Strategic motives that firms engage in cooperative R&D: A new explanation from four theoretical perspectives

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ABSTRACT:

Previous research has identified many benefits from strategic alliances. This article provides a new explanation for the motives that lead firms to undertake cooperative research and development (R&D), arising from four relevant theories: Transaction Cost Theory, Risk Theory, Learning Organization Theory, and Strategic Management Theory. Accordingly, four types of motives are for the first time categorized: cost sharing related motives, risk sharing related motives, skill sharing related motives, and market power related motives. An analysis of 199 useful questionnaire responses from participants working in the Chinese Aluminum Industry indicates that our method for grouping the strategic motives in terms of the four theories is valid and reliable.

Key words: *strategic motives, cooperative R&D, cost sharing, risk sharing, skill sharing, market power*

INTRODUCTION

Since the early 1980s there has been a striking change in the nature of the competitive environment in which firms operate. Growing evidence of increased collaborative activity demonstrates that firms must learn how to collaborate with their competitors to succeed in the new market landscape. The last two decades have witnessed a growing emphasis on the use of strategic alliances as the dominant form of business organization pursued by firms. Extant literature shows that there are diverse benefits for firms to combine some of their resources and capabilities in business activities. Porter and Fuller (1986) identify strategic alliances as a mechanism through which companies could hedge risk. Boateng and Glaister (2003) posit that strategic alliances can reduce average unit cost by pooling together each partner's capabilities and resources in order to achieve the benefits of large scale of production.

Beside the benefits mentioned above, there are some other benefits from strategic alliances such as: gaining access to a restricted market, speeding up the development of new goods or services, maintaining market leadership, overcoming uncertainty, gaining market power, overcoming trade barriers, and setting up barriers for new entrants (Hitt *et al*, 2005, p274). For these reasons, strategic alliances have been used widely in many different ways. R&D alliance as one of the major mechanisms of cooperative R&D is an arrangement among a group of firms to share the costs and results of an R&D project (Sakakibara, 1997). R&D alliances have been extensively used in high technology industries such as pharmaceuticals, biotechnology, and telecommunications (Odagiri, 2003; Bagchi-Sen, 2004; Sampson, 2004). More recently, as a result of their success, R&D alliances have been adopted by firms in many other industries such as forests, non-ferrous metals, and petroleum (Sakakibara, 2001; Nakamura *et al*, 2003). This new phenomenon raises the question: why do firms conduct cooperative R&D?

This paper seeks to identify all the relevant strategic motives that lead firms to pursue cooperative R&D from four perspectives: cost sharing, risk sharing, skill sharing, and market power. All previously identified strategic motives on both strategic alliances and cooperative R&D are grouped into these four categories (inducement factors). Moreover, rational explanations are provided for these four inducement factors. Transaction cost theory is used to explain cost sharing, risk theory is used to explain risk sharing, organization learning theory is used to explain skill sharing, and strategic management theory is used to explain gaining market power. Together these theories provide clear reasons why firms conduct cooperative R&D.

THEORETICAL EXPLANATIONS FOR MOTIVES

From a theoretical perspective, there are several advantages from R&D alliances. Four theoretical approaches are particularly relevant in explaining the benefits and choice of strategic alliances. One approach is derived from transaction cost theory (Williamson, 1975, 1985). The second approach focuses on strategic motivations (benefits) and consists of a catalogue of formal and qualitative models describing competitive behavior. A third approach is derived from organizational learning theory,

which has been developing quickly recently in terms of explaining the choice of strategic alliances as a vehicle to improve the capability of firms. Last, risk theory (Tyler and Steensma, 1995; Reuer and Leiblein, 2000; Das and Teng, 1999) can be used to explain the strategic motives arising from risk sharing inducing firms to participate in strategic alliances.

Cost Sharing Motives: Transaction Cost Theory

As is well known, transaction cost theory has been advocated most strongly by Williamson (1975, 1985). Proponents of the transaction cost perspective claim that the firm has distinct advantages over markets, but argues that these advantages primarily relate to the control or reduction of opportunism threats posed by transaction characteristics (Williamson, 1985). In the absence of opportunism, all transactions could be organized by a series of contracts, such that the firm would be an unnecessary organizational form. By the imposition of bureaucracy, partner incentives to behave opportunistically are diminished because there is greater monitoring and control over partner actions and greater incentives to work out disputes privately rather than by recourse to the courts. As a result, incentives to cooperate and share resources or/and knowledge are preserved (Sampson, 2004).

