

Determinants of R&D Outsourcing at Japanese Firms: Transaction Cost and Strategic Management Perspectives

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Abstract—This paper examines the factors, which determine R&D outsourcing behaviour at Japanese firms, from the viewpoints of transaction cost and strategic management, since the latter half of the 1990s. This study uses empirical analysis, which involves the application of large-sample data. The principal findings of this paper are listed below. Firms that belong to a wider corporate group are more active in executing R&D outsourcing activities. Diversification strategies such as the expansion of product and sales markets have a positive effect on the R&D outsourcing behaviour of firms. Moreover, while quantitative R&D resources have positive influences on R&D outsourcing, qualitative indices have no effect. These facts suggest that R&D outsourcing behaviour of Japanese firms are consistent with the two perspectives of transaction cost and strategic management. Specifically, a conventional corporate group network plays an important role in R&D outsourcing behaviour. Firms that execute R&D outsourcing leverage 'old' networks to construct 'new' networks and use both networks properly.

Keywords—Corporate Group Networks, R&D Outsourcing, Strategic Management Perspective, Transaction Cost Perspective.

I. INTRODUCTION

THIS paper focuses on R&D outsourcing behaviour at Japanese firms and aims to investigate the factors that determine the implementation of R&D outsourcing and its level by using large-sample firm-level data, covering the period beginning from the mid-1990s. Discussions in this paper draw on perspectives of transaction cost and corporate strategy.

Today, markets have changed drastically and rapidly due to diversification of demand and the rapid advance of globalisation and information technology. It seems that it is difficult for most firms, including large multinationals, to acquire all the resources required for their business activities. Therefore, firms undertake business collaboration and outsourcing to leverage the resources of other firms [1]. In the field of research and development (R&D), especially, outsourcing activities are important for risk sharing due to high investment costs and uncertainty of profits.

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Outsourcing has been discussed as an issue pertaining to decision-making concerning 'make' or 'buy' and as a setting for the boundary of corporate organization in previous years. Explanations concerning the determinants of outsourcing have been presented from several perspectives. First, transaction cost theory is one of the most common perspectives. This theory began as Coase's research for the boundary of firms, and has developed as the problem of a firm's choice between internal procurement and purchase from the market [2]-[4]. Almost exclusively, discussions on outsourcing, in this context, focus on operational or cost efficiency.

Subsequently, the recent surge in outsourcing is induced by the strategic development of corporate management. This is the perspective from the viewpoint of strategic management, including Resource-Based View (RBV). The competitive advantages of firms are yielded through the formation of valuable and unique resources, which are hard to imitate [5]. Accordingly, firms make a decision concerning execution of outsourcing in consideration with their core competency [6], [7]. Therefore, these discussions regarding strategic management are connected to innovation strategy, and studies on outsourcing too have developed to include R&D outsourcing. Several empirical studies on R&D outsourcing provide significant findings [8]-[11]. Simultaneously, the strategic management perspective also includes interrelation of sales, production and R&D strategies. Summarily, recent studies on outsourcing have expanded research target ranges from the conventional viewpoint, which focused on operational efficiency, to strategic viewpoints [12]. Simultaneously, resource dependence and organizational learning perspectives believe that firms execute outsourcing in order to supplement the necessary resources and abilities, which are not available in-house, and for improving core competency [13].

In Japan, previous studies related to subcontracts in corporate groups have accumulated, since before WWII. These studies show that a corporate group has a strong hierarchical structure where a parent firm is on the top, and subcontracting has been basically executed in the range of the corporate group to optimize the supply chain of a parent firm. In addition, it is mainly based on the viewpoints of transaction cost as well as strategic management. However, studies concerning outsourcing, which overstepped in the range of subcontracts, have not fully developed till date. In particular, studies on R&D outsourcing in Japan are still limited, e.g., case studies on the

top companies in certain industries and preliminary analyses through industry-level macro data [14], [15].

