes for R&D offshoring strategy and their motivations.

We argue that the motivations R&D truly challenge the effects and technology transfer based on the collaborative relationships, which in turn influences the governance decisions to offshore (Jeongho, 2020; Rilla and Squicciarini, 2011). When (exploitation-orientation) R&D offshoring firms customize their existing products and technological capabilities for the local market, local counterparts can help them to identify and assimilate some information on the local market and manufacturing conditions (Nieto and Rodriguez, 2013). In this case, such firms are more likely to choose the outsourcing mode to improve the efficiency of existing technology capabilities, thereby enhancing their productivity.

On the other hand, when (exploration-orientation) R&D offshoring firms wish to benefit from the relevant knowledge exchange in the host country to augment their technological knowledge or capabilities, R&D offshoring strategy based on local collaborative relationships can provide a channel for transferring knowledge back from their foreign location to the home country (Añón et al., 2011). The local collaborative relationships are associated with firm productivity, providing an important re-allocative channel for firms to enhance their effectiveness of technologic and knowledge assets. This is referred to in the literature as 'reverse technology transfer' (Ambos and Ambos, 2011). In this case, if the absorptive capacity plays a key role to raise the effectiveness of external knowledge resources' transfer, such firms will choice captive mode in the local environment.

This paper contributes to an intense debate on fragmenting theory and international business study. First of all, we provide a framework in which to explicitly verify the potential difference in different governance decisions for a R&D offshoring firm. By verifying the significance, we fill this gap by paying attention to the relationships between governance decisions and their motivations. This has been neglected in most cases so far. Secondly, Taiwan is an appropriate empirical setting to conceptualize the governance decision for R&D offshoring activities, because it occupies a middling position in the technological league. By using the comprehensive dataset information for Taiwan-based manufacturing firms covering the 2009-2012 period, the empirical results thus will provide in-

sights into the existing literatures obtained originally by focusing only on developed economies.

Following on from this introduction, the remainder of this paper is organized as follows. Section 2 proposes the background and hypotheses used in this study. This is followed by Section 3, which introduces the aggregate feature of Taiwan-based R&D offshoring firms that includes motivations and governance mechanism. Section 4 provides an introduction to the research methodology, including both the model and variable selections employed in the estimations. The empirical results of the estimations are presented in Section 5. The paper concludes with some remarks on the findings in the final section.

Background and Hypotheses

An increasing number of studies has found that the external network plays a crucial role in their strategic resources and specific capability building to respond to local needs quickly and establish stronger strategic positions in global environment (Xiao, et al., 2020; Ambos and Ambos, 2009; Chuang and Lin, 2010). The inter-organizational collaboration has been considered to consist of not only pure transactions but also of sharing knowledge and leveraging dispersed core resources in exploiting existing competencies and exploring new learning opportunities (Cui et el., 2020; Im and Rai, 2008).

Recent studies have emphasized the importance of offshoring activities and their strategy patterns have become one of the most important issues in international business (Almahendra and Ambos, 2015; Ambos and Ambos, 2009, 2011). Likewise, the R&D offshoring strategy based on local collaborative relationships has received considerable attention not only in identifying and assimilating some information on the local market but also searching and acquiring for new technology learning opportunities, thereby obtaining a leading position in the technology field (Cohle, 2021; Chuang and Lin, 2011; Hallin et al., 2011).

Firms can choose different governance modes for their R&D offshoring activities. They can establish its own R&D operation (captive mode) or

outsource them to other firms in local environment (outsourcing mode). Captive mode can be associated with internalization advantages such as lower coordination cost, few leaks of technical assets and lower transaction costs. On the contrary, outsourcing mode can eliminate bureaucracy costs and the higher fixed costs of establishing a foreign subsidiary (Raab et al., 2014; Nieto and Rodriguez, 2013).

