MANAGEMENT OF ALLIANCES IN DYNAMIC INDUSTRIES: MODULARIZATION AND INTER-FIRM TEAMS

Ricarda B. Bouncken, University of Greifswald, Greifswald, Germany
Thorsten Teichert, University of Hamburg, Hamburg, Germany
Michael Koch, University of Hamburg, Hamburg, Germany

ABSTRACT

Prior studies indicate that modularization improves innovation. The benefits are based upon by a flexible configuration of components and processes. This paper extends the intra- firm concept of modularity to the inter-firm level. We explore two facets of modularity and synergistic specificity and their consequences on the outcomes of alliances, particularly on outcome-blending. We differentiate the context-driven effects of modularity and synergistic specificity on outcome blending by a comparison of two dynamic industries. Biotechnology and new media represent two ends of a continuum between (1) highly science-laden with long time-to-market, and (2) highly IT- and design-laden with fast-to-market innovations. Based on a survey of more than 300 enterprises, we find that alliances in both industries achieve a synergistic blending of collaboration outcomes. Applying a two-group structural equation model, we reveal differences according to hypothesized relationships. Findings are related to market and technology characteristics.

Keywords: *Alliances, R&D collaboration, Modularity*

1. INTRODUCTION

Successful firms create knowledge internally but also by exposing themselves to a variety of knowledge from outside that encourage a re-shaping of their competencies. Aliances serve as an important vehicle to acquire knowledge from other firms (Mowery, Oxley and Silverman, 1996). In addition, it allows a flexible configuration of components, in which partnering firms contribute to a distributed innovation. This provides the basis for modular innovation, as products are bundles of components that can be mixed and matched in various ways (Sanchez, 1995a). Although modular innovation has been receiving increasing attention recently (e.g. Galunic and Eisenhardt, 2000), a research gap exists in respect to its interfirm functioning. To reduce the gap, this study investigates modular innovation and contextual factors. Extending the ideas on modular innovation within firms, this study intends to deliver a more fine-grained picture of modularity and synergistic specificity on alliance outcomes. Contextual factors on modular innovations are provided through the comparison of two industries: biotechnology and new media. This setting is especially interesting as both industries face consolidation after their immense growth. The industries are comparable in the sense that a) innovation mainly roots on alliances, b) industries consists predominantly of smaller firms, and c) learning plays an important role. But, biotechnology and new media portray two ends of a continuum between 1) highly science-laden with long time-to-market, and 2) highly IT- and design-laden innovations with short-time to market. So our study provides contextual factors open to transfer to other industries along this continuum.

2. THEORY

2.1 Alliances

We regard alliances as voluntary arrangements between two or more independent firms that are neither pure hierarchy nor pure market and are negotiated on an ongoing basis (Lawrence and Phillips, 2002). Alliances are regarded especially useful for creating, acquiring and transferring new knowledge necessary for innovation (Mowery et al., 1996). In alliances, firms carry out a project or work in a specific business area by coordinating the required skills and resources rather than by operating alone (Dussage, Garette and Mitchell, 2000). While companies are increasingly developing new products jointly on such a basis, those arrangements still appear to be very costly to manage (Mowery, 1992; Mowery et al., 1996).

Therefore, firms are in need to find effective tools to manage collaboration and the corresponding inter-firm learning process. As we will show in the following, modularity and synergistic specificity constitute two complementary design options to reap benefits from collaborative innovation projects.

2.2 Modularity and Synergistic Specificity

Modularity is a very general set of principles for managing complex systems. The general idea behind modularity is to decompose a complex system into components interdependent through standardized interfaces within a standardized architecture (Baldwin and Clarke, 2000). Modularization refers to the coupling between components and the rules of components' configuration (Shilling, 2000). Longlois (2002), p. 34 even calls for a 'modularity theory of the firm'. Modularity allows to select from a given set of inputs multiple configurations, which are a function of the number and heterogeneity of the inputs combined (Schilling and Steensma, 2001). Modularity has been extensively applied to products and configurations of their production (Sanchez and Mahoney, 1996b). Thus, modularization captures product- and process-architectures (Worren, Moore and Cardona, 2002). For example, modularity has been regarded as a concept to increase production flexibility (Garud and Kotha, 1994). Sanchez (1996) assumes that modularity of product designs is an important strategy for achieving modular organization designs. Loose couplings between components in modular product designs are co-ordinated through standardized component interface specifications (Sanchez and Mahoney, 1996a). Langlois and Robertson (2001) examine product modularization in vertical specialization ranging from producers to component manufacturers and ultimate users as well as horizontal collaboration between manufacturers. They show that product modularization may improve innovation through the division of labour as well as through simultaneous experimentation and learning. In modular collaboration, firms have to define interfaces of physical components and/or process components. Still, the interaction among the subjects of the collaboration remains as well a matter of communication, as alliances with their inter-firm modularization acts within social systems (Langlois, 2002).

