THREE ESSAYS ON THE CHOICE OF DECISION-MAKING STRUCTURES IN
ALLIANCES AND OTHER COMBINED VENTURES AND THE PERFORMANCE
IMPLICATIONS OF SUCH CHOICE AT THE DYADIC AND FIRM LEVELS

BY

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ABSTRACT

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The optimal choice of a decision-making structure in alliances and other combined ventures is an important yet underexplored question. There is no single theory that predicts what types of decision-making structures will be optimal in different alliances. Existing research, while offering insights into the factors influencing the choice of a decision-making structure, does not offer a unified framework of such a choice or the performance implications of various choices. The present dissertation is an attempt to fill this void.

The first essay is a conceptual examination of the various factors that may affect the optimal choice of a decision-making structure. I build a general model and outline gaps in the existing research. The second essay considers the implication of interdependence between the collaborating firms and the internal complexity of the firms for the optimal choice of a decision-making structure. I build a simulation model that shows how asymmetric interdependence and significant internal complexity of the partners can reduce the need to centralize decision making in alliances and other combined ventures. The third essay is a study of individual costs and benefits that each partner in an alliance enjoys or bears as a result of collaboration under interdependence. I use computer simulations to show that the size and sign of the individual performance benefits depends on the chosen decision-making structure and the pattern of interdependence between the collaborating firms.

The significance of this dissertation lies in the examination of factors unrelated to opportunism as antecedents of an optimal choice of a decision-making structure, which is part of

a wider concept of governance mode choice. The findings in this dissertation contribute to the

theory of the firm and to the theory of strategic alliances.

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Essay 1: Determinants of decision-making structures in alliances and other combined ventures: Review of the literature and a theoretical model

Introduction

The choice of a governance mode in combined ventures such as strategic alliances, joint ventures, mergers, etc. is an important theoretical and empirical question. Governance mode choice affects outcomes of combined ventures (Leiblein, 2003; Sampson, 2004). High failure rates of strategic alliances (Park & Ungson, 2001) could be partially attributed to problems with choosing a proper governance mode.

Many studies view the problem of governance mode choice as the choice between equity-based and non-equity-based participation (e.g. Pisano, 1989; Das & Teng, 1996; Hennart, 1988; Gulati, 1995; Dyer, Kale, & Singh, 2004; Oxley, 1997). Other papers study the contracts that the parties design in order to protect their interests and ensure collaboration (e.g. Parkhe, 1993; Poppo & Zenger, 2002; Reuer & Arino, 2002, 2006, 2007; Gong et al., 2007). Equity investments and contracts are examples of *governance mechanisms* that are available to the parties in a combined venture. Thus, an ostensible part of the governance mode choice consists of choosing the salient characteristics of the combined venture: equity investments and specific contractual stipulations. What often goes unstated is the problems that these governance mechanisms are supposed to address.

According to Stiglitz (1989, 1991), any governance mode must solve two problems: (1) setting up an appropriate incentive structure; (2) designing an appropriate decision-making structure. An incentive structure is important because the parties' interests are not necessarily

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aligned when the parties enter the combined venture. A properly designed incentive structure will ensure that the parties are trying to reach the same goals. A decision-making structure is important because contracts are incomplete (Hart, 1988; Hart & Moore, 1999) and not every contingency can be written into a contract. The parties have to agree how decisions will be made and who will make them.

The theory of incentive alignment is relatively well-developed. Transaction cost economics (e.g. Williamson, 1985; Hennart, 1988, 1991) and property rights theory (e.g. Alchian & Demsetz, 1972; Hart & Moore, 1990, 1999) argue that incentive alignment is more easily reached when ownership of equity is involved. In addition, contracts usually include monitoring and enforcement clauses that impose costs for breach of agreement and thereby promote cooperation (Ryall & Sampson, 2009; Faems et al., 2008). Less is known about the antecedents and consequences of the choice of a decision-making structure (DMS).

What determines the optimal choice of a DMS in inter-organizational relationships? There could be two answers to this question. One answer invokes the concepts of opportunism and exchange hazards. According to this logic, more centralized, hierarchical decision-making structures can be used to mitigate partner opportunism. Centralized decision making naturally follows from centralized ownership of assets (Das & Teng, 1996) which is used to curb opportunism (Williamson, 1991a; Foss, 1996a). In addition, centralized decision making may be contractually specified. Thus, we would expect to see longer and/or more detailed contracts in situations where exchange hazards are high. This line of reasoning has received solid empirical support (e.g. Masten & Crocker, 1985; Crocker & Reynolds, 1993; Deeds & Hill, 1999; Arrunada, Garricano, & Vazquez, 2001; Ryall & Sampson, 2009).