In particular, the motivations to offshore R&D challenge the effects and technology transfer based on the collaborative relationships, which in turn influences the governance decisions. On the one hand, when (exploitation-orientation) firms customize their existing products and technological capabilities in the local market, local counterparts can help them to identify and assimilate some information on the local market and manufacturing conditions (Nieto and Rodriguez, 2013). The benefits arising from the integration and sharing of knowledge, the ability to exploit information and quickly changing structures will enable firms to modify their products or processes soon as well as maximize their asset utilization in the market (Im and Rai, 2008; Rilla and Squicciarini, 2011). In such case, such firms are more likely to choose the outsourcing mode in improving the efficiency of existing technology capabilities. Given the above viewpoints, the hypothesis is as follows:

Hypothesis 1a (H1a): There are larger productivity effects in the case of outsourcing than captive mode of governance mechanism for R&D offshoring firms to exploit their existing products, process and capabilities in local environment.

When firms wish to augment their technological knowledge or capabilities from the relevant knowledge exchange in the host country, the collaborative relationships also serve as an important channel for organizational learning (Im and Rai, 2008). The inter-organizational relationships help firms to develop domain-specific technology assets through the inter-organizational learning, which can speed up more competitive innovations and the development of new-products/processes. Likewise, R&D offshoring strategy also provide a channel for transferring knowledge back from their foreign location to the home country (Pisani and Ricart, 2018; Añón et al., 2011). This is referred to in the literature as 're-

verse technology transfer' (Ambos and Ambos, 2011).

Many studies found that the absorptive capacity is required to raise the effectiveness of external knowledge resources' transfer (D'Agostino and Santangelo, 2013). The open innovation views not only suggest the importance of external knowledge, it also emphasizes that firms should organize their internal R&D activities to absorb the available external knowledge (Zhou et al., 2019). Likewise, (exploration-orientation) firms always be required a minimum level of absorptive capacity resources to raise the effectiveness of external knowledge resources transfer. Chuang and Lin (2011) further found that the influence of subsidiary R&D is larger than that of parent R&D in strengthening the influence of R&D offshoring on firm productivity due to the proximity to knowledge. In such case, firms should establish their own R&D operations in their foreign subsidiary (captive mode) more to raise their absorptive capacity in accessing advanced knowledge and technological capability. Given the above viewpoints, the hypothesis is as follows:

Hypothesis 1b (H1b): There are larger productivity effects in the case of captive than outsourcing mode of governance mechanism for offshoring R&D firms to improve their stock of knowledge and technological capabilities in the host countries.

Taiwan-Based Firms' R&D Offshoring Activities

The manufacturing advantages of global value chain activities offer Taiwan-based manufacturing firms the opportunities to build the cooperative relationships with leading foreign firms. The network integration has moved up from very simple original equipment manufacturing (OEM) arrangements, which focus on cost saving to increasingly complex original design/Brand manufacturing (ODM/OBM) arrangements, which involve product development (Li et al., 2020; Chen and Chen, 2002, 2003). To develop core competitive capability in design engineering, Taiwan-based manufacturing firms typically concentrate on a specialized field of applica-

tion or technology and constantly augment their technological knowledge or capabilities.

Table 1 shows the distribution of R&D offshoring by Taiwan-based manufacturing firms. A total of 692 of the 2,075 observations (33.34%) are found to have implemented R&D offshoring strategy in local environment. China occupies the greatest number of R&D offshoring cases among the host countries, followed by the U.S. and Vietnam. The share in DCs is larger than that in LDCs. USA and the Association of Southeast Asian Nations (ASEAN) countries have been the major overseas destinations for Taiwan-based manufacturing firms since the 1990s. China is highly preferred destination for most Taiwan-based manufacturing firms owing to culture and language similarities along with lower labor costs and huge market size. As expected, more and more Taiwan-based manufacturing firms are engaging in R&D offshoring strategy and we also can see that Taiwan-based manufacturing firms can be mainly characterized by the outsourcing of their R&D activities to East Asian (China and/or ASEAN).

Table 2 shows the main motivations for R&D offshoring strategy. Reducing production costs accounts for more than 60% of the cases, even reaching 74.10% in 2011, followed by expanding new markets (more than 54%) and improving process quality (more than 47%). New product development and accessing local R&D networks are the fourth and fifth place, respective, while there are still limited to a small segment and an increasing trend. Tax treatment and government subsidy are not observed as an important motivation. We can thus see that the main motivations are still the exploitation-orientation of existing knowledge and technical assets. At the same time, an increased sharply can be observed in accessing local R&D networks, jumping from 10.78 % in 2009 to 21.16% in 2012. This reflects the fact that the exploration-orientation to augment firm's capabilities such as accessing local R&D networks has been increasing over the period. As a result, it is worth examining whether there are different influences between exploitation-orientation and exploration-orientation.