Modularization has its costs and limitations, as modules may be inseparable defined. Firms may find it inappropriate to implement modularization of products or processes because of performance advantages of integration or organizational inertia (Shilling, 2000). Forces limiting performance advantages root on synergistic specificity, which defines the degree to which a system achieves greater functionality through specific components inseparably aligned to one another (Shilling, 2000). Synergy emerges through the specificity of particular components to a distinct configuration. Inter-firm systems with a high degree of synergistic specificity in alliances can achieve results that are impossible to achieve in pure modular systems due to non-recombinability. Synergistic specificity is particularly the case when processes or products accomplish their functionality only by collocation. Then, performance is impeded if firms co figurate these components or processes non-specific. Thus, firms can apply a more synergetic process of alliances in addition to the more predefined and formal management of modularity. In this way, the process of collaboration becomes more dependent on the interactive contributions of partners. Such a higher-order frame of process-integration across firms fosters synergistic process specificity.

We argue that in collaborations, some of the components and processes across firms can be re-combinated in a variety of configurations that have little or none loss of functionality, while others will be relatively dependent on each others. So, collaborating firms can opt for modularity or synergistic specificity while taking interactions between modular and synergistic elements into consideration. We assume modularity to be an integral part in alliances as collaborating firms have to define some modules and interfaces to coordinate for an outcome. The web of processes and products necessary for alliance coordination will have both modular as well as synergistic elements. Even complementary effects may exist as Worren, Moore, and Cardona (2002) state that firms need complementary organizational resources and capabilities to exploit the 'economics of substitution' afforded by modular product structures (Cusumano, 1988).

H1: Modularity and synergistic specificity are two distinct but interrelated dimensions of inter-firm collaboration in alliances.

2.3 First- and Second-Order Outcomes of Modularization

The mechanism of modularization has been well researched. However, the picture of outcomes which can be achieved through modularity within and across firms is still blurred: Firstly, outcomes can be pre-specified or more open. Sanchez draws on the specification of intended outputs of components that permits to partition processes into tasks that can be carried out autonomously and concurrently by loosely coupled systems (Sanchez et al., 1996b). From a different perspective, Galunic and Eisenhardt (2001) analyze modular organizational design. Uncovering organizational antecedents of innovation, they explore how corporate divisions as combinations of capabilities and product-markets areas can be recombined. This architectural innovation explains how modular organizational structures independent but related achieve innovation and adaptation at both the subsystem and system levels (Galunic and Eisenhardt, 2001). Here the output of modularity is understood to occur more emergent.

In another differentiation, Sanchez (1995) distinguished first- and second-order benefits of modularity. First-order effects are based upon a higher number of product variations as well as reduced costs and time of switching between options. Second-order effects come from parallel and distributed business processes that support incremental innovation by separating component-level and architectural learning processes, and which facilitate interactive and real-time research of market needs (Sanchez, 1995b). These second-order effects can have direct but especially long-term indirect effects. Thus, outcomes of product- and process-modularization can either be 1) more efficiency, especially more directly effectiveness-orientated, or 2) more innovation and learning-, respectively more indirectly orientated. Interfirm collaborations may achieve direct- and indirect outcomes of modularization. Direct outcomes address the efficiency and effectiveness of defined subtasks (technical components/processes) and standardized interfaces across firms. Indirect outcomes address the learning, innovativeness, and long-term effects on the relationship between firms.