It has been argued that the smaller the number of capable partners for a desired relationship, the lower the bargaining power of the firm relative to any given potential partner. Likewise, the need to invest in assets specific to the cooperative project and of limited value outside the relationship can lead to higher switching or exit costs for the firm (Kogut, 1988; Williamson, 1985). These two factors are particularly pertinent for technology-based relationships. There are generally a limited number of firms capable of providing expertise in advanced technology development or customization. Leading-edge technology can also require extensive sophisticated training and equipment, which may be of limited value outside its relatively narrow domain. Such conditions constrain the opportunities for the firm and may increase its dependence upon the partner. This dependence can allow the partner to charge excessive prices and perhaps behave opportunistically unless such actions are offset through stringent contracting and monitoring (Tyler and Steensma, 1995).

It is well recognized that it is economical to produce a certain product or service in a large volume or jointly with other products/services. It is often argued that increases in the minimum efficient scale of a number of economic activities have led firms to enter into strategic alliances. For example, the desire to reduce costs through economies of scale in the aluminum industry is usually given as a cause for the spate of strategic alliances in this industry. Today, the minimum efficient scale of a bauxite mine or of an alumina refinery is larger than that of an aluminum smelter. Only the largest aluminum firms have enough downstream capacity to absorb the output of an efficiently sized upstream facility. As a result, most recent bauxite mines and alumina refineries have been built by consortia of aluminum producers, and strategic alliances account for more than half of the world's bauxite and alumina capacity (Hennart, 1988).

Risk Sharing Motives: Risk Theory

Risk theory provides an additional lens through which technological cooperative partnerships can be evaluated. According to risk theory, executives explicitly consider the probabilities of risk and reward associated with investment choices in an effort to maximize their expected return. A collaborative relationship that increases the probability of success will have positive value. Companies may through technological collaboration gain valuable experience and skills, which lower development risk and thus improve the probability of success. Such is often the case when two or more firms with related skills combine those skills to develop technology. In these situations the expertise of the various firms causes the combined effort to have a higher probability of success than would be the case if a single firm tried to develop the technology alone. Collaborative technological opportunities that are expected to increase the probability of success would be attractive to executives of firms (Tyler and Steensma, 1995).

Empirical studies have identified that one objective of research partnerships is to share risks and decrease market and technological uncertainty. Such risk has been thought to increase the further away is the subject of the cooperative research from extant activities of the firm (Caloghirou, *et al*, 2003). Porter and Fuller (1986) identify strategic alliance as a mechanism through which companies could

hedge risk. The high levels of uncertainty in R&D and the high level of failure in R&D allow for risk-balancing organizational arrangements, such as alliances (collaborations) with other organizations and firms to promote innovation so as to mitigate the risk (Bagchi-Sen, 2004).

Market Power Gaining Motives: Strategic Management Theory

The main purpose of strategic management theory is to help firms gain competitive advantage in the marketplace. A cooperative strategy is one in which firms work together to achieve a shared objective. Strategic alliances, as cooperative strategies in which firms combine some of their resources and capabilities to create a competitive advantage, are the primary form of cooperative strategies (Hitt *et al*, 2005). In an era of intense global competition, firms realize that the effective use of proper strategy contributes significantly to their market performance. Increasingly, successful firms use a higher level of strategic alliance to gain competitive advantage. Strategic alliances may enhance a firm's superior performance through the combination of resources and capabilities in unique ways (Murray, 2001). Many firms enter into strategic alliances with a wish to strengthen their competitive advantages in the market.

But "competitive advantage" is an ambiguous term and there is much confusion about the term. George S. Day and Robin Wensley (1988) in their article, "Assessing Competitive Advantage: A Framework for Diagnosing Competitive Superiority", have developed a process that can be used to ensure a thorough assessment of the reasons for competitive success or failure. Day and Wensley propose that a firm, which has superior sources of advantage (superior skills and superior resources), will win a superior position in the markets. A positional advantage will lead in turn to superior performance outcomes (greater customer satisfaction and, hence, greater customer loyalty), and obvious result of greater customer satisfaction and loyalty is more market share. From the previous discussion, now we can infer that firms participating in strategic alliances want to gain competitive advantage, and the competitive advantage will result in more market share for the firms, which means, in other words, more market power.