Contributions of this paper concerning R&D outsourcing at Japanese firms are as follows. First, Japanese firms that operated within the purview of strong corporate groups, have changed flexibly since the burst of the bubble economy in the first half of the 1990s. One contribution, therefore, is to clarify the fact that Japanese firms form groups for constructing new and flexible networks through outsourcing. Second, in Japan, where natural resources are limited, the influence of technological progress on national growth and corporate R&D activities is more pronounced. Consequently, R&D outsourcing behaviour occupies a significant position within corporate strategy. Accordingly, it is important to investigate the determinants of R&D outsourcing by using large-sample data from Japanese firms in order to obtain information regarding national strategy for R&D.

This paper is organised as follows. The analytical framework is developed in the next section. Section III explains the data used in this paper, and outlines the transition of R&D outsourcing at Japanese firms. Section IV executes empirical analyses concerning the determinants of R&D outsourcing, and presents the results. Section V summarises the findings, and Section VI concludes the paper.

II. ANALYTICAL FRAMEWORK

Factors determining outsourcing are explained from several perspectives as mentioned before. This section develops transaction cost, which includes search cost, and strategic management perspectives, and derives examined hypotheses towards the end.

1) Transaction cost perspective

The choice of whether a firm outsources certain R&D activities or procures R&D technology in internal activities can be explained by the transaction cost theory [16]. This is the so-called 'make or buy' problem. A firm compares transaction costs that occur through procurement from a market with the costs of domestic production, and executes outsourcing when the transaction costs are lower. A firm's decision-making for outsourcing is influenced by factors related to transaction costs and domestic production costs. Transaction costs are influenced by some factors such as specificity of investment, frequency and duration, complexity and uncertainty, difficulty of measuring performance, and connectivity related to transaction [17]. More concretely, they consist of negotiation costs with business partners, monitoring costs to control opportunism, and information gathering costs that include search costs for optimal partners.

This part discusses the relationship between search costs and corporate group networks, which are some of the features of a Japanese firm. It is not true that all other firms become outsourcing partners when a firm executes outsourcing. A firm searches for an optimal partner, who is adapted to the entire R&D activities. Some studies show that firms receive the influences from networks to which they belong [18], [19]. From this finding, it can be interpreted that firms attempt to reduce

search costs by utilizing the networks. There is a high possibility that we can observe such firm behaviour in R&D outsourcing. It is considered that search costs for R&D outsourcing partners are relatively high to include information on technology characteristics, which are generally difficult to obtain.

With respect to Japan, corporate networks such as corporate groups based on capital relation with transaction have existed for a long time. According to the data used in this paper, the proportion of companies that possess subsidiaries (extent of ownership: 50–100%) including affiliates (25–50%) is approximately 60%. The ratio whereby a parent company exists is 30% (15% of these are parent companies themselves), and 25% of the sample are independent companies. In Japan, three quarters of manufacturing companies belong to a network of corporate groups. It is shown that long-term trustworthiness is built among firms that belong to Japanese corporate groups based on transaction and capital relation, and learning and information sharing are executed in the corporate group [20], [21]. Moreover, such a long-term relationship is effective and functional with regards to system management between firms [22]. Accordingly, it is believed that a Japanese corporate group functions as an information gathering network.

2) Strategic management perspective

Two dimensions regarding R&D outsourcing are discussed from this perspective. One is the viewpoint from strategic resource management. This view deals with the strategy related to choice and concentrated decision-making and explains that firms internally retain the resources of core competency and outsource the rest, and resources as core competency are valuable and hard to imitate [6], [7]. Thus, a firm's decision-making for R&D outsourcing, which is influenced by the possessed R&D resources, depends on this view. In terms of quantity and quality of R&D resources, firms that have a lot of such resources also possess a variety of these. Thus, there is a high tendency that they select and concentrate R&D core competency. Moreover, R&D resources are yielded by accumulating past R&D outputs within companies as technological knowledge and become subjacent technology for further technological development. The accumulation of new R&D resources, however, yields obsolete R&D resources. Firms that possess a higher quality of these resources might accumulate a lot of conventional and obsolete resources. As a result, there is the possibility that a greater quantity and higher quality of R&D resources are related to active R&D outsourcing behaviour.