Moreover, we assume that outcomes can be more or less comprehensive to collaborators or external parties. Components that generate joint outcomes can even be able to interact and exchange resources e. g. data, energy in a specific way. Especially, indirect effects of modularity will create more causal ambiguity. Furthermore, higher degrees of collocation with its social interactions will generate social ambiguity. Due to such a complex web of interacting functions and processes, the indirect outcomes in terms of innovation, learning, and improvements of relationships can be less comprehensive or traced back to single contributions. Collaborating firms may achieve a blending of contributions to long-term outcomes. Thus, the pattern of interconnected elements will be more or less ambiguous; it can vary in the degree to which contributions are traceable to each collaborating firm. This is recognized as outcome blending. We define first-order outcome blending as the degree to which collaborating firms cannot define which partner contributed to functionalities and second-order outcome-blending as the indirect benefits through a melding of knowledge, in particular embodied knowledge. This covers a blend of technical contributions that are to a large extent ambiguously embedded in functionalities and social interactions.

2.4 Relationship between Modularity and Synergistic Specificity on Outcome Blending

In alliances we require more information about the indirect and long-term effects through modularity. Especially, indirect effects and the blend can have a potential of developing hard to imitable outcomes, which produce relational rents between collaborating firms. The achievement of relational rents (Dyer and Singh, 1998) improves the long-term competitive advantage of inter-firm relationships. Therefore this paper investigates in the preconditions of blending in terms of modularity and synergistic specificity. We argue that both modularity and synergistic specificity may have effects on blending, dependent on the technological context of the innovation.

Sanchez (2000) assumes modular architectures to impact organizational learning and knowledge assets, which helps to determine strategic competitiveness. Worren, Moore and Cardona (2002) did not find a significant effect between product modularity and the two indicators of strategic flexibility: new model introductions and new product introductions. We reason that modular systems can strive to clearly define each component and their configuration according to an not ambiguously defined architecture of decomposition and recombination of product and process modularity. Similar Worren, Moore, and Cardona (2002) notion that a architecture the notion of architecture implies that certain higher-level elements (e.g., interface specifications) need to be ‘frozen’ for a predetermined period of time to allow modular development processes at the component level. Modularization of business processes thus requires a relatively high degree of formalization and codification. Also, codification and partitioning of knowledge and processes allows the leveraging of resources across organizational boundaries (Zander and Kogut, 1995; Szulanski, 1996). The deterministic approach of growing level of modularization could hinder serendipitous findings and emergent structures in the architecture and modules. Instead the more interactive and less determined processes and products within higher degrees of synergistic specificity may increase learning and knowledge-spill-overs in blending.

Sanchez (1995) proposed that modularization is suitable for all firms that face dynamic market conditions (Sanchez, 1995). It has neither been explored the effect on blending and the character of dynamic market conditions. To specify the relations, we investigate two industries that especially cover the structuring of the technology face dynamic markets. Still, the complexity and type of technology differs. Also, at difference is the integration respectively customization of the outcome. Those two industries are: biotechnology and new media (SIC Code 737, especially 7371, 7373, 7375, and 7379). Overall, biotechnology and new media are two ends of a continuum between 1) highly scientific-laden with long time-to-market, and 2) highly design-and IT-laden innovations associated with customer integrations. In biotechnology, high demands in resources and speed of R&D especially motivate firms to join partnerships with downstream and upstream partners that provides access to complementary knowledge necessary for successful development and commercialization of innovations (Rothaermel and Deeds, 2004). Main services of New Medias are web-design and related programming, data-base management, promotional strategies, and media consulting. New Medias typically develop services to industrial clients. Services include specific customer configurations of hard- and software in the field of information technologies and web-design. Table 1 gives and overview.

TABLE 1: BIOTECH AND NEW MEDIA-INNOVATION

	Biotech **“Hard featured innovation”**	**New Media** **“Soft featured innovation”**
Foundation	Science and Engineering	IT and design
Environment	Technological uncertainty long lead times	Market uncertainty, short lead times, customer integration
Process	Planning and ex-ante task distribution possible	Creative industry with technical and design laden emergent innovation process
Team	Highly integrated teams of inter-related working partners with pre-specified and assigned tasks	Loosely coupled teams with integration of entire organizations
Project results	Primarily distinguishable features of physical products	Primarily embedded services contribution of partners often not visible from outside (market)
Impact on program level	Highly independent Blockbuster-innovations; single shots of high novelty	Web of different, often incremental innovations
Consequences for collaborative setting	Project-driven collaboration	More across-project, diffuse collaboration

