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Critical role structures in technological innovation process in Korea: A contingency approach

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Abstract

This study empirically examines the contingency relationship among the specialization of critical role structure, system and problem complexity, and process and outcome performances of innovation projects. Based on data from 91 NPD projects in Korea, this study found that system complexity leads to the specialization of role structure, while problem complexity has nothing to do with role structure. The specialization of role structure has an indirect effect on outcome performance (technological and commercial success) of the innovation project through four different process performances (technological and market intelligence, resource supply and organizational support). The fit between system complexity and the role structure also has an indirect effect on technological and commercial performance through market intelligence and resource supply, whereas the fit between problem complexity and the role structure has a marginal positive impact only on organizational support.

I. Introduction

Technological innovation has been commonly acknowledged as an essential ingredient for organizational success in today's competitive, rapidly changing environment. Continuous product development is increasingly instrumental for business survival of the firms in advanced countries as well as those in late industrializing countries such as Korea. Especially, as the firms in Korea have developed technological capability and moved their target market from a low-end segment to a more value-added one, new product development based on radical innovations, rather than on imitative efforts, has become imperative for survival and continued growth of these firms (Kim, 1997). So, many Korean firms have substantially increased their R&D investment and attempted to establish a creative organizational system conducive to technological breakthrough.

Innovation, however, is not just a technological but a socio-political process of contested change. This multifaceted nature of innovation requires diverse roles that key people play in the innovation process. Existing studies (Rothwell et al., 1974; Maidique, 1980; Roberts & Fusfeld, 1981; Chakrabarti & Hauschildt, 1989; Hauschildt & Kirchman, 2001) found many critical roles for the successful implementation of innovation projects such as technical champion (or expert), project champion, and executive champion (or sponsor). As a means of encouraging internal entrepreneurial efforts, the existence of certain roles and the impact of key people on the success of innovation projects have been examined by many researchers in advanced countries (Chakrabarti, 1974: Roberts & Fusfeld, 1981; Markham 1998; Hauschildt & Kirchman, 2001).

Nevertheless, most studies have been descriptive in nature focusing on identifying critical roles in the innovation process, and only a few studies have empirically examined the relationship between innovation performance and the specialization of role structures in the process. Moreover, studies on innovation in the late industrializing context from a socio-political perspective are very few.

To address these knowledge gaps, the current study empirically explores how role specialization promotes innovations, which factors affect the degree of role specialization, and what effect role specialization has on projects in a late industrializing country, Korea. This study offers a contingent framework for the analysis of critical roles structure in the innovation process and examines the relationship among organization and project complexities, role structure, and project performance, based on data from 91 new product development projects in Korea.

II. Literature Review

Innovation as an uncertainty-reduction process

Technological innovation can be defined as an uncertainty-reduction process (Avlonitis, Papastathopoulou & Gounaris, 2001). Uncertainty occurs because relevant information is unavailable when a development project is initiated (Zirger & Hartley, 1994). Traditionally, technical and market uncertainties have been recognized as inevitable ingredients in technological innovation efforts (McDermott & O'Connor, 2002; Song & Montoya-Weiss, 2001; Veryzer, Jr., 1998).

Technical uncertainties refer to questions concerning how to formulate the technology into a product, while market uncertainties include issues related to whether or not a market exists for that product, either existing or latent customers' needs for that product, and so on (Leifer, O'Connor, & Rice, 2001). Lack of both technological and customer knowledge has been a major cause of new product failure (e.g., Rothwell et al., 1974; Zirger & Maidique, 1990).

Two other sources of uncertainty, organizational and resource uncertainty are also considered as critical for the radical innovation process (Leifer, O'Connor, & Rice, 2001). Organizational uncertainty addresses questions about the capabilities of the project team for managing relationships with the rest of the firm and cultivating a coalition of support within the firm, while resource uncertainty is concerned with the funding resources and acquiring competencies required to complete the project. Coping with these uncertainties, which mainly stem from the conflict between the project team and mainstream organizations, is essential for enhancing the possibility of radical innovation success (Leifer, O'Connor, & Rice, 2001). As a result, specialized roles and functions emerge to manage uncertainties in the innovation process.

Critical roles in the innovation process

Ever since Schumpeter (1934) pointed out that innovation needs the cooperation of different persons such as inventor and entrepreneur, many researchers have explored the phenomenon of the division of labor in the innovation process. A number of functions must be performed to transform an idea into a viable commercial business (Day, 1994), because innovation creates resistance to new ideas from many organizational members who are uncomfortable with the uncertainty of the innovation process (Van de Ven, 1986).

Existing studies have identified the variety and richness of the key functions or roles in the innovation process. In a seminal study of radical military innovations, Schon

(1963) observed that a champion, a highly enthusiastic and committed individual, played the key role in successful technological innovation. Champions make a decisive contribution to the innovation by initiating frequent and varied influence attempts, facilitating the allocations of critical resources to the innovation projects, and overcoming the inertia and resistance that radical change provokes (Howell & Higgins, 1990; Maidique, 1980).

Successful radical innovation, however, requires a special combination of entrepreneurial, managerial, and technological roles within a firm (Maidique, 1980). Like any organized phenomenon, innovation is brought about through a concerted effort of a set of people who interact in a combination of critical roles (Galbraith, 1982).

One of the first studies that attempted to break the champion functions into multiple sub-roles was Witte (1973). He developed the promoter model for technological innovation, which normally comes up against massive resistance partly due to ignorance and partly due to unwillingness on the part of those affected by or engaged in the innovation. To overcome barriers of ignorance, the technology promoter contribute specific technical knowledge to innovation process, while, to deal with the psychological barrier of unwillingness, the power promoter uses hierarchical power to shelter the innovation from opposition and to establish it in the face of resistance. Furthermore, the innovation process is most successful when the technology promoter and the power promoter work together, cooperate closely and provide enthusiastic support for the new idea.

The SAPPHO Investigators (Rothewell et al., 1974) address the role of key managers and technologists, and define four categories of key individuals: technical innovator, product champion, business innovator, and chief executive. Research findings indicate that (1) the individual that emerged as the principal factor to explain the success of an innovation was not the product champion, but the business innovator, (2) besides commitment and enthusiasm, the power and status of the sponsoring executive played an important role in determining the success of an innovation, and (3) the presence of product champion also explained the success of an innovation.