Skill Sharing Motives: Organizational Learning Theory

Organizational learning theory is regarded as the key factor in achieving sustainable competitive advantage. Organizational learning refers to the process by which the organizational knowledge base is developed and shaped. The ability of firms to acquire knowledge and to transfer it into a competitive weapon has long been a part of the research agenda. Stata (1989) even predicts that the rate at which individual and organizational learning may grow to become the only sustainable competitive advantage. As Hamel (1991) says, learning through internalization, which refers to acquiring skills to close the gap between partners, and sustainable learning helps reapportion the value-creating core competencies in an alliance context, giving partners the ability to match or overtake competition. Therefore, learning, be it related to technology transfer, acquiring skills, or improving learning capability ("absorptive capacity", Cohen and Levinthal, 1990), is a critical consideration for firms (Iyer, 2002).

Alliances are viewed by partner firms as vehicles that provide opportunities to learn to enhance their strategies and operations. Kogut (1988) argues, based on organizational learning theory, that alliances by their inherent long-term partnering/"melding-of-organizational-structures" nature provide opportunities for partners to transfer embedded knowledge between them. This embedded or tacit knowledge is generally difficult to transfer between firms. Alliances are like a short-circuit method for acquiring critical tacit knowledge (Hamel, 1991). Characteristically, however, alliances are long-term exchange relationships. Learning occurs all along the evolutionary path, and the dynamics of learning and relationship interactions continuously change as the alliance grows. Learning priorities evolve and change with the alliance process. The different phases of alliance evolution represent an ongoing managerial task of balancing cooperation and compatibility between partners on the one hand and learning/building of new sources of competitive advantage on the other (Iyer, 2002). So in a sense, the alliance creates a laboratory for learning (Inkpen, 1998).

CONSTRUCT MEASUREMENT AND DATA

The four perspectives of transaction cost theory, risk theory, strategic behavior theory, and organizational learning theory provide distinct, though at times, overlapping explanations for strategic alliances behavior. Transaction cost theory has theorized inter-firm partnering as an economic phenomenon between market transaction and hierarchies. Transaction cost theory analyzes strategic alliances as an efficient solution to the hazards of economic transactions. Risk theory takes strategic alliance as a mechanism through which companies could hedge risk. Organizational learning theory regards strategic alliances as a vehicle by which organizational knowledge is exchanged and imitated. Finally, strategic management theory places strategic alliances in the context of competitive rivalry and collusive agreements to enhance market power (Kogut, 1988). According to the four theories, in this study, we use four relevant constructs (factors) to study the strategic motives that firms engage in cooperative R&D activities.

Cost Sharing

Costs sharing related motives are also called scale based motives (Sakakibara, 1997). Five independent variables are adopted to measure the factor of cost sharing. In previous economic theoretical research, fixed cost-sharing among R&D participants, the realization of economies of scale in R&D, and the avoidance of 'wasteful' duplication, are frequently referred to as scale-based motives (Katz, 1986; D'Aspremont and Jacquemin, 1988; Katz and Ordover, 1990; Motta, 1992; Sakakibara, 1997). Additionally, Glaister (1996) points out that a strategic alliance may also lower costs by pooling the comparative advantages of each partner. There are potential cost savings from centralized functions when firms work together (Ugboro *et al*, 2001). Accordingly, 'pursuing R&D cost reduction' is added to the factor of cost sharing as the fourth variable. And the fifth variable, sharing complementary R&D resources among R&D consortium participants is also accepted from the papers of Sakakibara (1997) and Nakamura *et al* (1997).

Risk Sharing

The strategic risks that companies face stem from uncertainty in their technological, market and competitive environments. This means that they cannot be confident of the pay-off of a given strategic

move, such as investment in a new plant or development of a new product. Strategic alliance is one approach, which can help to strategic risks (Gomes-Casseres, 2000). Strategic alliances not only help company hedge risks, but also help them mitigate the costs of responding to unpredictable trends and threats. In this current study, four variables are adopted from previous research papers to measure the factor of risk sharing motives: (a). Risk spreading among participants (Porter and Fuller, 1986). (b). Buffering threats from external competitors (Souder and Nassar, 1990). (c). Reducing competition among participating firms in the marketplace (Contractor and Lorange, 1988; Boateng and Glaister, 2003). (d). Reducing uncertainty due to cooperative R&D (Bagchi-Sen, 2004; Hagedoorn, 1993).