Another discussion from this perspective is consistency of sales, production and R&D strategies with respect to the corporate strategy. In terms of the diversification of products, a firm generally diversifies new products surrounding core products [23], [24]. This means that the width of R&D technology needed by a firm expands on the correspondence with new products. At this time, a firm might possess more of the core as well as non-core R&D competency than it did previously. Accordingly, its firm will actively execute R&D outsourcing. The same effects appear in the case of the

expansion of sales markets involving globalisation.

From the above discussion, the following hypotheses as advancement factors for R&D outsourcing shall be established for verification in this analysis:

H1: Width and fineness of corporate group network

H2: Diversification of products and sales markets

H3: Quantity and quality of R&D resources possessed by firms

Regarding the discussion of the strategic management perspective, firms basically outsource non-core R&D resources, which have a relatively lower value than core resources, and are easy to imitate. Firms that execute R&D insourcing (insourcing firm) receive an order R&D concerning relatively low technology. Therefore, the level of R&D resources that insourcing firms possess is lower than that of firms that execute outsourcing (outsourcing firm). Conversely, insourcing firms absorb the high technology of outsourcing firms, who are customers, or have the incentive of possessing high value R&D resources, in order to acquire the trust of outsourcing firms and to establish a bright position in the market for R&D. Accordingly, we will analyse the differences in the level of R&D resources between outsourcing and insourcing firms.

III. DATA AND R&D OUTSOURCING IN JAPAN

The data for the analyses in this paper is taken from the 'Basic Survey of Japanese Business and Activities (*Kigyo Katsudo Kihon Chosa*, in Japanese)' conducted by the Ministry of Economy, Trade and Industry (METI) of Japan. This survey, one of the largest datasets of Japanese corporate business activity, covers companies with an employee base larger than 50 or with a capital of 30 million yen. A specific feature of this large dataset is that it includes comprehensive information on domestic and overseas business activities. The data from the 1995–2004 surveys, which reflects corporate data of fiscal years from 1994 to 2003, is provided for these analyses. The number of subject companies and the sample size for each year are approximately 37,000 and 27,000 (response ratio 70%), respectively. The information on R&D outsourcing activities is obtained from these datasets. This paper uses two indices concerning a firm's R&D outsourcing behaviour; one is a dummy variable that firms execute outsourcing (=1), and other is an outsourcing level, which is the ratio of sponsored R&D costs on sales values. After the elimination of data for non-manufacturing companies, the pooled data from 10 years contains 61,847 samples for 10,857 firms. This paper uses the panel data identified by firms in the empirical analyses of the next section.

Fig. 1 shows the transition of R&D outsourcing behaviour in Japan since the mid-1990s, based on these datasets. R&D outsourcing execution ratio stays at a level of around 15%, although it temporarily rises around 1997. R&D outsourcing cost ratio shows the increasing tendency from 1994 onwards, except 2000. These indices suggest that firm behaviour has polarised.

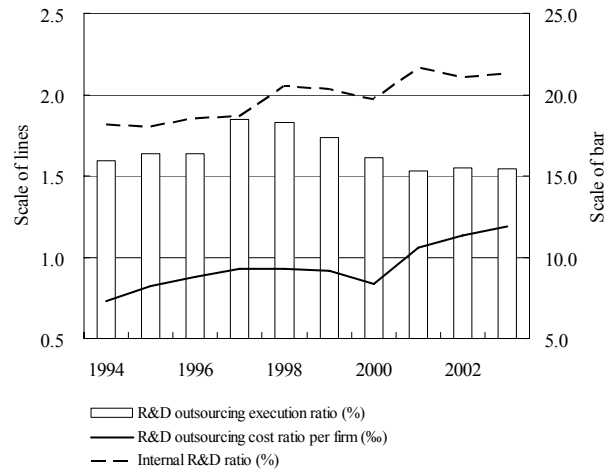


Fig. 1 Transition of R&D outsourcing indices in Japan

IV. EMPIRICAL ANALYSIS

This section executes two empirical analyses, based on the discussions in the last section.