The second function of a DMS is coordination. In many alliances and other similar combined ventures, two or more parties undertake a joint project. It is difficult to specify *ex ante* all the tasks that need to be completed and all the actions that need to be taken to complete those tasks. In addition, it may be unclear how to evaluate certain events and actions of the partners because their short-term or long-term consequences may be difficult to predict. The parties need to have a structure that will assign decision-making rights to a certain party under certain circumstances or, alternatively, will specify the procedure for joint decision making. Allocation of decision rights and joint decision making may matter even without opportunism (Saxton, 1997). However, currently there is no single theory about when decision making should be coordinated or centralized and when it is optimal to decentralize decision making without invoking the concept of opportunism.

Traditional organization theory (OT) was concerned with the question of decision making. The "rational" school in early OT (e.g. Taylor, 1911; Fayol, 1949) emphasized the design of an organization as a machine that serves a well-defined purpose or goal. The work of all parts of this machine was supposed to support the movement of the whole toward reaching the goal. As a result, any organization was to be led by managers who determined what needed to be done and who would do it. Thus, the rational school in OT suggested centralized decision making as a necessary condition of a well-functioning organization.

A later approach took a more "natural" view of organizations. This approach, represented by the works of Mayo (1945), Barnard (1938), and Selznick (1949, 1952), concentrated on the more "human" side of organizations. "Natural systems" theorists considered some decentralization essential because it promoted worker motivation and participation. Lawrence and Lorsch (1967) suggested that the rational design and centralized decision making were more

appropriate in stable environments while the natural design and decentralized decision making were more appropriate in changing environments.

Thus, organizational theorists were among the first to suggest that centralization or decentralization of decision making may depend on the characteristics of the environment in which the organization functions. Later research in management and strategy has added to the list of factors and environmental characteristics that may influence the choice of a decision-making structure.

Factors that may affect the choice of a DMS include knowledge substitution (Conner & Prahalad, 1996), the need for quick decision making (Eisenhardt & Bourgeois, 1988; Marengo, 1992), integration of knowledge (Grant, 1996), uncertainty and risk (Sah & Stiglitz, 1986, 1988; Kim & Burton, 2002), and complexity (Thompson, 1967; Simon, 1962). None of these factors necessarily invoke opportunism as an explaining factor. All of them ultimately rely on the presence of bounded rationality (Simon, 1945) of the participants in the transaction.

The present paper is an attempt to give an answer to the question, "What factors affect the choice of a decision-making structure in combined ventures?" I will review the existing literature and synthesize the main conceptual arguments and empirical findings, outline unexplored areas, and suggest avenues for future research.

DMS choice: Opportunism vs. other factors

I would like to begin the discussion of DMS choice with a brief review of opportunism-related factors. This discussion will serve as a baseline to compare the findings of the opportunism-based theories with non-opportunism-based arguments.

A standard recommendation for dealing with opportunism in combined ventures is centralized or common ownership of assets. It has been argued that asset ownership would not matter in a "moral utopia" (Foss, 1996a) in which no-one is ever opportunistic. In the real world where opportunism is present, common asset ownership serves to mitigate opportunism by making the investor a residual claimant. Even if the investor is not the sole owner of the venture, he/she will be less likely to engage in opportunistic value appropriation because such actions are likely to decrease the value of his/her investment. In addition to residual claimancy, ownership of assets establishes residual control rights (Grossman & Hart, 1986; Hart and Moore, 1990). The owner of an asset has the rights to use this asset in any legally permitted way that has not been explicitly specified in the contract. The stipulations of the contract complement the residual rights of control to determine the decision-making structure. In many combined ventures, the contract that the parties have signed will limit the residual rights of control of the asset owner and give some rights to use the asset to the other parties. The contract may also specify more general decision rights regarding the operations of the alliance or joint venture. For example, the contract may impose limits on what some of the parties are allowed to do (Leblebici & Shalley, 1996).

Existing research supports the notion of decision making rights as a factor that can mitigate opportunism. In a sample of contracts between auto manufacturers and Spanish auto dealers, Arrunada, Garicano, & Vazquez (2001) found that the auto manufacturer had more decision rights when there was greater potential for opportunism and moral hazard of the dealer. In a similar argument, Das and Teng (1996) suggested that joint decision making inherent in equity alliances could serve to restrain partner opportunism in addition to the rewards and control systems. In general, the decision-making rights that come with ownership work to mitigate

opportunism. In terms of optimal contract design, a party will tend to retain more decision-making rights if it is more vulnerable to the other parties' opportunism (Arrunada, Garicano, & Vazquez, 2001).