Skill Sharing

Learning based motives are also called skill-based motives. They are the most frequently mentioned motives in the literature. More and more scholars and business leaders have recognized that inter-organizational learning is critical to competitive success, noting that organizations learn by collaborating with other firms as well as by observing and importing their practices (Powell *et al*, 1996; Levinson and Asahi, 1996; Dyer and Nobeoka, 2000). For the factor of learning based motives, five variables are adopted from previous research: (a). Access to complementary knowledge (Sakakibara, 1997; Brockhoff *et al*, 1991; Hagedoorn, 1993). (b). Technology transfer (Souder and Nassar, 1990; Smilor and Gisbson, 1991). (c). Information exchange (Gibson *et al*, 1994; Aldrich *et al*, 1998). (d). Management training (Souder and Nassar, 1990). (e). Researcher training (Souder and Nassar, 1990; Bagchi-Sen, 2004).

Market Power

In this study, six variables identified in previous papers are used to measure the factor of market power. These six strategic motives are: (a). Developing new and advanced products (Bradmore, 1996). (b). Developing new markets or access to new markets (Hagedoorn, 1993). (c). Speeding up products from development to market (Oliver and Liebeskind, 1998; Contractor and Lorange, 1988). (d). Expansion of product range/product diversification (Katz, 1993; Seldon, 1992). (e). Setting up barriers

against new market entrants (Hart, 1993; Nelson, 1996). (f). Facilitating international expansion (Nelson, 1996; Glaister, 1996; Boateng and Glaister, 2003).

Data Collection

Questionnaires about strategic motives that firms participate in cooperative R&D between firms are used to obtain the data for this project. The questionnaire is aimed at high-level managers in companies because high-level managers are believed to have knowledge to answer the questions. Most answers are reported on a 5-point Likert scale with 5 meaning 'strongly agree with the motives' and 1 meaning 'strongly disagree with the motives'. Questionnaires were distributed to the senior and middle managers who work for companies in the Chinese Aluminum Industry. 22 companies were randomly sampled and 550 questionnaires were sent out with the help from Chinese Aluminum Industry Association. 199 returned questionnaires were completed with all the questions. So the useful return rate is 36.2 percent.

ANALYSIS

Confirmatory factor analysis (CFA) of a measuring instrument is most appropriately applied to measures that have been fully developed and their factor structures validated. The legitimacy of CFA is tied to its conceptual rationale as a hypothesis-testing approach to data analysis. That is to say, based on theory, empirical research, or a combination of both, the researcher postulates a measurement model and then tests for its validity given the sample data. In testing for the validity of factorial structure for an assessment measure, the researcher seeks to determine the extent to which variables designed to measure a particular factor (latent variable) actually do so. AMOS is a computer software package which is designed and based on confirmatory factor analysis. AMOS tests the validity of the indicator variables (Byrne, 2001, p147). In this study, we firstly use AMOS to validate our proposed measurements for each of the four inducement factors and then, the CFA module of SPSS is used to test the reliability of the validated measurements for each of the four inducement factors.

Descriptive Statistics

The mean, standard deviations of all variables in the four inducement factors are displayed in Table 1. The highest mean value among all the observed variables is 4.56 for the variable q12, which is 'information exchange' in the factor of skill sharing. The lowest mean value among these observed variables is 3.35 for variable q24, which is 'setting up barriers against new market entrants' in the factor of market power.