Maidique (1980) proposed a similar role structure of technologist, product champion, executive champion, and entrepreneur. The technologist contributes on the technical side to the development and design of the innovation, while the product champion actively promotes the progress of innovation using his or her organizational skills. An executive champion has influence over the resource allocation process to channel resources to the project, protects it from excessive risk, and absorbs some, if not all, of the risk. In the meantime, the entrepreneur as a CEO orchestrates all the critical functions in the innovation process and architects the organization to facilitate innovation activities.

Roberts & Fusfeld (1981) also identified five different roles critical to the success of innovation: idea generator, champion, project leader, gatekeeper, and sponsor. They also mentioned that the importance of five different roles varies as the innovation project progresses from the idea generation to the commercialization stage, and some individual can carry out more than one of these roles concurrently.

Since then, researchers continued to add plenty of new and often confusing roles associated with innovation. For example, Smith et al.'s (1984) study found the twelve different role structures of top management, R&D sponsor, business sponsor, project manager, product/ process champion, quality controller, R&D strategist, problem solver, idea generator, scientific gatekeeper, process user gatekeeper, and product user gatekeeper. "So the literature leaves unresolved questions as to how many of these proposed roles must be fulfilled to enhance the innovative success and how many of them can be played by the same person" (Beaty and Gordon, 1991, p.75). Table 1 summarizes the number of roles and their functions identified in existing studies.

Based on a meta-analysis of the literature, Chakrabarti & Hauschildt (1989) have conceptualized a three-person constellation role structure as a basic concept for the division of labor. They found the division of labor according to the bases of power of key role players in most empirical cases. Expanding a dyadic promoter model of Witte (1973), they proposed three critical roles in the innovation process, composed of experts (technology promoter) based on expertise power, sponsors (power promoter) based on hierarchical potential, and champion (process promoter) based on organizational knowledge and communication ability.

In a similar manner, Quinn (1985, p. 74) said "For a high probability of success, an innovation needs a mother (champion) who loves it emotionally and will stay with it when others would give up, a father (authority figure with resources) who can support it, and pediatricians (experts) who can see it through technical difficulties."

Hauschildt & Kirchmann (2001) empirically investigated hypotheses of the existence and efficiency of the troika constellation of separate technology, power, and process promoters based on 133 product innovations in the German plant construction and engineering industry. The results revealed that (1) dyads and troikas are present in a considerable number of cases, (2) of all the promoter structures, the troika constellation of separate technology, power, and process promoters make the highest contribution to the performance of innovation.

However, existing studies also found no division of labor in the innovation process in a considerable number of cases (Hauschildt & Kirchmann, 2001). For instance, Witte (1973) noted that 21% of the 233 cases had no promoters at all. In project SAPPHO, considerable accumulation of roles was found (Rothwell et al., 1974). Chakrabarti (1974) and Chakrabarti & O'Keefe (1977) reported that in half of the cases they investigated, all innovative activity is concentrated in a single key person. Markham, Green, & Basu (1991) also found a number of projects had no key person or only a single person to play the critical roles in the innovation process.

But, this concentration of the innovation function in one person seems to be the exception. Souder (1984) found that one-man shows are seldom successful. In Witte's study, the dyadic structure with both the technology promoter and the power promoter accounts for 37 % of total cases (Witte, 1973). More recent studies focused on champion activities show that several persons to play critical roles involved in the innovation process (Chakrabarti & Hauschilidt, 1989; Howell & Higgins, 1990; and Hauschildt & Kirchmann, 2001).

Although a few studies have directly addressed the question of the existence and efficiency of the troika constellation of separate promoters (i.e., Hauschildt & Kirchmann, 2001), it is still unclear why some innovation projects have no or only one key player, while others have two to several separate key players? Which factors are determining the specialization of role structure in the innovation process? Furthermore, can the specialization of role structure reduce the uncertainty entailed in the innovation project, and what is the relationship between the specialization of role structure and the performance of the innovation project? These issues are addressed in the following section.

III. Hypotheses

Role specialization and its antecedents

Chakrabarti & Hauschildt (1989) propose that a three-person constellation model of innovation promoters can be reduced or expanded according to contingent conditions. Situational contingencies, they suggest, include firm size, repetition of activities, nature of the industry, and novelty and the level of diffusion of the innovation. These contingencies can be integrated into two different factors of organization complexity and project complexity, which affect the division of labor in the innovation process. If both complexities are high, then the innovation team's capacity has to be increased by including more members and the differentiation of roles, while less division of labor may be acceptable in the case of low complexities. In simpler situations, two or three different functions are more likely to be combined into one person (Chakrabarti & Hauschildt, 1989).

The organization complexity can be conceptualized both in terms of how differentiated the structure is and how numerous are the tasks that refer to different kinds of operations and activities. So, organization complexity increases when the size of the organization grows, department or division becomes differentiated, and the firm diversifies into different business areas. As a source of organization complexity, the organizational context, within which innovation occurs, can have a profound effect on the overall quantity and quality of innovation activities in an organization.

It usually becomes increasingly difficult for large firms to successfully achieve radical innovations, primarily due to organizational inertia (Chandy & Tellis, 2000). The firms that have a large number of employees develop hierarchical layers of administrative staff to adapt to manage large firms. In a large firm, new innovative ideas generated by technical champions must move through more layers of hierarchies with resistance to get approval. In other words, growth in size and complexity can lead to bureaucratic inertia that dampens the innovativeness of firms (Chandy & Tellis, 2000). When the innovation project is to be accomplished in a large, complex firm, Charkrabarti & Hauschildt (1989) propose that a third champion (i.e., process champion) is required in addition to the technology champion and the power champion,.

. In a similar vein, Maidique (1980) found that the network of roles were a function of the stage of development of the firm. By analyzing the evolution of the entrepreneurial network for radical innovations in small, integrated, and diversified technological firms, he asserted that as the firm grows and evolves from a small firm to a large, diversified firm, the entrepreneur network becomes more specialized, and these roles tend to be performed by different people in different ways. For instance, small, entrepreneurial firms have a simple technologist and entrepreneur network, while, in integrated firms, the entrepreneur network evolves into a three-person constellation of technologist, product champion, and entrepreneur. In the case of diversified firms, a more differentiated network composed of technologist, product champion, executive champion, and entrepreneur is needed.

Hypothesis 1: Organization complexity is positively associated with the specialization of role structure in the innovation process.