A R&D offshoring firm faces two modes of governance mechanism:

they can offshore its R&D services by either to own subsidiaries in another country (captive mode) or by outsourcing R&D work to other firms in the host country (outsourcing mode). We follow UNCTAD (2004), those firms that the R&D services is provided through inter-firm activities rather than simply contracting-out to other independent legal entities are considered as outsourcing mode group. Table 3 shows the distribution of governance mode to offshore R&D. The share of R&D offshoring accounts for more than 30% and remained a steady trend.

Interestingly, the share of captive mode was observed to remain at a lower level but with an upward trend from 12.58% to 23.80%, while the share of outsourcing mode has been at a higher level but with a downward trend from 22.38% to 12.25. Is there trade-off between the captive mode and the outsourcing mode correlated with the transform of motivation to offshore R&D? They must be further examined.

Methodology

To explore the decisions of governance mechanism for R&D offshoring firms, theory studies argued that each individual should have a pair of outcomes (productivity) between captive mode and outsourcing mode. However, it is impossible to measure such effects at the individual level, since we never observe the potential (counterfactual) outcome in observational studies. Namely, each individual receives only one observable outcome in observational empirical studies. Such unobservable productivity is referred as the potential (counterfactual) outcomes in observational data. To correct the bias from the effects of potential outcome and self-selection problem in observational data, this study employs a propensity score method (PSM) of the multiple treatment that was developed by Lechner (2001) to mimic the potential outcomes for each individual even the state (mode) did not happen. In such case, we can easily examine the potential difference in different governance mode directly.

We firstly use the multinomial response model to obtain the (estimated) predicted probability which will be denoted as the propensity score. Then, matching methods based on the

Table 1. Distribution for R&D Offshoring by Country

	Number of firm (1)	Engaging in R&D Offshoring Strategy: Number (2)	Engaging in R&D Offshoring Strategy: % Of Firms (3) = (2) / (1)
DCs	201	68	38.80
United States	117	40	34.18
European	32	4	12.50
Hong Kong	30	6	20.00
Singapore	9	4	44.44
Canada	5	2	40.00
Japan	5	3	60.00
South Korea	6	3	50.00
Other American Country	20	6	30.00
LDCs	1,874	624	33.29
China	1,772	584	32.95
Vietnam	28	13	46.42
Thailand	16	9	56.25
Malaysia	10	6	60.00
Indonesia	9	4	44.44
Philippines	6	5	83.33
Other Asian Countries	10	3	30.00
Observations	2,075	692	33.34

Notes: 1. Source: Calculated by the study, based on the databank of Investment Commission, 2009-2012, MOEA.
2. If a firm has an experience to carry out her R&D services to another country then the firm is considered to be R&D offshoring firm.
3. The numbers are the total number of firms engaging in a R&D offshoring strategy in the host country.

Table 2. Motivations for R&D Offshoring Strategy

Unit: %

	2009	2010	2011	2012
Reducing Production Cost	63.57	69.42	74.10	69.70
Expanding New Markets	65.00	54.28	54.98	54.37
Improving Process Quality	47.14	52.57	56.17	50.36
New Product Development	46.15	49.71	55.77	52.55
Accessing Local R&D Networks	10.78	15.14	13.14	21.16
Tax Treatment and Subsidy	11.54	13.14	12.93	14.96
Others	6.78	4.57	5.57	7.66

Notes: 1. Source: Calculated by the study.
2. Multiple answers are possible.
3. The numbers are the total number of firms engaging in a R&D offshoring strategy in the host country.

Table 3. Governance Decision for R&D Offshoring

propensity score will be used to assess whether the propensity score has been adequately specified for active individuals in matched sample. Two different criteria, kernal matching and caliper matching, are employed to determine the optimal match (Leuven and Sianesi, 2003). Once such matched individuals have been formed, the (average) outcomes for matched individuals, which have similar characteristics with such an active individual in term of the propensity score, will be considered as the counterfactual outcome for this active individual in observational data.