Table 1 Descriptive statistics for all variables

Factor	Variable	Description of variable	Mean	Standard. Deviation
Cost sharing (CS)	q1	Sharing fixed cost	4.22	.784
	q6	Avoidance of wasteful duplication	4.47	.744
	q11	Earning economy of scale in R&D	4.13	.818
	q16	Sharing R&D resources	4.31	.720
	q21	Pursuing R&D cost reduction	4.25	.802
Learning based motives (LB)	q2	Access to complementary knowledge	4.46	.716
	q7	Technology transfer	4.33	.840
	q12	Information exchange	4.56	.632
	q17	Management training	4.11	.907
	q22	Researcher training	4.34	.713
Risk sharing (RS)	q3	Risk spreading among participants	4.25	.809
	q8	Buffering threats from external competitors	3.98	.904
	q13	Reducing competition	3.86	.903
	q18	Reducing uncertainty in cooperative R&D	3.93	.929
Market power (MP)	q4	Developing new and advanced products	4.27	.897
	q9	Developing or accessing to new markets	4.04	.878
	q14	Speeding up products from R&D to market	3.99	.945
	q19	Expansion of product range	3.76	.953
	q24	Setting up barriers against new entrants	3.35	1.023
	q27	Facilitating international expansion	3.93	.922

Validating the Measures of Each Factors

All of the measures (observed variables) for each factor were tested. For example, the factor, cost sharing, with its five variables was analyzed by AMOS GRAPHICS (see Figure 1). Once the factorial measurement model is drawn, a Goodness of fit test was applied. For the goodness of fit, four indices were adopted: IFI, TLI, CFI, and RMSEA. For IFI, TLI, and CFI, a value greater than 0.90 is considered indicative of a well-fitting model (Bentler, 1990). There is no generally accepted criterion for RMSEA, but recently Byrne (2001) suggests less than 0.08 as an acceptable value for RMSEA.

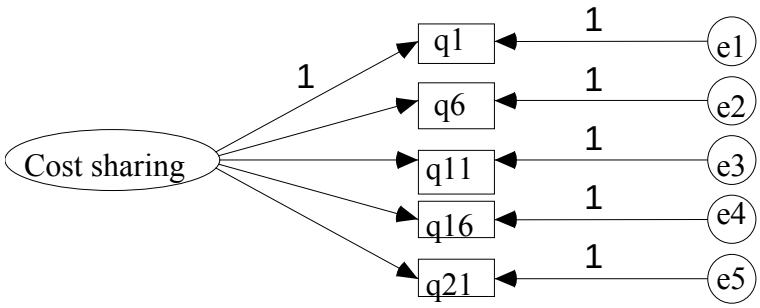

Figure 1 Measuring instrument for Cost Sharing

For the four factors, three yielded a well-fitting measuring instrument with values greater than 0.90 for all of IFI, TLI, and CFI, and RMSEA values are all under 0.08. These three factors are: skill sharing, risk sharing, and market power. The hypothesized model for measuring the fourth factor, cost sharing, fits the data set poorly with a TLI of 0.802 and an RMSEA of 0.119. On examining the report of 'modification index', it was seen variable q11 (earning economy of scale in R&D activities) correlates highly with variable q21 (pursuing R&D cost reduction). Highly correlation between the two variables means that either of two variables can represent the other.

As mentioned above, economies of scale are concerned with the average cost of production in relation to the productive capacity of a plant. A joint venture can reduce average unit cost by pooling together each partner's capabilities and resources in order to achieve the benefits of large-scale production (Boateng and Glaister, 2003). This suggests that 'pursuing R&D cost reduction' can be represented by "earning economies of scale in R&D activities' in the factor of cost sharing. Thus, one variable q21, 'pursuing R&D cost reduction' was dropped from the factor of cost sharing (see Figure 2 the adjusted instrument model).

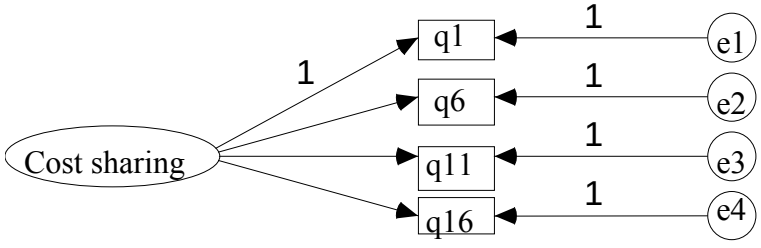

Figure 2 Adjusted measuring instrument for Cost Sharing

The new RMSEA value for the adjusted model is 0.000, which indicates a good fit of the new measurement model with the data. The IFI is now 1.008, TLI is now 1.024 and CFI now is 1.000, all greater than the 0.90 threshold. Thus the adjusted model is a good fit with the observed data. So after the validity testing for every single factor, only one variable was dropped, that is variable q21, pursuing R&D cost reduction from the factor of cost sharing.