1) Determinants of R&D outsourcing

First, variables used in the analyses are as follows. Dependent variables consist of an R&D outsourcing execution dummy variable (RDOD) and the ratio of sponsored R&D costs on sales values (RDOR).

Independent variables are described along the examined hypotheses. H1 employs three variables as indices concerning corporate group networks; the first dummy variable that a parent firm exists (PAED), the second dummy variable of a firm, which is a parent firm itself (PASD), and dummy variables concerning the number of regions where corporate groups expand (three regions of Europe, North America and Asia excluding Japan; NCGD (1) means that corporate groups develop (one) region of three and Japan).

H2 employs the following two variables concerning corporate sales strategy: the number of regions where a firm activates (three regions mentioned before, NSMD) and sales share in core product market on total sales value (CPMS). It is predicted that these have a positive and a negative effect, respectively. This study does not use the number of product markets, where a firm sells products as a product diversification index although it is prepared, because it is suggested that multicollinearity occurs in relation with a firm size control variable.

Finally, H3 employs the following three variables of R&D resource circumstances: internal R&D cost ratio on total sales as a quantitative index (INRDR), the average market values of patents owned (total revenues from technology transfer/the number of patents owned, AMVP) and the average R&D costs per R&D researcher as qualitative indices (ARDC). Square terms of H3 variables are also used in the analyses (See statistical summary of TABLE a1 in appendix).

TABLE I
DETERMINANTS OF R&D OUTSOURCING

Estimation methods	Random effects probit regression				Random effects tobit regression			
Dependent variable	R&D outsourcing execution =1				Log of R&D outsourcing ratio (/sales)			
PAED	0.003 **	0.002 **			0.437 **	0.347 **		
PASD	0.000	0.002 *			0.242	0.251 *		
NCRD1	0.001 +	0.001 **			0.097	0.154 **		
NCRD2	0.004 **	0.005 **			0.564 **	0.693 **		
NCRD3	0.007 **	0.007 **			0.795 **	1.006 **		
NSMD1	0.000		0.001 **		0.145 +		0.259 **	
NSMD2	0.001		0.003 **		0.164 +		0.394 **	
NSMD3	0.002 **		0.005 **		0.224 **		0.633 **	
CPMS	-0.001		-0.001 +		-0.032		-0.166 *	
INRDR	0.078 **		0.0832 **	11.341 **			-4.313 +	12.634 **
Squared term	-0.133 **		-0.1445 **	-46.082 **				-55.565 **
AMVP	0.000		0.0000	0.000				0.002
Squared term	0.000		0.0000	0.000				0.000
ARDC	0.000		0.0000	0.000				0.000
Squared term	0.000		0.0000	0.000				0.000
Number of obs	16813	32827	56186	25223	16813	32827	56186	25223
Log likelihood	-6039	-10504	-16373	-8624	10942	14431	19132	13938

Statistical significance: +, 10%; *, 5%; **, 1%

On the other hand, firm size, industry, establishment year and time trend are used as control variables. The dataset of this paper is panel data identified by firms mentioned before. Therefore, random effects panel probit and tobit regressions are adapted in the analyses of determinants for outsourcing execution and level, respectively. Estimated results are shown in the Table I. The main points are as follows:

- The existence of a parent firm has positive effects on execution as well as level of R&D outsourcing.
- Global expansion of subsidiaries has positive effects on both independent variables.
- Global expansion of product markets also has a positive effect.
- Core product market on total sales value has a negative effect.
- Internal R&D cost ratio on total sales has a positive effect, and its squared term has a negative sign.
- Two qualitative indices show no effect on R&D outsourcing behaviour.

2) Differences in R&D resource level

This part examines the differences between insourcing and outsourcing firms by selecting samples of firms that execute sourcing activities. The dependent variable is a dummy variable that a firm executes insourcing activities, and dependent variables are the same as determinants analyses. The main results are shown in Table II.

- In terms of the estimation using all independent variables, R&D resource variables have no effect.
- On the other hand, in terms of estimation using only R&D

resources variables, internal R&D ratio (squared term) has a negative effect on becoming an insourcing firm, and the average R&D costs per R&D researcher (both linear and squared terms) has a positive effect.