What other factors could affect the choice of a DMS? In order to answer this question, let us turn to the nature of a DMS. I will examine the concept of decision making and show why a DMS matters.

Decision-making structures without opportunism

The concept of decision making is inextricably tied to the concept of choice. If no choice exists, no decisions need to be made. Intuitively, it seems clear that decision making will matter more in situations where there are more options available to the parties, where the options are more varied, or where consequences of the various choices are more significant. The existence of options may not have to do anything with opportunism. I would like to survey the literatures that explore non-opportunism-related antecedents of decision-making structure choice.

Decision making and knowledge substitution

Conner and Prahalad (1996) suggested that differences in knowledge of the various parties may be one reason why decision making needs to be centralized. The focus of their paper was on the knowledge substitution effect that occurs when one party ("the manager") has valuable knowledge that is difficult to transfer to another party ("the employee"). Conner and Prahalad argue that in this case it will be optimal for "the employee" to sign an open-ended employment

contract that delegates the decision-making rights to "the manager." In employment contracts, the valuable knowledge of "the manager" is substituted for the relatively less valuable knowledge of "the employee." Now, "the manager" does not have to explain why something needs to be done – he/she may simply order "the employee" to do something according to "the manager's" decision.

The logic that Conner and Prahalad (1996) use is intriguing and potentially insightful, yet it breaks down under close scrutiny. In particular, the implicit assumption that Conner and Prahalad make is that "the employee" is not rational. If "the employee" believes that "the manager" has superior knowledge, it will be rational for "the employee" to submit to "the manager's" directions without any employment-type contract. If "the employee" does not believe that "the manager" has superior knowledge, it is not clear why "the rational employee" would sign such an open-ended employment-type contract in the first place. Thus, irrational behavior of "the employee" needs to be assumed: "the employee" believes that "the manager" has superior knowledge but refuses to follow "the manager's" instructions without having signed an employment contract. Barring irrational behavior, the only reason for "the employee" to sign such a contract would be the managerial control over some of the assets that are necessary to do the job[1] in the presence of opportunism hazards (cf. Holmström & Roberts, 1998). Thus, knowledge substitution alone is not sufficient to explain the existence of employment-type contracts.

Despite the failure of Conner and Prahalad's (1996) theory to explain the existence of employment contracts, their reasoning is applicable to the choice of a decision-making structure. In particular, their theory predicts that it is optimal to allocate decision making rights to the party

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[1] The manager may be the owner of the assets or an agent of the owner. The important fact here is that the manager controls the assets that the employee needs to do the job.

that has critical, inalienable knowledge (Hart & Moore, 1990)[2]. If this critical knowledge is difficult to transfer to other parties (e.g. because it is tacit), decentralized or consensus-based decision making does not make sense. Decentralized decision making in such situations would result in worse decisions due to inferior knowledge of other parties (Geanakoplos & Milgrom, 1991; Jensen & Meckling, 1995). Consensus-based decision making may also result in protracted negotiations in which each party will try to convince others of the superiority of its solution. The only complication of centralized decision making is how to determine whether any one of the parties has critical knowledge.

Decision making under environmental and task uncertainty

Another reason why decision making may matter without opportunism is uncertainty that stems from a lack of perfect information about the world. Pioneering research in this direction was done by Sah & Stiglitz (1986, 1988). They studied stylized firms making decisions about what projects to adopt. The key feature of those projects was lack of perfect information about their true value. Sah & Stiglitz (1986) studied hierarchies and polyarchies as their decision-making structures. A hierarchy is a structure in which the project is approved if each of N decision makers in the firm approves it. A polyarchy is a structure in which the project is approved if any one of N decision makers in the firm approves it. In their 1988 paper, Sah and Stiglitz also introduce a consensus-based structure ("committee") that approves a proposal if n members out of all N members of the committee accept the proposal ($1 <= n <= N$). Polyarchies in general accept the greatest number of proposals. Hierarchies accept the smallest number of proposals.

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[2] It may be difficult to ascertain which party has critical knowledge. However, I will ignore this complication in order to concentrate on DMS choice in principle.

The acceptance rates of committees decreases with an increase in n. The reverse side of the acceptance rate is the quality of proposals. The average quality of proposals accepted by a hierarchy will be the highest; the average quality of proposals accepted by a polyarchy will be the lowest. A committee will accept higher quality proposals on average with an increase in n, while the number of proposals accepted will decrease.