The four relevant theories used to explain the motives that induce firms to participate in cooperative R&D differ principally and fundamentally in the objectives attributed to firms, but they also share several commonalities. Kogut (1988) points out that these theoretical approaches are not carefully distinguished from one another when he explains the phenomenon of joint ventures from theoretical and empirical perspectives. Kogut's viewpoint is echoed by Odagiri (2003) that the theories for explaining why firms conduct cooperative R&D need not be mutually exclusive. From previous studies, we can conclude that the four theories we use for grouping motives into four factors are supportive of each other, in some way. They are somewhat overlapping and complementary rather than either exclusive or separate. In order to improve the validity of the measuring instruments, we provide a new hypothesized instrument model, in which four motivation factors are put together (see Figure 3). AMOS has the capability to test the factorial validity of scores from a measuring instrument with correlated factors.

In this model, CS, LB, RS, and MP denote the four factors: cost sharing, learning based motives, risk sharing and market power, respectively. The variable q21 has already been dropped from this model. For consistency, we use the same criteria for testing this model: IFI, CFI, TLI, and RMSEA. In the output report for this model, IFI is 0.898, TLI is 0.879, CFI is 0.896, and RMSEA is 0.068. These values are indicative of a poor fit of the model to the data. Thus, it is apparent that some modification is needed in order to determine a model that better represents the sample data. The modification indices were used to identify possible areas of misfit, we examined the modification indexes.