TABLE II
DIFFERENCES IN R&D RESOURCES BETWEEN IN-AND OUTSOURCING

Estimation method	Random effects probit model	
Dependent variable	Execution of R&D insourcing = 1	
PAED	0.990 **	
PASD	-0.643	
NCRD1	-0.021	
NCRD2	-1.024 **	
NCRD3	-2.157 **	
NSMD1	-0.433 +	
NSMD2	-0.633 *	
NSMD3	-0.861 **	
CPMS	-1.130 **	
INRDR	1.793	9.923
Squared term	-34.847	-86.188 *
AMVP	-0.036	-0.004
Squared term	-0.001	-0.001
ARDC	0.001	0.001 *
Squared term	0.000	0.000 +
Number of obs	3850	5283
Log likelihood	-887.7	-1243.0

Statistical significance: +, 10%; *, 5%; **, 1%

V. FINDINGS OF THIS PAPER

From the perspectives of transaction cost and strategic management, this paper analyzes the determinants of R&D outsourcing behaviour at Japanese firms, using large-sample

firm level data.

First, this part summarises the consistency of analytical results and hypotheses. The existence of a parent firm and global expansion of subsidiaries in their corporate group facilitate a firm's R&D outsourcing behaviour from both aspects of execution and level. Firms that belong to the wider corporate group network execute R&D outsourcing more actively. Accordingly, H1 is supported. In terms of H2, global expansions of product markets and core product sales share have a positive and a negative effect, respectively, as assumed before. These results are consistent with H2. Finally, the internal R&D ratio has a predicted effect; however, qualitative indices such as the average market values of patents owned and the average R&D costs have no effect. These results support H3 partially, and the findings suggest that decision-making concerning R&D outsourcing at Japanese firms can be explained from transaction cost, particularly, searching for partners and strategic management perspectives.

In addition, one striking result is the fact that conventional corporate groups play an important role in a firm's R&D outsourcing behaviour, as they are found to be strongly statistically significant. This finding suggests that Japanese firms leverage old networks to construct new networks and use both networks properly. It is extremely important to find optimal partners for constructing a new network involving R&D activities such as outsourcing and joint businesses. Conventional corporate group networks, therefore, might be a key factor for corporate success. This paper does not have enough information to verify this. Future expansion of this discussion is described in the next section.

VI. CONCLUSION

Finally, with regards to differences of R&D resource level between outsourcing and insourcing firms, quantitative expansion of R&D resources is related to R&D outsourcing, and the qualitative improvement plays a role in insourcing activities. The meaning of this difference should be examined in relation to the market for R&D sourcing. This is one of the highly interesting topics concerning R&D activity networks.

This paper examines the factors determining R&D outsourcing through the explicit requirement that a firm increases its performance through improvement of cost efficiency and innovative outputs. Can firms actually improve corporate performance by leveraging R&D outsourcing? Do R&D outsourcing activities lead to sustainable improvement? In any case, it is important to examine the relation between R&D outsourcing and corporate performance.

Several issues remain concerning R&D outsourcing, including above subjects.

APPENDIX

TABLE AI
STATISTICAL SUMMARY

Variable	Obs	Mean	Std. Dev.	Min	Max
RDOD	61847	0.1652	0.3714	0	1
RDOR	61847	0.0009	0.0057	0	0.5
PAED	58160	0.2883	0.4530	0	1
PASD	54614	0.6707	0.4699	0	1
NCRD1	37379	0.2572	0.4371	0	1
NCRD2	37379	0.1048	0.3063	0	1
NCRD3	37379	0.1146	0.3185	0	1
NSMD1	61697	0.1665	0.3725	0	1
NSMD2	61697	0.0809	0.2727	0	1
NSMD3	61697	0.1903	0.3926	0	1
CPMS	60192	0.8100	0.2149	0	1
INRDR	61847	0.0198	0.0284	1.58E-05	0.887
AMVP	33888	0.7249	12.037	0	954
ARDC	45940	15.298	168.83	0.012	2.89E+04

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