Data and Sample

To understand the governance mechanism for Taiwan-based manufacturing R&D offshoring firms, a longitudinal dataset is taken from the Report on Foreign Investment Strategies of the Manufacturers provided by the Department of Statistics of the Ministry of Economic Affairs (MOEA), Taiwan for 2009-2012. This dataset provides detailed data such as size, sales and technology sources and their most prominent subsidiary, classified by their destinations and sources based on the amount of investment from a list of 18 countries and regions.

To identify the three groups of observations, we firstly divide our sample into two groups according to whether the observation had implemented R&D offshoring strategy or not. A firm is considered to be a R&D offshoring group when she has experience to offshore their R&D activities and services to another country, while those groups, which did not implement such strategy, are considered to be non-offshoring.

Then, we follow UNCTAD (2004), when R&D services are only offshored to the independent firms, it is considered to be outsourcing mode,

while those groups that R&D services are offshored to firms' own subsidiaries are considered as captive mode.

Lastly, we are interested to understand whether the governance decisions are diverse under different kinds of motivation to offshore R&D, the sample further classifies two categories based on their motivation. The individual is considered to be exploitation-orientation when the motivation is only 'Reducing Production Cost', 'Improving Process Quality' or 'Expanding New Markets, while the motivation includes 'New Production Development, or 'Accessing Local R&D Networks, it is considered to be exploration-orientation.

Variable Selection

Three types of explanatory variables are employed in multiple choice model based on existing studies (Cantwell and Mudambi, 2005). The first one comprises the firm-specific factors that include the firm size, domestic R&D and labor intensity. The second one consists of the subsidiary-specific factors, which include subsidiary size, subsidiary R&D, market localization, local purchase, and export ratio. The third one considers the host countries characteristics, which account for the local environment faced by the firms. The factors include local demand, local technological capacity, and intellectual property rights (IPR) protection in the host countries. Finally, time and industry dummies are included in which industry dummies are included that control for the difference in technological opportunity in different kinds of industry. The explanatory variables are briefly explained below.

In terms of the firm-specific factors, captive offshoring more often involves a large amount of fixed costs and only larger firms are able to bear these costs (Ono and Stango, 2005). On the contrary, larger firms are more likely to engage in R&D cooperation with its clients and suppliers (Chun and Mun, 2012). Larger firms are thus expected to have a greater likelihood to offshore their R&D activities to own subsidiary or offshore vendors. R&D intensive firms are outsourcing more in open innovation strategies (Das and Teng, 2000). However, a higher asset specificity means firms suffer from greater risk and difficulty in modifying their products or processes (Im and Rai, 2008). Firms with greater R&D are expected to be associated with the decision for captive mode and outsourc-

ing mode simultaneously. The labor-intensive production reflects that knowledge is mainly embedded in the labor force (Ramstetter, 1999). The higher labor intensity is thus expected to be more likely to use outsourcing mode to enhance the efficiency of existing technological assets.

Concerning the subsidiary-specific factors, firms often conduct more local activities to strengthen the local environment penetration (Chuang and Lin, 2011). The market localization is thus to be expected to have a positive impact on the propensity to outsource their R&D services (Martínez-Noya and García-Canal, 2011). Size is founded to be positively associated to external cooperation for innovation (Chun and Mun, 2012) and to enjoy economies of scale and scope (Ono and Stango, 2005). We expect larger subsidiaries thus tend to offshore R&D service to own subsidiaries or local counterparts. By utilizing subsidiary R&D, firms not only can create synergies from exploiting existing capabilities in the local market, but also can have opportunities to access desired technological capabilities (Marin and Sasidharan, 2010). Subsidiary R&D is thus expected to be associated with the decision for captive mode and outsourcing mode simultaneously. Prior experience in local purchase is found to be an important determinant for the exploitation of their current capabilities in the local market (Prestini and Sebastiani, 2021; Moore et al., 2020). Firms with more local purchase are expected to prefer to adopt the outsourcing mode. A firm with greater export from host country often develops closed relationships with global firms to win their next orders in host country (Chen and Chen, 2002, 2003). Firms with higher local export ratio thus tend to outsource more R&D activities in local market.