In settings of hard featured innovation, a fine-grained project structure may reduce the complexity of technological interdependencies. While a joint execution is neither needed nor feasible, inter-organizational teams of highly specialized experts need a freezing of specifications and a clear-cut definition of interfaces in order to work on separate aspects of problem solving in parallel. Codification and partitioning of knowledge and processes are needed to leverage resources across organizational boundaries (Zander and Kogut, 1995; Szulanski, 1993). This is in line to the discussion on architectural innovation, whereby ”… modularization of business processes thus requires a relatively high degree of formalization and codification” (Worren, Moore, Cardona, (2002), p. 1126).

H1a: Modularity and synergistic specificity are negatively interrelated in settings of hard featured innovations.

The modularity in collaborations requires to defining tasks in advance. Thus, firms have to define components and to develop patterns of configuration, which state standardized interfaces. Therefore, firms will define the alliance-process, feed-back slopes between steps, and criteria, as well as gates and corresponding criteria of control. These aspects are especially relevant in complex and more complete contracts when the alliance is established. Firms need then complementary organizational resources and capabilities to exploit the 'economics of substitution' afforded by modular product structures (e.g. Cusumano, 1988).

H2a: Modularity has a positive effect of outcome blending in settings of hard featured innovations.

As an alternative firms can apply a more synergetic process of alliance coordination. Within the synergistic-process-specificity, establishing collocated joint teams between the collaborating partners will be a dominant means. The process of collaboration is more dependent on the interactive contributions of partners.

H3a: Synergistic specificity has a positive effect of outcome blending in settings of hard featured innovations.

In settings of soft featured innovation, interdependencies occur less within the technological sphere but between different socio-technological spheres, especially the interaction between IT, design and between producer and consumer. Thus, technology- and market uncertainty may interact and cause an inherently higher ambiquity which prevents an ex-ante structuring. In such settings, flexible structures of a joint team are more needed than control mechanism. Collaboration processes in settings of soft featured innovation develop on iterative terms.

H1b: Modularity and synergistic specificity are positively interrelated in settings of soft featured innovations.

In order to achieve synergetic collaboration, the interaction is rich of affective trust (Lewis and Weigert, 1985), which promotes the transfer of knowledge between individuals in the team and the openness of knowledge exchange and idea articulation. Team members will then develop specific skills and knowledge that are less recombinable in other teams (Shilling, 2000). Also the contributions of team members will not fully comprehensive to external persons. Still, the achievements through collocation and intensive direct interaction of members of the collaborating firms will contribute to a blend of outcome. Synergistic specificity may also enable the emergence of trust and shared routines which can lead to relational rents of collaboration. Collaboration processes in settings of soft featured innovation develop on iterative terms. In order to achieve synergetic collaboration, the interaction is rich of affective trust (Lewis et al., 1985) which promotes the transfer of knowledge between individuals in the team and the openness of knowledge exchange and idea articulation. Still, some aspects of the collaboration can be put in modular products and processes. In case of an outcome blending that covers ambiguous relations, the collaborating partners may find it even difficult to measure which components achieve a value from the perspective of the client (see Holt and Sherman, 1986). As such, outcome blending will be a function of synergistic specificity in new media.

H2b: Modularity has no positive effect on outcome blending in settings of soft featured innovations.

H3b: Synergistic specificity has positive effect on outcome blending in settings of soft featured innovations.