The project complexity is also considered to be associated with the emergence of role specialization (Green, Gavin & Aiman-Smith, 1995; Markham, Green, & Basu, 1991). Project complexity can be defined as the number of different disciplines or departments involved in the project as well as intricacy of the design itself (Larson & Gobeli, 1989). So, the project complexity increases as the technological and market uncertainty, radicalness or unfamiliarity, and the size of the innovation project increase.

Schon (1963) and Veryzer, Jr. (1998) have shown that champions are more likely to be involved in radical innovations than in incremental ones. A radical innovation project represents significant risks to the firm because of its inherent technological and commercial uncertainties (Green, 1995), and thus needs specialized role players who enthusiastically commit to the innovation and actively reduce uncertainties and risks in favor of the innovation project.

Familiarity or congruence of an innovation project in terms of technology and market also has an impact on the role structure. Technological or market congruence represents the extent to which the organization is adequate in terms of the technology or market necessary to develop the new product or process (Green & Basu, 1989). When the innovation project appears unfamiliar to organizational members, they are more likely to question its feasibility and thus, stifle the progression of an innovation from the idea generation to the idea realization phase, without an appropriate role to defend the project (Waldman & Bass, 1991).

The size of the firm’s investment in the project (i.e., long-term development time, large-scale manpower, and millions of investment dollars) also relates to the risks entailed in the project and invokes organizational resistance against them (Green, 1995). Given that these innovations are risky, role specialization emerges to engage in promoting projects, since these projects frequently encounter organizational inertia and resistance regardless of the potential payoff. Multiple champions can make a concerted effort with a combination of technical knowledge and information, as well as hierarchical power, to promote highly risky innovations. Charkrabarti & Hauschildt (1989) predict that the complex innovation activities are more likely to be split between separate but mutually complementary promoters, who provide the appropriate power bases to overcome each of the different barriers.

Hypothesis 2: Project complexity is positively associated with the specialization of role structure in the innovation process.

Role specialization and project performance

Performance variables of innovation projects usually include both intermediate process performance and final outcome performance (Griffin & Hauser, 1996). This study considers reduction of four different uncertainties as process performance variables, and technological and commercial success as outcome performance measures. To achieve both technological and commercial success of an innovation project, uncertainties inherent to the project must be resolved first (Song & Parry, 1996). In a sense, process performance can be viewed as a necessary, but not a sufficient, condition for final project success (Griffin & Hauser, 1996).

This study posits that the specialization of role structure has an impact on the reduction of uncertainties, which in turn results in higher technological and commercial performance of innovation projects. The division of labor for critical roles in the innovation process enables the project team to collect more technological and market information, get political support from various organization members, and acquire material resources required for successful implementation. As a result, the four different uncertainties aforementioned can be drastically reduced. Management of such information processes may therefore be interpreted as an intervening variable in the direct relationship between role structure and innovation success (Hauschildt & Kirchmann, 2001).

Existing literature on diverse champion roles offers the central idea that champions operate using three resources - information, material resources, and political support of organization (Beath, 1991; Kanter, 1983). Champions need to procure information from diverse sources both inside and outside the organization to identify potentially successful new product ideas and generate or mobilize support for new ideas (Ancona & Caldwell, 1992; Beath, 1991; Burgelman, 1983; Burgelman & Sayles, 1986; Kanter, 1988).

Beyond identifying potential innovation ideas, champions persistently work at gathering the support from key stakeholders and try to procure resources needed to advance those ideas. They devote their time and energy to cultivating a coalition of support within the firm, and to obtaining approval from key decision makers (Green, 1995; Madique & Zirger, 1984; Pinto & Slevin, 1987). Markham, Green & Basu (1991) found that champions were associated with higher levels of organizational support throughout the firm.

Champions also attach importance to securing resources and display various skills in doing so (Frost & Egri, 1991). Maidique (1980) characterized championing as a process of redirecting resources within a firm to certain projects, that is, champion behavior aims primarily to affect resource allocation decisions within a firm. Markham (2000) also found that the presence of champions was associated with greater resource allocation for a project.

In summary, through their roles as collectors for innovation-related technical and market information, and gatherers of political support and the resources needed to advance the innovation, role specialization contributes to project performance. Hence, it might be proposed that specialization of role structure makes a positive contribution to the project performance by providing more information, material resources, and organizational support.

Several empirical studies have demonstrated the relationship between role structure and performance of innovation projects. Witte (1973) has shown that the two-person constellation of promoters is more efficient than the one-person constellation, which in turn outperforms the structure without any promoter. Chakrabarti & Hauschildt (1989) advocate that a three-person constellation model of promoters can make the specific contribution of each member to the innovation process most efficacious, with the right mix of knowledge and information, as well as hierarchical power. Hauschildt & Kirchmann (2001) empirically investigated the hypotheses of efficiency of the three-person constellation and found that of all the promoter structures, the troika constellation makes the highest contribution in terms of the acquisition of innovation-related information, the degree of innovation achieved, and a high level of both technical or commercial success.

Hypothesis 3: The specialization of role structure is positively associated with the performance of the innovation project.

Hypothesis 3a: The specialization of role structure will be positively associated with process performance of the innovation projects.
Hypothesis 3b: The specialization of role structure will be positively associated with outcome performance of the innovation projects.

The information processing model suggests organizations must be able to cope with work related uncertainties in order to survive and grow (Galbraith, 1977: Tushman & Nadler, 1978). Organizations should have information processing capacity to match information processing requirements of work conditions to deal efficiently with uncertainty. In other words, a proper fit between the complexity of work and the information processing activities of an organization results in high performance.

In this study, the complexity of the organization or project requires more information processing needs on the one hand, while the specialization of role structure provides an appropriate information processing capacity on the other hand. Thus, the specialization of role structure may not have positive effects equally on the performance of all the innovation projects. Rather, higher performing innovation projects will be those that match information processing capacity and information processing requirements. If the organization or project complexity of an innovation project is very high, for instance, then the innovation team's capacity to deal with this complexity also has to increase by specialization of role structure. On the contrary, if the complexity of the organization or project is substantially low, less specialization of role structure may be acceptable. So the role structure must be specialized to the level commensurate with the requirement of information processing, which depends on the organization or project complexity of the innovation project.

Hypothesis 4: The fit between organization complexity and role structure will be positively associated with the performance of the innovation project.

Hypothesis 4a: The fit between organization complexity and the role structure will be positively associated with process performance of the innovation projects.
Hypothesis 4b: The fit between organization complexity and the role structure will be positively associated with outcome performance of the innovation projects.