When might it be beneficial for a strategic alliance or a joint venture to use a hierarchy-like decision-making structure? Hierarchies described by Sah and Sliglitz minimize the acceptance rate of bad proposals. This will be the most valuable when the cost of making a mistake is very high, for example in the aerospace industry. On the other hand, a decentralized decision-making structure (a polyarchy) will be adopted when it is costly for the partners to let a "good" project escape their field of vision, while the cost of accepting a "bad" project is not very high. Polyarchies maximize the number of projects approved. Such structures might be adopted in alliances that engage in basic or exploratory research where the goal is to explore the maximum possible number of different projects.

Another factor that may affect the adoption of a more hierarchical or a more polyarchical structure is the expected quality of the projects. If the average potential project is expected to be of low quality, the hierarchy is the best structure because it will weed out a greater number of "bad" projects. If the average potential project is expected to be of high quality, a polyarchy may be the most efficient structure because it will retain a greater number of "good" projects. In addition, the level of uncertainty regarding the potential quality of the projects is likely to be positively related to the use of hierarchical decision making. Well-defined projects that are expected to yield predictable payoffs can be chosen in a decentralized way while ill-defined projects with highly uncertain payoffs are likely to be chosen hierarchically.

This line of reasoning has received empirical support. For example, Macher (2006) found that ill-structured problems were more likely to be solved hierarchically in a sample of semiconductor manufacturers. Similarly, Lerner & Malmendier (2010) studied partnerships between research-based biotech firms and financing pharmaceutical firms. They found that the financing firm was more likely to have unconditional termination rights if there was no specifiable lead product at the outset. While this latter result may be explained using the concept of opportunism (the financing firm held key decision rights to guard against potential shirking of the biotech firm), it is also consistent with the idea that key decisions will be centralized when severe uncertainty is present. Colombo & Delmastro (2004) found that delegation of decision making to plant managers in large companies was positively related to the size of the company and the number of levels in the corporate hierarchy. This finding is consistent with the idea that polyarchical decision making is best when there are more decisions (due to information overload of top managers) and with the previously discussed idea that decision making should be delegated when the top management does not have all the necessary knowledge.

The importance of the research by Sah and Stiglitz (1986, 1988) for this discussion lies in the fact that the decision-making structures studied by Sah and Stiglitz did not use the concept of opportunism. The performance differences that emerged among the decision-making structures in their models were due to differences in the quality of projects and the uncertainty regarding the incoming information. Thus, Sah and Stiglitz were among the first researchers who formally showed how the choice of a decision-making structure may result in performance differentials without invoking the concept of opportunism.

Further work on the importance of decision making structures was done by Kim and Burton (2002). Using modeling techniques similar to those employed by Sah and Stiglitz, Kim

and Burton showed that the effect of centralization of decision making on the duration, cost, and quality of projects depended on task uncertainty. In particular, centralized structures resulted in longer project times and higher costs under medium or high task uncertainty. However, under all levels of task uncertainty (low, medium, and high), centralized structures resulted in better quality of decisions (the difference was very large under medium and high task uncertainty). These results further confirmed the importance of decision-making structures in situations of environmental and task uncertainty even when opportunism is not an issue.

Decision-making in rapidly moving markets

Sometimes, the value of a decision may greatly depend on the speed at which the market is moving. Making a well-considered, high-quality decision may matter less than making an acceptable decision quickly. Fast-paced markets will most likely demand fast decision making. The more decision makers are involved in the decision, the more time the decision will likely take. A hierarchy similar to one described by Sah and Stiglitz (1986) may be counterproductive in fast-paced markets. A project has to be evaluated by all levels of the hierarchy before it is approved. A polyarchy requires only one decision maker to approve a project. Thus, polyarchies may be more suitable in fast-paced environments than hierarchies.

Hierarchies and polyarchies described in Sah and Stiglitz (1986, 1988) are not the only possible decision-making structures. Decision making could be centralized at the top of the organization or alliance or delegated to the individual parties. According to the results of Wally and Baum (1994), centralization of decision making was positively related to the speed of decision making in a sample of York County, Pennsylvania manufacturers. One reason for that

could be politics that may play a prominent role in decentralized firms (Eisenhardt & Bourgeois, 1988). Also, Radner (1992) argued that decentralization of decision making leads to a loss of control which may be detrimental in fast-paced markets.