3. EMPIRICAL STUDY

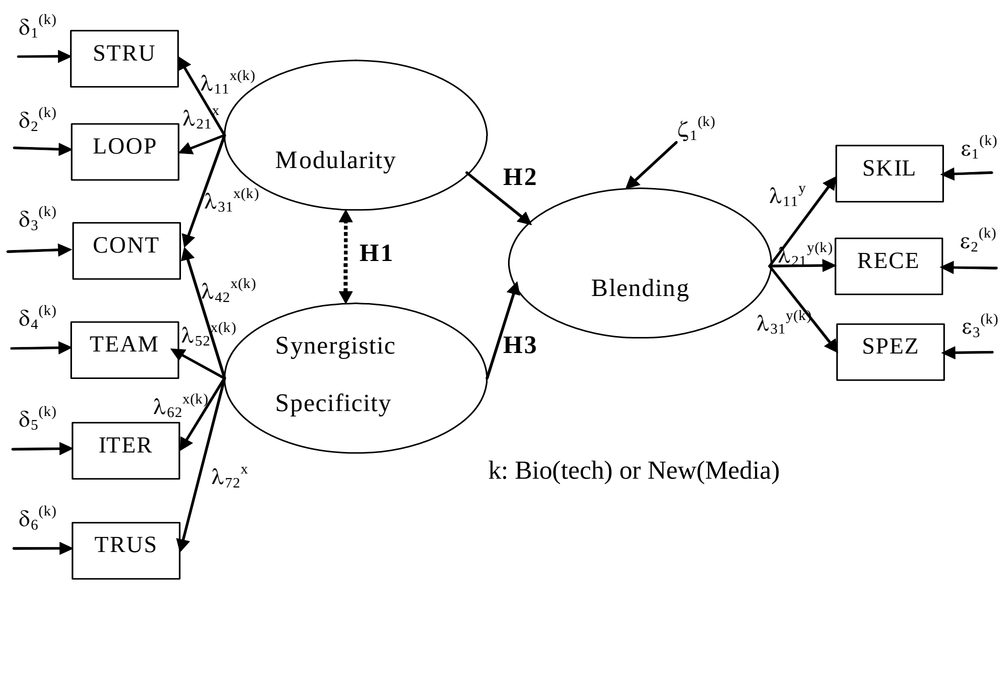
The data was collected from two surveys of managers in two industries. Measures obtained from executives' evaluations are prominent in the literature. Subjective indicators are often found suitable for performance measures, as strong correlations between subjective and objective measures were found when they were made available. Since most of the firms in our sample are small to medium sized firms and the respondents were their senior executives, we are confident that the respondents had an intimate knowledge of the performance. The first survey was undertaken in the New Media industry regarding their relationships to their collaborating firms and the governance of the alliance. The sample is composed of 222 non-equity innovation collaborations. The second survey addressed the biotechnology industry with 114 non-equity collaborations. All items were measured on a 5-item Likert scale (see table 2). In the questionnaire we separated scale items. Variables were not labelled on the basis of the reported constructs in order to reduce the likelihood of respondents guessing the relationship between predictor and criterion variables and deliberately adjusting their responses to the two measures.

TABLE 2: CONSTRUCTS AND INDICATORS

Construct	Items/Measures	Variable
	structured projects	STRU
Modularity	feed-back loops	LOOP
	control	CONT
Synergistic	control	CONT
Synergy	joint project team	TEAM
	iterative and creative project structure	ITER
	affective trust	TRUS
Outcome	skill-learnings and technical learning	SKIL
Blending	receiving of knowledge related and limited to the project	RECE
	specialization of partners' contributions	SPEZ

Figure 1 presents our hypothesized model to examine our postulated hypotheses 1 to 3 that is in the standard shape of LISREL models by Joreskog and Sorbom (Jöreskog and Sörbom 1996). For comparison of the biotechnology group and the new media group to be meaningful the measures have to be equivalent across the two groups. We use the approach of Jöreskog (1971) by testing different, increasingly different forms of measurement invariance that are imposed on the factor loadings, measurement intercepts and factor (co)variances (Steenkamp and Baumgartner, 1995). The overall fit of the resulting two group model is good.

FIGURE 1: RESEARCH MODEL AND HYPOTHESIZED RELATIONSHIPS



4. RESULTS AND CONCLUSIONS

The goal of this study was to investigate in modular innovation and their contextual factors in interfirm collaboration. Extending the ideas on modular innovation within firms, this study delivers a more fine-grained picture of structural- and outcome-modularity in alliances.
The sign and the statistical significance of the path coefficients serve as a test of the hypothesized relationships in hypotheses. For the values see table 3 that includes path coefficients, estimates and t-values. The data provides strong support for hypothesis 1. Also hypothesis 2a, b and 3a, b can be confirmed.