Hypothesis 5: The fit between project complexity and role structure will be positively associated with the performance of the innovation project.

Hypothesis 5a: The fit between project complexity and role structure will be positively associated with process performance of the innovation projects.
Hypothesis 5b: The fit between project complexity and role structure will be positively associated with outcome performance of the innovation projects.

IV. Research Methods

Sample and Data Collection

A pilot case study was carried out with 21 new product development (NPD) projects in 7 manufacturing firms. These NPD projects were selected using multiple criteria. First, the project was new to the firm on the dimensions of technology and/or market by in-house development. Second, the project had strategic implications for the firm with considerable resources. Third, the project was finished within the 3 years prior to the study to ensure more accurate recall of the NPD process by participants. Finally, only projects with identifiable key people (i.e., champions) who were deeply involved in the project being selected were chosen.

Liaison persons (mostly R&D planning managers) at these sample firm, based on a collaborative search with research teams, identified the NPD projects and the key people involved in these projects. Subsequent interviews were conducted with them, together with project leaders and team members. The interviewees were first asked to identify the key people involved in the projects, and were also asked to describe the roles each of them played for the project. Then, they were given a set of role definitions[1] (technical champion, project champion, and executive champion) derived from the innovation literature (Rothwell et al., 1974) to identify the person(s) who clearly fit each of these roles. This preliminary study showed that interviewees had no trouble to identify the role players, and had a high level of convergence for them.

In a subsequent survey study, all the winners of the Jang Young-Shil[2] Award between 1999-2002, 103 Korean firms, were initially contacted. Among them, 50 firms agreed to participate in the study. The Jang Young-Shil Award is given every week in the name of the Minister of Science and Technology in Korea to the innovation projects which achieve the most prominent performances in terms of technological superiority, originality, economic value and technical spill-over effect. In close collaboration with the research team, liaison persons (mostly R&D planning managers) at the sample firms introduced 112 projects, which satisfied the same multiple criteria used in the pilot study. Then, the survey questionnaire was directly mailed to both project managers and team members, with a cover letter providing detailed instructions. The respondents were assured of confidentiality and asked to return the completed questionnaire by mail. Especially, project managers were asked to list the person who best fitted the description of the given three critical roles. The people nominated by the project manager were identified as the key role player(s). Hauschildt & Kirchmann (2001) used a similar procedure in identifying the promoter structures. Subsequent interviews with the project managers confirmed that the key people who are deeply involved in the project indeed acted in that role for the project.

Questionnaires were collected from 298 respondents (91 project managers and 207 project members) in 98 project teams from 39 firms (The overall response rate is 53.2 %). However, only 91[3] new product development projects from 34 Korean firms

[1] To minimize the risk of attribution bias, description of role definition does not reveal the name of role, following Hauschildt and Kirchmann (2001) and Howell and Higgins (1990).

[2] One of the greatest inventors in the Korean history

[3] Included among them are 18 pilot cases and two additional cases, which are not winners of the Jang Young-Shil Award

in various industries such as electronics/telecommunication, machinery, and chemical industries, comprising 286 respondents (on average 3.14 per projects), were finally used for further data analysis, after excluding projects that did not receive responses from the project manager or champion. On average, respondents were 37.3 years old, had 11.1 years of work experience, and were predominantly male (97.1%). The proportion of respondents with a bachelor degree was 33.7%, master's degree 40.5%, Ph. D. 20.4%, and others were 5.4%.

Thirteen projects (14.3%) were collected from small firms (the number of employees is less than 100), another 13 were from medium firms (between 100 to 2,500 employees), and the remaining 65 projects (71.4%) were sampled from large firms (more than 2,500 employees). Using the six-category scheme proposed by Booz, Allen and Hamilton, 20.9% of the sample projects were classified as a "New to the world product," 69.2% as a "New product line," 5.5% as a "Product line extension," and only 4.4% as an "Improved product." There were no cases for "Repositioning" and "Cost reduction." The average number of team members was 15.7, the average budget size of the projects was 2.5 billion won (about $2,270,000), and the average development time was 30.6 months.

Measurements

Organization Complexity and Project Complexity

<u>The organization complexity</u> can be conceptualized both in terms of how differentiated the structure is and how numerous are the tasks that refer to different kinds of operations and activities. In this study, it is measured by a composite index of size (sales volume and the number of employees) of the firm and level of diversification.

Previous studies (for example, Blau & Schoenherr, 1971; Marsh & Mannari, 1981) have consistently shown that increase in size fosters structural differentiation or complexity in several dimensions - number of departments, number of hierarchical levels, and degree of functional specialization. Similarly, diversification and some aspects of organizational complexity are highly positively correlated (Grinyer & Yasai-Ardekani, 1981).

Sales volume and the total number of full-time employees of a firm were obtained from annual reports. Level of diversification was based on the four-level classification introduced by Wrigley (1970): single product, dominant product, related product, and unrelated product strategies being scored successively from 1 to 4. The distribution of sales data and the number of employees of the firm were skewed so they were transformed into its logarithm prior to statistical analysis. In the case of several projects obtained in the same firm, scores for firm-level variables were allocated to all projects in the firm respectively.

The project complexity refers to the variety or diversity of some aspect of a task (Baccarini, 1996), such as the number of different disciplines or departments involved in the project (Larson & Gobeli, 1989), the number of parts (Murmann, 1994), the number of functions a project performs (Griffin, 1997) as well as intricacy of the design itself (Larson & Gobeli, 1989). A poor understanding of the technology and market involved in radical projects can increase the complexity encountered by the team (Kim and Wilemon, 2003). In this study, it is measured by a composite index of product radicalness, size (manpower and budget) of the project. Radicalness or newness of the project was measured using the five-category scheme proposed by Booz, Allen & Hamilton (1982) and Kleinschmidt & Cooper (1991). The increase in the number of individuals and functional groups and larger investments of company resources can produce the complexity that the team must deal with (Kim & Wilemon, 2003). Data for manpower and budget size of the project were acquired from project documents and verified with project leaders. All variables were standardized due to scale differences.

To verify the underlying dimensions of organizational and project variables, all these variables are analyzed using the principal component analysis with Varimax rotation and resulted in a two-factor solution. Table 2 shows that all of the variables relating to organizational characteristics (i.e., level of diversification, sales volume, and the number of employees of the firm) clearly loaded on factor 1 and thus are named “organization complexity.” The other variables highly loaded on factor 2 share the common feature of project characteristics. We labeled this factor “project complexity.” For each dimension of organization complexity and project complexity, an average score of relevant variables was used, respectively, in the subsequent analyses.