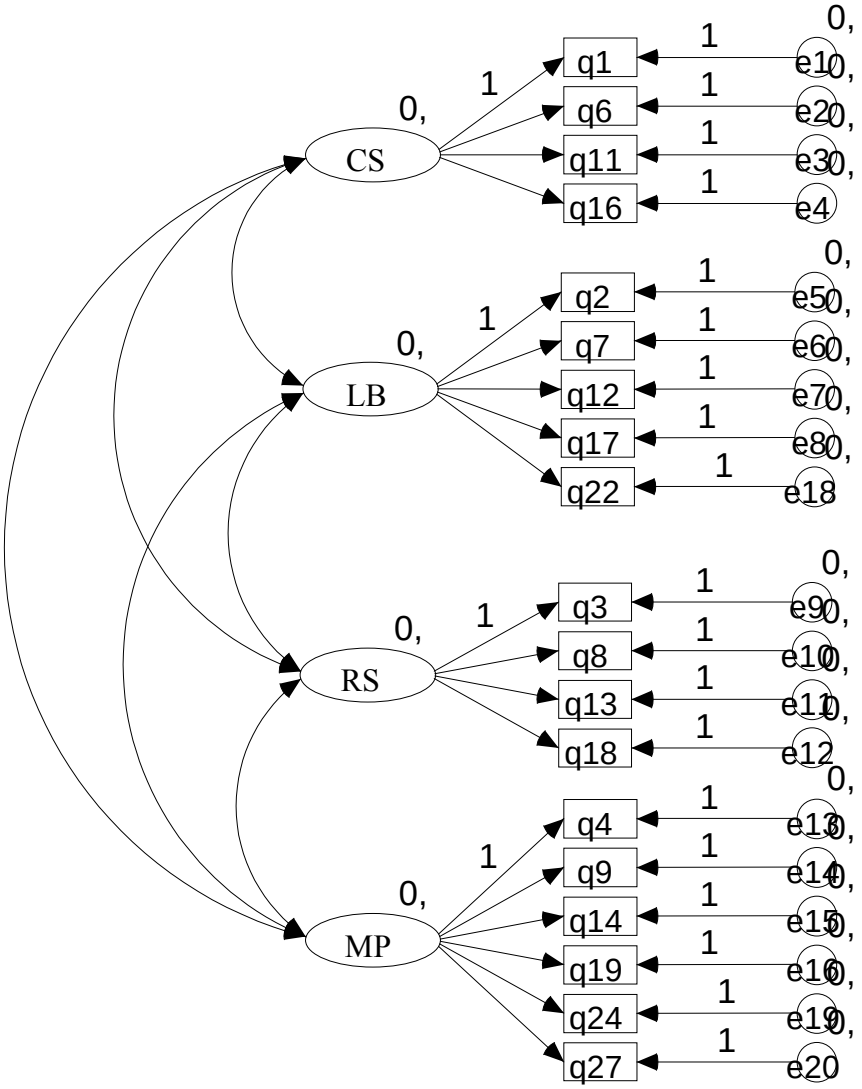

Figure 3 Hypothesized 19-variable model of factorial structure for motives

Based on the CFA model, error terms close to a value of 0.0 are of substantial interest; and large M.I.s in modification index would indicate the presence of error covariance. In AMOS, M.I.s are computed for all parameters implicitly assumed to be zero, as well as those that are explicitly fixed to zero or to some nonzero value. In the modification indices, we draw attention to the highest value (M.I.=20.396) between errors, e13 and e16. This is clear evidence of misspecification associated with the pairing of variables q4 and q19. These two variables are both included in the factor of market power motives. Variable q4 is 'developing new and advanced products' and variable q19 is 'expansion of product range or product diversification'. Cooperative R&D can help to develop new and advanced products, so that product range is expanded and diversified. We believe that the second reason is true for this

instrument. Thus, variable q19 was excluded. The output report for the new instrument yielded values of IFI=0.914, CFI=0.912, and RMSEA=0.062, but TLI is still under 0.90, standing at 0.896. According to the modification index, we found that variable q17 and variable q18 have the highest error covariance even though the value of error covariance is not substantial larger than others, but variable q17 is also highly correlated to variable q11 and variable q16. So, we decide to remove variable q17 from the instrument model. The finalized model has a good fit to the sample data with IFI = 0.937, CFI = 0.936, TLI = 0.923, and RMSEA = 0.055.

Reliability Testing of Factors

After testing and validating the measuring instruments, this section describes the results of the tests undertaken to examine the finalized constructs after AMOS in this study. As suggested by Nunnally (1978), the most recommended measure of reliability is provided by coefficient alpha or Cronbach's alpha (α) as it provides a good reliability estimate in most situations. The value of α ranges from 0 to 1. The nearer of α to 1, the better the reliability of the constructs. A widely cited minimum threshold for Cronbach alpha is 0.70. However, some scholars suggest that an α as low as 0.60, is acceptable (Churchill, 1991).

The coefficient alphas for the different constructs were computed through CFA in SPSS and are presented in Table 2. Most of the constructs used in this study exceed the 0.60 threshold. We also took two steps to test the reliability. The first step is to calculate the alpha for each of the four factors individually without considering their overlap. In this step, the values of alpha range from 0.614 for cost sharing to 0.861 for market power. The second step is to compute alpha for each of the four factors when consider their overlaps. The values of alpha range from 0.614 for cost sharing to 0.830 for market power in step two.

Table 2 Construct Reliability Statistics

Construct	Initial variables	Step one		Step two	
		Used variables	Cronbach's Alpha	Used variables	Cronbach's Alpha
Cost sharing	5	4	0.614	4	0.614
Learning based motives	5	5	0.733	4	0.696
Risk sharing	4	4	0.704	4	0.704
Market power motives	6	6	0.861	5	0.830

Validity Testing

Construct validity refers to the degree to which instruments (variables) measure the constructs that they are intended to measure. In other words, validity is defined as the accuracy of measurement. In this paper, we tested the validity of the measurements validated by AMOS for each factor by conducting CFA in SPSS. There are two categories of construct validity, both of which are examined in this study: convergent validity and discriminant validity. The results of CFA in this study support the measurements validated by AMOS.

CONCLUSION

Past research into the underlying driving forces which induce R&D cooperation between firms has focused only on the motives, and has not generally provided rational explanations for these motives. Some of the previous studies used exploratory factor analysis to group the motives, but the results are very diverse. In turn, these results have confused some researchers. The main contribution of this research is to overcome this confusion. Firstly, we use four theories to explain the driving forces that induce firms to pursue cooperative R&D. Secondly, based on these four theories, we identify the relevant motives from extant research papers and group them into these four categories. Lastly, statistical techniques are used to justify this grouping. The results of the confirmatory factor analysis show that our measurements are reliable and valid. The techniques in this study when applied to group these motives could produce useful information in later research.

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