As for the host environment characteristics, a larger local demand growth reflects a greater opportunity for a firm to exploit its existing capabilities at foreign locations (Ancarani et al., 2021; Bustamante et al., 2021). It is thus expected to have a positive influence on the offshore R&D decision and firms will prefer to use the outsourcing mode to understand the local consumer and manufacturing

conditions. Firms are more likely to operate in the host countries with abundant capacity for learning technology (Belderbos et al., 2013). Local technological capacity is thus expected to have a positive effect and firms have greater propensity to use their foreign subsidiary to benefit from localized spillovers.

The degree of IPR protection accounts for the protection of intellectual property rights and we expect that there will be a positive impact on the decision to offshore their R&D activities to local counterparts. Indexes for the degree of IPR protection in the host countries is obtained from the World Economic Forum (WEF). Finally, we added the time and industry dummies in the empirical model. Firm productivity is used to measure the performance of the utilization of R&D offshoring strategy. The firm productivity is defined by total factor productivity (TFP).

Empirical Results

To construct counterfactual observations, the empirical results of the multinomial logit model are presented in Table 4, from which we can derive the propensity score for each individual. We employ two matching algorithms (Caliper matching and Kernel matching) and check the robustness of our estimation results. Models (1) and (2) in Table 5 provide ATT estimators for multiple treatments and show the potential differences in governance modes when firms utilize R&D offshoring strategy to enhance firm productivity.

The empirical results in the multinomial logit model in Table 4 are consistent with the previous empirical studies. In terms of the firm-specific factors, empirical results show that firms with the larger firm size and greater R&D are more likely to adopt captive mode and outsourcing mode simultaneously (Chun and Mun, 2012). Firms with higher labor-intensive will choose outsourcing mode.

Turning to the subsidiary-specific factors, the larger subsidiary or subsidiary with more R&D is found to likely to tend to develop R&D activities themselves and local counterparts at the same time. The prior experience in local purchase play a significant role in increasing its probability of outsourcing R&D for their current capabilities (Rahko, 2021; Lee, 2020). Finally, a more export-oriented firm is found to be likely to develop outsourc-

ing mode (Chen and Chen, 2002, 2003).

As for the host country environment, a larger local demand growth encourages firms to use the outsourcing mode to understand the local consumer and manufacturing conditions (Shimizutani and Todo, 2008). On the contrary, a greater propensity to use their foreign subsidiaries can benefit from localized spillovers for learning technology (Belderbos et al., 2013). Finally, the stronger IPR protection in the host countries will be a positive impact on the decision to offshore their R&D activities to local counterparts in exploiting its existing capabilities at foreign locations.

The main concern of this study is to assess the potential differences in governance modes and examine the relationships with the different kinds of motivation when firms utilize R&D offshoring strategy to enhance firm productivity. All coefficients in Table 5 obtained are positive and significant, implying R&D offshoring strategy based on local collaborative environment i ests em nd McFadden (stpacity in 38383838383838383838383838383838383838383838383838 38383838383838383838383838383838383838383838383838 38383838383838383838383838383838383838383838383838 [38] ndeed not only improve the efficiency of existing capabilities, but also enhance the effectiveness of new capabilities and resources than non-offshoring firms.

The empirical results of ATT estimators in Model (1) and (2) in Table 5 indicate significantly difference between captive mode and outsourcing mode. Moreover, the productivity-enhancing effect significantly differs between exploration-orientation and exploitation-orientation. On the one hand, the average treatment effects for captive mode are significantly positive and fluctuated, ranging from 7.5% to 18.3%. Moreover, the average effects for exploration-orientation are larger than those for exploitation-orientation. The empirical results show that (exploration-orientation) firms are more likely to choose captive mode in accessing advanced knowledge and technological capability in the local environment.

On the other hand, these empirical results in model (2) show that the estimated average treatment effects for

outsourcing mode are significantly positive, ranging from 7.3% to 16.2% and the productivity-enhancing effects for exploitation-orientation are larger than those for exploration-orientation. The results reflect when firms use the R&D offshoring strategy to adapt and exploit current technology capabilities in conjunction with local market and manufacturing conditions, they are suggested to choose outsourcing mode more to benefit the collaborative advantages in the host country.

In sum, these empirical results show the significant differences in the decision of governance modes for the different kinds of motivation when firms utilize R&D offshoring strategy in the local collaborative relationships to enhance their productivity.