Specialization of role structure

The specialization of role structure is defined as the number of separate people who play such critical roles as technical champion, project champion, and executive champion in the innovation process, which correspond to the ‘promoter structures’ introduced by Hauschildt & Kirchmann (2001).

The fit between organization complexity (or project complexity) and the role structure

The fit between organization complexity (or project complexity) and role structure is measured by an absolute difference between the values for organization complexity (or project complexity) and role structure, following Keller’s (1994) approach. The absolute difference technique is considered as appropriate for testing relationships when fit is conceptualized as a theoretically defined match between two variables (Venkatraman, 1989). Thus, it implies that for each value of organization complexity (or project complexity), there is a best value of the specialization of role structure that results in high performance. This technique for measuring fit, however, can be susceptible to bias since difference scales are used (Keller, 1994). To minimize these scaling differences, the scores were standardized before difference scores were computed. The two fit measures were reverse-scored so that higher values could reflect higher fit.

Process performance of project

Four types of uncertainty such as technological, market, resource and organizational uncertainties have been identified (Leifer, O'Connor & Rice, 2001). This study, thus, considers four matched process performances to reduce four different uncertainties, respectively (i.e., technological and market intelligence, resource supply and organizational support).

Technological intelligence refers to the firm's understanding of a new product's technical requirements and technology, as well as the product's manufacturing requirements and technology (4 items, Song & Parry, 1996). Market intelligence refers to the firm's understanding of a new product's target market such as the firm's knowledge of market size, customer needs, price sensitivity, and competitors (4 items, Song & Parry, 1996). Resource supply measures the extent to which resources (i.e., personnel, money, facility, time) may be given to the project. Organizational support measures the extent to which organizational support may be given to the project. Resources supply and organizational support were assessed by the 4-item scale, respectively, used by Shim & Lee (2001), an abbreviated scale of the project viability[4] measures developed by Markham (1998).

Outcome performance of project

Outcome performance of the project was measured in terms of technological and commercial performance in the present study, using subjective ratings. Team members and the project leader were asked to assess the project's success on performance dimensions suggested by several researchers (Clark & Fujimoto, 1991; Keller, 1986). While more objective ratings such as percentage over budget or actual

[4] Markham's (1998) project viability refers to the level of general support a project enjoys, resource adequacy, and the level of risk (16 items).

sales have been suggested (Clark & Fujimoto, 1991), these numbers are affected by a multiple of factors beyond the control of the innovation team (e.g., economic recession) (Ancona & Caldwell, 1992). Due to difference in environments, it is difficult to find objective measures that are consistent across teams (Guinan, Cooprider, & Faraj, 1998). Venkatraman & Ramanujam (1987) suggest that perceptual assessments of performance provided by knowledgeable managers have a high level of convergence with other objective measures of performance.

Technological performance refers to a product's perceived superiority such as product's relative performance and quality, as well as the presence of unique features and capabilities (5 items, Song & Montoya-Weiss, 2001). Commercial performance measures the overall impact of the new product project on a set of representative business goals. Scoring for the five-point Likert type scales of: (1) profitability; (2) sales volume; (3) market position, were summed up.

In this study, as the same person reports both degrees of uncertainty reduction and performance measures, the association between these variables may be influenced by common method variance. To assess the variance, we conduct Harman's (1967) single-factor test. Our results reveal neither a single nor a general factor; instead, six factors are derived from factor structure, which represent four different degrees of uncertainty reduction and two outcome variables. This result indicates that the relationship between these variables is not merely caused by common method variance.

The unit of analysis in this study is an individual NPD project. To justify the aggregation of the measures completed by multiple respondents to the project level, rwg analyses (James, Femaree, & Wolf, 1984) were performed. In all cases, the inter-rater agreement score provided support for combining team members' perceptions to produce aggregated scores for the measures (i.e., rwg indices > 0.8). Also, all the variables measured by multi-item scales were found to be reliable (all Cronbach's alpha coefficients exceed 0.7. See figures on the diagonal in Table 1).

V. Results

Table 3 gives a correlation matrix among the variables. Role structure is significantly and positively correlated with organization complexity and four different process performance variables and the technological performance variable, yet marginally correlated with project complexity and commercial performance. Fit between organization complexity and role structure shows significant positive correlation coefficients with two variables of process performance - market intelligence and resource supply - and technological performance. On the contrary, fit between project complexity and role structure has no significant relationship with any other performance variables.

Table 4 presents the results of the regression analysis for the specialization of role structure and its two antecedents (i.e., organization and project complexity). The result reveals that organization complexity did predict the role structure of the innovation process ($p < .05$), while project complexity fails to do that. So the results shown in Table 3 and 4 support H1, but not H2.

Table 5 reveals that the specialization of role structure had a significantly positive impact on all indicators of process performance of the projects such as technical intelligence, market intelligence, resource supply and organizational support. In other words, the specialization of role structure makes a significant contribution to reducing all kinds of uncertainties in the innovation process. As a result, it is concluded that H3a is accepted.

Table 6 indicates the results of hierarchical multiple regression analyses between role structure and two outcome performance variables. A restricted model of regression shows role structure significantly ($p<0.01$) and marginally ($p<0.1$) predicts the technological and commercial performance, respectively. However, a full model, including four process performance variables simultaneously, fails to show a significant relationship to both outcome variables. The result strongly implies that the role structure has an indirect effect on technological and commercial performance through process performance variables, which mediate the relationship between the role structure and the outcome performance variables. So it would be fair to conclude that H3b is partially supported.

Hypotheses 4 and 5 are concerned about the relationships between two fit variables and performances of the projects. Table 5 reveals that fit between organization complexity and role structure significantly predicts market intelligence and resource supply for process performance. However, fit between project complexity and role structure does not show any significant relationship with process performance variables. So only H4a is partially supported and H5a is not supported.

For the relationship with outcome performance variables, Table 6 indicates that although fit between organization complexity and role structure marginally predicts technological performance in a restricted model, two fit variables have no significant direct effects on both technological and commercial performance. Thus, all hypotheses which predict the relationship with outcome performance (i.e., H4b and H5b) fail to be accepted.