TABLE 3: PATHS

Group	Path	Hypothesis	Parameter	Standardized Estimate	t-value
NewMedia	structural modularity ↔ synergistic specificity	**H1**	$\varphi_{12}^{(new)}$	0.79**	5.63
	structural modularity→ outcome blending	**H2a**	$\gamma_{12}^{(new)}$	-0.27	-1.11
	synergistic specificity → outcome blending	**H3a**	$\gamma_{11}^{(new)}$	0.91**	3.16
Biotech	structural modularity ↔ synergistic specificity	**H1**	$\varphi_{12}^{(bio)}$	-0.64**	-3.19
	structural modularity → outcome blending	**H2b**	$\gamma_{12}^{(bio)}$	0.66**	2.29
	synergistic specificity → outcome blending	**H3b**	$\gamma_{11}^{(bio)}$	0.35	1.27

standardized path coefficient significant at **p<0.05, *p<0.10

Our findings inform theory and practice. Both the industry economic view of R&D Management and the organizational economics (OE) view do not completely describe modularization and its outcomes of alliances. In terms of R&D Management collaboration is a prominent motive for cost and risk sharing as, thus modularity of processes common. In OE, modularity is used to limit interfaces in interorganizational setting, if so, alliances not necessary but less intensive modes of interaction. But outcome modularity is reasonable to position oneself and hedge against opportunism of partner. In this regard, the metaphors of “learning races”, “rat races” or “winner-takes-it-all” games are used to explain a teaming-up of independent partners (Oxley, 1997). In practical terms, collaboration are often even characterized by an ex-ante specification of interfaces and an ex-post exchange of outcomes, whereby the actual project undertaking is been executed by each of the partners separately. This emphasize on opportunism hinders second-order and long term effects. Following both lines of argumentation, innovation alliances should be structured by purely modular processes in order to achieve first-order effects of modularity, i.e. efficiency gains in executing complex and (highly) risky RD projects while avoiding the potential pitfalls of co-opetition.

However, we argue that this short-term gain in efficiency may be outweighted by a loss in long-term effectiveness. By emphasizing the potentially dysfunctional effects of collaboration, possible gains from synergistic effects may be excluded: The more modular a collaboration is organized, the fewer the interfaces in daily project works become, which prevents mutual learning and transfer of tacit knowledge in actual practice. From a theoretical perspective, the relational view (Dyer and Singh, 1998) goes further: Alliances are regarded as competence for partners, thus specificity aimed for – not necessarily restricted to processes, but as well enhancing joint outcomes (i.e. differentiating outcomes against outside competitors on the market). To achieve second-order effects in an alliance setting, the creation of a relational network among alliance partners seems advisable. According to the relational view companies may only gain competitive advantage from their inter-organizational network, if they build up unique relationships based on mutual trust, shared norms and values, which help to position themselves against outsiders. The creation of specifics within an alliance should provide the basis for sustainable advantages. Furthermore, specificity should not be restricted to joint outcomes, i.e. for differentiating shared outcomes against outside competitors, but as well to processes. This requires synergetic structures at the process level, by which inter-linkages are been created and enhanced.

In sum, modular and synergetic structures are two different faces of innovation alliances: Modular (project) structures may build the basis for utilizing existent resources and capabilities from alliance partners, which supports an immediate success of joint project undertakings. In contrast hereto, synergistic process components may enable the emergence of trust and shared routines which can lead to competitive advantages of networks. Both dimensions may be realized in alliances, as this mode is a hybrid between (modular) markets and (specific) hierarchies.

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AUTHOR PROFILES:

Prof. Dr. Ricarda Bouncken is professor for Organization, HR, and Innovation at the University of Greifswald, Germany. She has published more than 90 articles and books. The accomplished her Habilitation at the University of Lueneburg, Germany in 2002. She received her Ph. D. from the University of St. Gall, Switzerland in 1997.

Prof. Dr. Thorsten Teichert holds the chair for Marketing and Innovation at the University of Hamburg. Research topics and consulting projects include issues of new product development, global innovation management as well as issues of consumer behavior. Previous to his current position, Prof. Teichert was the director of the Institute for Innovation Management at the University of Berne, CH.

Dr. Michael Koch is assistant professor at the Chair of Marketing and Innovation at the University of Hamburg. He received his Ph.vD. (Dr. rer. pol.) from the Ernst-Moritz-Arndt-University of Greifswald, Germany. He obtained his degree in Business Administration at the University of Osnabrueck (Dipl.-Kfm), Germany.