Conclusion

To understand how a R&D offshoring firm choose her governance mode (captive and outsourcing mode) to raise their productivity. We further pay attention to the relationship between the potential differences in the different governance modes and the motivation to offshore R&D. However, an unbiased estimate at the individual level cannot be obtained directly, since we never observe the counterfactual outcome in observational data. To fill the gaps, this study employs a propensity score of multinomial choice method, which enable us to construct potential outcomes problem. The analysis also takes advantage of the longitudinal dataset for subsidiaries of Taiwan-based manufacturing firms by the Ministry of Economic Affairs (MOEA) for 2009-2012, Taiwan in order to provide more empirical evidence.

The findings of this study are as follows. First of all, this study has identified that when a R&D offshoring firm exploit their existing technologic assets to enhance productivity, they should outsource more R&D services to other firms in the host country. Since local collaborative relationships can help them not only to identify and assimilate local information but also to share risks and information more (Ambos and Ambos, 2009, 2011). Secondly, this study confirms the importance of absorptive capacity at foreign subsidiary in enhancing the effectiveness of external technology transfer (Nieto and Rodriguez, 2013). To access local sources of excellence for technology learning purposes through local collaborative relationships, a R&D offshoring firm should attempt to

Table 4. Results of the Multinomial Logit Model for 2009-2012

	(1) Captive Mode	(2) Outsourcing Mode
Firm-Specific Factor		
Firm Size	1.268***	0.647*
Log (Firm sale)	(3.68)	(2.08)
Domestic R&D	0.198**	0.209***
Log (Domestic R&D / Firm Sale)	(1.99)	(2.81)
Labor Intensity	-0.031	0.064**
Log (Employee/ Firm Sale)	(-0.19)	(2.10)
Subsidiary-Specific Factor		
Subsidiary Size	1.591***	0.782***
Log (Subsidiary Sale)	(4.74)	(2.67)
Subsidiary R&D	0.391**	0.131*
Log (Subsidiary R&D / Subsidiary Sale)	(2.21)	(1.82)
Local Purchase	-0.005	0.003**
Ratio of local intermediate goods purchased	(-1.39)	(2.03)
Market Localization	-0.037	0.022**
Subsidiary Sale/ Firm Sale	(-1.51)	(2.13)
Local Export Ratio	-0.005	0.003*
Export/ Subsidiary Sale	(1.17)	(1.91)
Environment Factor in Host Country		
Local Demand Growth	0.051*	0.079**
	(1.65)	(2.36)
IPR Protection	-0.435	0.713***
	(-1.48)	(2.36)
Local Technology Capacity	0.071*	0.240
Log (Average number of patents applied)	(2.88)	(1.30)
Industry Dummy	Yes	Yes
Year Dummy	Yes	Yes
Constant	9.161	-20.49
	(0.46)	(-0.90)
P Value	0.000	
Log-likelihood	-609.692	
Observation	2,075	

Notes: 1. The dependent variable is the multiple treatments regarding governance decisions.
2. The numbers in the parentheses are t statistics.
3. The comparison benchmark is non-offshoring cases in each column.
4. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.
5. All variables are deflated by the corresponding price deflator.

Table 5. Treatment Effect by Governance Decision

Matching Method	Model (1) Captive Mode	Model (2) Outsourcing Mode
All Sample		
Kernel (bwidth = 0.06)	0.130***	0.162**
	(3.96)	(2.04)
Caliper (caliper = 0.01)	0.158***	0.098*
	(3.14)	(1.901)
Exploration-Orientation		
Kernel (bwidth = 0.06)	0.172***	0.121*
	(2.57)	(1.94)
Caliper (caliper = 0.01)	0.183**	0.073*
	(2.49)	(1.67)
Exploitation-Orientation		
Kernel (bwidth = 0.06)	0.089**	0.186***
	(1.97)	(2.74)
Caliper (caliper = 0.01)	0.075*	0.125**
	(1.67)	(2.08)

Notes: 1. Source: The study.
2. The numbers in the parentheses are t statistics.
3. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

develop.