Table 6 indicates that rather than role structure and two fit variables, process performance measures better account for the outcome performance variables. Especially, market intelligence and organizational support seem to be certainly the best predictor of both technological and commercial performances. Technological intelligence predicts the technological performance, but has nothing to do with the commercial performance. Further, resource supply fails to predict both project outcome performances. Overall, the results seem to show the mediating effects of process performance variables between role specialization or two fit variables and outcome performance measures. Put differently, the specialization of role structure or fit between organization complexity and role structure can substantially diminish uncertainties in the innovation process in terms of technology, market, resources, and organizational support, which, in turn, lead to an increase in the technological and commercial performance of the project.

Further examining these mediating effects of process performance variables, Partial Least Squares Analysis (PLS) was performed as a post hoc analysis (Wold, 1982). In PLS, sample size requirements can be smaller, with a rule of thumb suggesting that it be ten times larger in number than either (a) the largest number of formative indicators for any given construct, or (b) the largest number of structural paths directed at a particular construct in the model. Our sample size of 91 NPD project teams exceeded the recommended minimum for model testing. PLS-Graph version 2.91 (Chin & Frye, 1996) was used in this study. The adequacy of the measurement model can be tested by examining: (1) individual item reliability, (2) convergent validity, and (3) discriminant validity (Hulland, 1999). The factor loadings (or the weights) of the measures with their corresponding constructs for reflective (or formative) indicators reveal a high level of individual item reliabilities. Convergent validity was assessed using internal consistency measures developed by Fornell & Larker (1981). In all cases, the internal consistency reliabilities well exceed the 0.7 criterion. Discriminant validity, assessed by comparing the correlation matrix of the constructs with the square root of the average variance extracted (ρvc: Fornell & Lacker, 1981) by the measures for each construct, was also found satisfactory. To assess the structural model, PLS produces standardized regression coefficients using ordinary least squares to minimize the residual variance. To conduct significance tests, a jackknife analysis was performed. A p value of 0.05 was used to test significance. The result of the PLS analysis is illustrated in Figure 2 along with the path coefficients, significance levels, and multiple R^2 values in the PLS model.

In the restricted model (not shown here), PLS results are consistent with those of regression analyses, except only the fit between project complexity and role structure marginally predicted technological intelligence and organizational support (β= .15, p < .10; β= .16, p < .10). For the prediction of outcome performance, the specialization of role structure had direct effects on both performance variables (β= .35, p < .005; β= .21, p < .05), and the fit between organization complexity and role structure predicted technological performance marginally (β= .17, p < .10). In a restricted model, the total variance explained in technological performance was 15.7%, in commercial performance it was 5.9%.

In a full model (Figure 1), however, the specialization of role structure failed to predict both performance variables. Neither of the two fit variables were predictors of either of the performance variables. Technological and market intelligence were clearly the best predictors of technological performance (β= .25, p < .05; β= .27, p < .05). Organizational support predicted technological performance marginally (β= .19, p < .10). For the prediction of commercial performance, technological performance (β= .45, p < .005) was the best predictor, followed by market intelligence (β= .18, p < .10) and organizational support (β= .16, p < .10). Resource supply had a negative effect on the commercial performance marginally (β= -.15, p < .10). As summarized in Figure 2, in a full model, the total variance explained in technological performance was 40.0%, in commercial performance it was 34.9%.

VI. Summary and Discussion

This study empirically examines the contingency relationship among the specialization of critical role structure, organization and project complexity, and process and outcome performances of the innovation projects. Based on data from 91 NPD projects in Korea, this study found that:

1) organization complexity leads to specialization of role structure in the innovation process, while project complexity is not associated with the role structure;
2) role structure has a significant positive impact on all four process performance

variables, which in turn lead to better technological and commercial performance of the innovation project;

3) the fit between organization complexity and the role structure also has an indirect effect on technological and commercial performance through market intelligence and resource supply, whilst the fit between project complexity and the role structure has a marginal positive impact only on organizational support;
4) technological intelligence has an indirect positive impact on commercial performance through technological performance;
5) market intelligence and organizational support have a direct positive impact on both technological and commercial performance of the project; and
6) resource supply, on the contrary, has only a direct negative impact on commercial performance of the project.

Role structure in the innovation process: contingencies and consequences

The results found in this study offer several theoretical implications. First, the specialization of role structure is more influenced by organization complexity than by project complexity. Complexity of organization, within which innovation occurs, requires more information processing activities than complexity of the project itself, since more constituents are involved in the innovation process and these people must deal with a diverse network of champions in large complex organizations. The essence of role specialization in the innovation process in large firms is the emergence of a project champion and an executive champion (or sponsor), in addition to a technical champion (or, expert), which are found in most innovation projects. As the firm grows larger and diversified, a mangers who have organizational knowledge and interpersonal and communication skills, and executives who identify and support promising innovation ideas in the organization are needed for successful innovation.

Contrary to the hypothesis in this study, project complexity does not affect the specialization of role structure. Probably, information processing needs due to project complexity may be resolved by a sole champion (usually technical champion) or other coordination mechanisms. Markham, Green & Basu (1991) and Markham & Griffin (1998) also found that project champions were involved equally with radical and incremental innovation projects, contrary to Schon (1963). As a result, more differentiated role structures in the innovation process emerge in complex organizations than in the cases of complex projects.

Second, the role structure in the innovation process has a positive impact on commercial and technological performance of the project in an indirect way through process performance variables, which represent the reduction of four different uncertainties inherent to the innovation such as technological and market intelligence, organizational support, and resource supply. The specialization of role structure in the innovation process is quite helpful to get more market and technical information, more moral support and legitimacy from the organization for the project, and thus for acquisition of more tangible and intangible resources required for successful implementation of the innovation project. This reduction of uncertainties in the innovation process is indispensable for the outcome performance. As a result, the role specialization indirectly leads to higher technical and commercial success of innovation projects.

Third, not just the specialization of role structure in the innovation process, but the fit between organization complexity and role specialization have a direct positive impact on market intelligence, and resource supply, and indirectly on technological and commercial performance. When the organization complexity and specialization of role structure matches, innovation projects are more likely to reduce market uncertainty and to acquire more resources needed for the implementation of innovation. In other words, the fit between organization complexity and role specialization, together with the specialization of role structure itself, has an augmented effect on the performance of innovation projects. When the organization becomes more complex, the importance of diverse specialized roles in the innovation process is more alleviated for the successful implementation of innovation projects.

Fourth, four different process performance variables also have different impacts on technological and commercial performance of the project. While technological intelligence makes a contribution to technological performance, market intelligence and organizational support increase both technological and commercial performance. For the success of an innovation project, it is very important not just to reduce technological and market uncertainty, but to manage uncertainty within an organization by building coalitions with influential people. Existing studies also acknowledge the importance of top management support and management of technological and market information to better fulfill customer needs (Cooper & Kleinschmidt, 1987; Song & Parry, 1996; Zirger & Maidique, 1990). This study further discloses these critical factors for the success of innovation projects are influenced by designing the level of specialization in role structure of the innovation project.

Surprisingly, this study found that resource supply had a negative effect, even if marginal, on commercial performance of the project. It means that projects with lower level of commercial performance have been provided more resources due to the specialization of role structure. Previous studies also report that the size of the resource commitments to the project is not always associated with achievement of business goals (Green, 1995: Markham, 2000). This result raises a possibility of downside of role specialization in the innovation process. Although the specialized critical role players for a specific innovation project make contributions to the reduction of uncertainties inherent to the project, they do not necessarily promote its technological or commercial success. Markham (2000) also attests to the influence of champions because they can be successful at providing resources to projects that are no more likely to succeed than other projects.

Management of innovation using role specialization

Given the ever increasing needs of technological innovation in fast paced environmental change, the firm must recognize the importance of informal roles key people play in the innovation process. Especially, as the firm grows larger and diversified, and thus becomes more complex, people who can play a critical role in the innovation process can contribute to the successful development of technological innovation. However, a large and diversified organization naturally becomes more likely to be structured to handle such complexity, and thus informal roles key people can play in the innovation process tend to be discouraged.

With this tendency in mind, top management, especially in large and complex firms, must create organizational contexts and cultures in which people who generate creative ideas, champion promising ones, support and help to develop them, and provide required physical and socio-political resources, can work together and be free from bureaucratic obstacles. Setting a corporate vision which facilitates innovation and a flexible resource allocation system and risk-taking culture would be a possible means to do that (Tushman & Nadler, 1986).

Especially firms in late industrializing countries, like Korea, are now being caught between advanced countries which have a competitive advantage in knowledge-intensive industries and developing countries which have a cost advantage in labor-intensive industries. In the face of the rapid erosion of their competitiveness based on imitative technology development, continuous product development based on creative innovations appears to be a strategic mandate for them to sustain their competitiveness in the global market arena. Given their aspiration for more innovation performance and commitment to heavy investment in technology development, they must recognize the importance of informal roles of champions in the innovation process and design the specialization of critical role structures according to their organizational complexity and project characteristics. The findings in this study offer insights to both top management and project managers of technological innovation.

VII. Conclusion

Existing studies in advanced countries found various types of specialized role emerged in the innovation process. These studies are more descriptive and exploratory in delineating these roles. However, they focused on firms in advanced contexts and lacked a systematic method in delineating distinctive roles and did not empirically examine the relationship between these role structures and performance of the innovation project.

This study empirically examines the structure of critical roles in the innovation process and the relationships with its contingency factors and performance consequences. As a result, this study extends the current knowledge on critical roles in the innovation process by generalizing their importance in innovation projects to a newly industrializing context, Korea, and further sheds light on the contingent relationship between organization complexity and specialization of role structure in the innovation process, and its direct and indirect impact on project performances.

However, given the small number of samples in Korea, this study is an exploratory attempt in nature and has many limitations. The results found and the relationships proposed in this study must be validated by further research employing a more rigorous research method in diverse research settings. In-depth case analyses and a process approach with a longitudinal analysis are needed to understand the individual role of champions and their collaboration networks in the innovation process and to examine the relationships between critical role structures and other situational factors or innovation performance. Further, specialization of role structure seems to be one of uncertainty reduction activities from the information processing perspective, and certainly there are other information processing mechanisms to cope with the uncertainties inherent to the innovation project. For a comprehensive model of role specialization in the innovation process, future research must consider other coordination mechanisms, which may have complementary or substitute relationship with role specialization for the performance of innovation.

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TABLE 1

Key roles or functions

Role	Technical innovator	Project champion	Executive champion	Chief executive	Others
Schumpeter (1934)	Inventor	-	-	Eentrepreneur	-
Klein (1974); Witte (1973)	Facht-promotor	-	Macht-promotor	-	-
Rothwell et al. (1974)	Technical innovator	Product champion	Business innovator	Chief executive	-
Maidique (1980)	Technologist	Product champion	Executive champion	Technological entrepreneur	-
Roberts & Fusfeld (1981)	Idea generating	Championing;	Sponsoring or Coaching	-	Gatekeeping; Project leading
Galbraith (1982)	Idea generator	Idea champion	Sponsor	Orchestrator	-
Charkrabarti & Hauschildt (1989)	Expert: fachpromotor	Champion: process promotor	Sponsor: machtpromotor	-	-
Day (1994)	-	Principal Champion	Organizational Sponsor	-	-
Markham (2000)		Champion			Antagonist
Hauschildt & Kirchmann (2001)	Technology promotor	Process promotor	Power promotor	-	-

TABLE 2

Factor analysis

Variables	Organization Complexity	Project Complexity
Number of employees	**.92**	.10
Sales Volume	**.92**	.10
Level of Diversification	**.69**	-.01
Product Radicalness	-.13	**.77**
Budget of the Project	.11	**.63**
Manpower of the Project	.37	**.45**
Eigenvalue	2.4691	1.1472
Proportion	.4115	.1912

TABLE 3

Correlation Analysis

	1	2	3	4	5	6	7	8	9	10	11
1. Organization Complexity	-										
2. Project Complexity	.23*	-									
3. Specialization of Role Structure	.24*	.18+	-								
4. Fit between Organization Complexity and role structure	.00	.07	.00	-							
5. Fit between Project Complexity and role structure	-.14	-.28**	-.17+	.17+	-						
6. Technological Intelligence	.11	.00	.22*	.04	.10	(.79)					
7. Market Intelligence	.10	-.03	.32***	.38***	.05	.50***	(.80)				
8. Resource Supply	.30***	.08	.27**	.33***	.11	.38***	.46***	(.87)			
9. Organizational Support	.04	.08	.33***	.09	.11	.30***	.38***	.54***	(.87)		
10. Technological Performance	.07	.11	.34***	.18+	.01	.46***	.52***	.36***	.41***	(.88)	
11. Commercial Performance	.06	-.15	.18+	.11	.06	.29***	.38***	.17+	.33***	.54***	(.91)

Diagonal elements denote the Cronbach's Alpha coefficients. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .005$.