Implications for Policy Makers

Our study has implications for policy makers. First of all, it seems that there is a positive influence of R&D strategy on firm productivity, merely stimulating R&D activities at home at a policy level may be an ineffective solution in changing global value chain activities. The knowledge and information obtained from the collaborative relationships in the host country play an important role in positive driving firm productivity. This call for attention to the R&D offshoring strategy. Government policies that subsidize and reward investments in R&D and innovation may be effective not only in boosting domestic R&D investments but also in enhancing overseas R&D at both the firm and industry levels.

Secondly, with network integration has moved up from very simple original equipment manufacturing (OEM) arrangements to increasingly complex original design/brand manufacturing (ODM/OBM) arrangements, knowledge and information obtained from the collaborative relationships needs to be internalized and recombined. Therefore, firms should reconsider their governance decisions for

R&D offshoring strategy. In particular, establishing more subsidiary R&D in enhancing the absorptive capacity will grant them access to unique experiential knowledge and technical resources in raising more firm productivity than those outsourcing their R&D service to other local counterparts. In this case, more guidance should be given to get more R&D investments and commitment to foreign subsidiaries into the improvement of firms' absorptive capacity in responding to the changing network integration. This measure will effectuate the learning effects based on local cooperative relationships. In other words, governments should deploy more resources and human in helping them to upgrade the absorptive capacity and to create more opportunity in building cooperative relationships with leading foreign firms in the form of technological licensing, ODM/OBM, marketing activities, etc., along with continuing to provide full support for R&D and innovation.

Implications for Managers

Our findings conceptualized and empirically validate the importance of R&D offshoring strategy and provide strategic insights on how to optimize resource allocation to enhance the productivity effect. First of all, the R&D offshoring strategy itself does not automatically drive the greatest firm productivity. In particular, the benefits from reverse knowledge transfers (from the foreign subsidiary back to the headquarters and the rest of the firm) may increase but at a diminishing rate, which need to require the adoption of sophisticated mechanisms for the dissemination and integration of both explicit and tacit knowledge (Ambos and Ambos, 2009, 2011). Moreover, establishing own R&D activities in local connection generally enjoy a high degree of autonomy in managerial decision-making and local adaptation at the expenses of the whole organizational coherence (Mudambi and Navarra, 2004). The change of governance mode is in themselves high-level managerial strategies requiring different resource deployment and top management attention.

Secondly, our study further quantifies the productivity effects of R&D offshoring are influenced on their motivation and provide guide on how to

optimize resources allocation to enhance the influence of R&D offshoring strategy. In other words, firm productivity gains are triggered not only directly by the R&D offshoring behavior itself but also by their motivation and governance mechanisms. Depending on the effectiveness of each governance mode, a firm's top management can assess the potential trade-offs between captive mode and outsourcing mode, deciding which governance decision would be most beneficial to the firm's international activities or overall productivity. This provides guidance for firms to strengthen their strategic orientation and efficient allocation of valuable resources.

Limitations and Future Research

Although the sample in this study is a longitudinal dataset (2009-2012), the limited time series cannot fully explain the time-dimensional difference of productivity, technology specific factors, and other basic attributes. The limitation that the time period is not sufficiently long should be considered in future research. Moreover, there is still a long way to go to establish a well-developed and complex construct to improve our understanding of the influence of the various kinds of local counterparts in determining firm productivity differentials in future research. Despite there being some limitations, this empirical analysis does, however, still provide some interesting results that should be of value to firms especially those from emerging economies in the field of developing a R&D offshoring strategy with local counterparts in the host countries.

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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:

$$\ln TFP_{it} = \left(lnVA_{it} - \overline{lnVA_t}\right) + \sum_{s=2}^{t}\left(\overline{lnVA_s} - \overline{lnVA_{s-1}}\right) - \left[\sum_j \frac{1}{2}\left(\alpha_{ijt} + \overline{\alpha_{jt}}\right)\left(lnX_{ijt} - \overline{lnX_{jt}}\right)\right] + \left[\sum_{s=2}^{t}\sum_j \frac{1}{2}\left(\overline{\alpha_{js}} + \overline{\alpha_{j(s-1)}}\right)\left(\overline{lnX_{js}} - \overline{lnX_{j(s-1)}}\right)\right]$$

where $\ln VAit$, $lnXijt$, and αijt are the log value added, input j, and the cost share of input j for firm i in year t. $\overline{lnVAt}$, $\overline{lnXjt}$, and $\overline{\alpha jt}$ 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.