TABLE 4

Regression Analysis

Variables	Specialization of Role Structure
	β
Organization Complexity	.21*
Project Complexity	.13
R^2	.07
F	3.72*

β is the standardized regression coefficient. N = 91.

†p < .10, * p < .05, ** p < .01, *** p < .005.

TABLE 5

Regression Analyses

Variables	Technological Intelligence		Market Intelligence		Resource Supply		Organizational Support	
	β	β	β	β	β	β	β	β
Specialization of Role Structure	.22*	.25*	.32***	.33***	.27**	.29***	.33***	.36***
Fit between Organization Complexity and Role Structure		.01		.37***		.31***		.06
Fit between Project Complexity and Role Structure		.15		.05		.10		.16
R^2	.05	.07	.10	.25	.07	.20	.11	.14
F	4.77*	2.32†	10.87***	10.09***	7.21**	7.27***	11.23***	5.01***
R^2 increment		.02		.15		.13		.03
F		1.09		8.76***		6.83***		1.79

β is the standardized regression coefficient. The R^2 increments and F-values are derived from hierarchical regression analyses. N = 91.
†p < .10, * p < .05, ** p < .01, *** p < .005.

TABLE 6

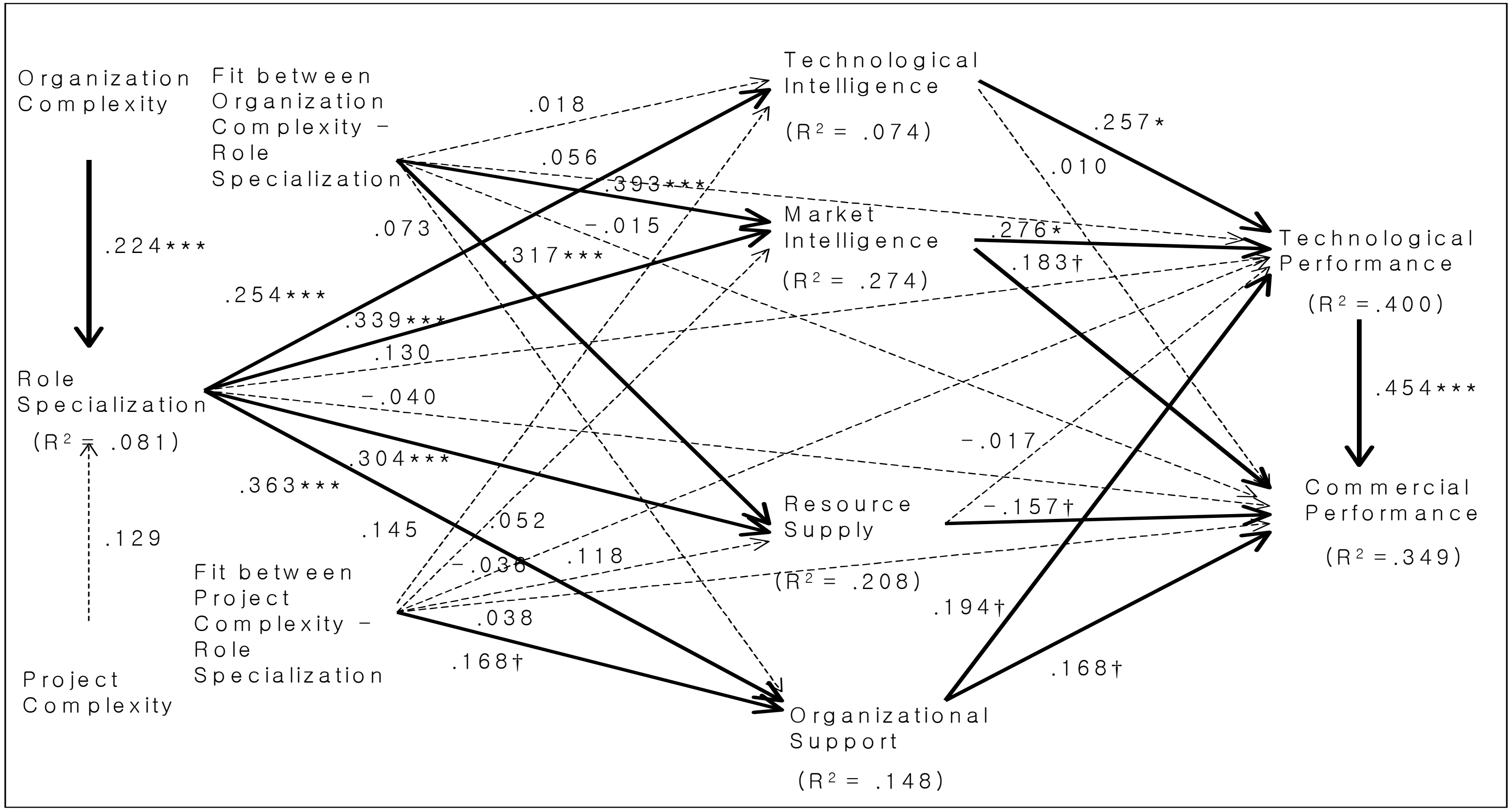
Regression Analyses

Variables	Technological Performance			Commercial Performance		
	β	β	β	β	β	β
Specialization of Role Structure	.34***	.35***	.13	.18†	.19†	.02
Fit between Organization Complexity and Role Structure		.17†	.06		.10	.02
Fit between Project Complexity and Role Structure		.04	-.03		.07	.01
Technological Intelligence			.25*			.13
Market Intelligence			.25*			.27*
Resource Supply			-.01			-.16
Organizational Support			.19†			.26*
R^2	.12	.15	.38	.03	.05	.21
F	12.19***	5.40***	7.54***	3.17†	1.63	3.25***
R^2 increment		.03	.23		.02	.16
F		1.88	7.87***		0.87	4.27***

β is the standardized regression coefficient. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .005$.
The R^2 increments and F-values are derived from hierarchical regression analyses. N = 91.

FIGURE 1

Parameters of the full model: Path coefficients and R^2 value



β is the standardized regression coefficient. † p < .10, * p < .05, ** p < .01, *** p < .005