Based on simulation models, Marengo (1992) found that in stable markets, centralized structures outperformed decentralized structures initially; then the difference disappeared. In a regularly changing environment, the decentralized structure outperformed the centralized structure. Finally, in a randomly changing environment, the centralized structure outperformed the decentralized structure initially. Then, the difference diminished but did not disappear. Marengo's models involved agents learning about the states of the world. Based on incoming information about the success of past actions, agents modified their existing rules and generated new ones. The difference between the centralized and decentralized structures was in the presence of direct ties between "the shop level" and the environment in the decentralized structure, while in the centralized structure, it was the central management only that had access to information from the environment. Marengo's results suggest that not only the speed of change but also the presence or absence of pattern in change may affect the choice of optimal decision-making structures, and that centralized decision making has certain advantages even though it may reduce the amount of information processed by the organization.

Decision-making structures and integration of knowledge

Grant (1996) argued that an important function of the firm is integration of knowledge of its individual members. In all but the smallest firms, information and knowledge are decentralized

(Radner, 1992). Any rational decision is based on certain information[3]. A problem with firms, alliances, and joint ventures is that the person making the decision does not usually have full information. What is more, the necessary information may be dispersed throughout the organization. In order to make a decision, the decision maker may need to (1) ascertain who has the relevant information, and (2) obtain the necessary information from the party or parties that have it. These two problems are different and require different solutions.

Discovering a source of relevant information may be difficult. The most obvious way of looking for information is by asking the people whose duties directly relate to the information being sought. For example, if the CEO needs to make a decision about investing in a project and the information needed is the amount of liquid capital that the firm has, the CFO will be the most obvious source of this information. However, many decisions need information whose location in the firm is unclear. In this case, the decision maker may seek the input of many people. For example, the decision maker may specify the information need and announce it to all employees in the firm. If the decision maker has much of the relevant information and only needs a relatively small part to "complete the picture", it is likely that some of the newly acquired information will be relevant to make a good decision. Complications may arise if none of the people in the firm or alliance have the necessary information; if the information arriving from different people is fragmented and needs to be integrated prior to use; or if the decision maker cannot distinguish between relevant and irrelevant information due to his/her lack of relevant knowledge and absorptive capacity (Cohen & Levinthal, 1990).

Having received communication from different people in the organization does not mean that the decision maker will be able to make an informed decision. First, the information that was received must be interpreted (Daft & Lengel, 1986; March, 1987). It could be argued that

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[3] If there is no information upon which to make a decision, then any decision is as good as another.

information becomes knowledge only after it has been assimilated and integrated into the existing cognitive schemata of the person (Dretske; 1981; Nonaka, 1994). A decision maker may be unable to assimilate new information if (1) it is communicated in an unclear way; (2) it conflicts with the existing beliefs of the decision maker; (3) the person receiving the information does not have the absorptive capacity to assimilate it (Cohen and Levinthal, 1990).

In many firms, decision making is concentrated at the top of the firm, usually within the top management team (TMT). However, many other firms decentralize decision making. Generally, with an increase in the amount of information that the TMT members lack, decision making should be delegated to lower levels of the corporate hierarchy. The hypothesis that decision making will be more decentralized in firms with greater information dispersion has received empirical support (Breshanan, Brynjolfsson, & Hitt, 2002; Acemoglu et al., 2007).

Alliances and other IORs are not fundamentally different from single firms in this respect. It makes sense to decentralize decision making if key information is possessed by different parties. This will be especially true if the information in question is either difficult to communicate (tacit knowledge) or proprietary (knowledge that needs to be protected from leaks). On the other hand, if the combined venture is commonly owned (e.g. a joint venture) and if the managers of the combined venture possess the necessary information, it makes sense to centralize decision making at the top.

There has been less research on the effects of information decentralization in combined ventures on the choice of DMS compared to similar research within firms. This constitutes a potentially fruitful avenue of future empirical inquiry.

To summarize the arguments based on integration of knowledge: centralization of decision making will be positively related to centralization of key information and knowledge

within the firm. The less knowledge the top managers have, the more decision-making rights will be delegated to the lower levels of the corporate hierarchy. The same argument applies to alliances. We will expect to see more centralization in decision making in alliances if the key knowledge is available to the people who are supposed to manage the alliance activities in a centralized fashion.

Decision-making structures and complexity

Many alliances are characterized by significant complexity that may make decision making difficult. There are different kinds of complexity; each of them will have a special effect on the choice of the decision-making structure.

The first kind of complexity that is described in the literature concerns uncertainty and the number of items that need to be considered before a decision can be made (e.g. Thompson, 1967; Astley et al., 1982). Due to the cognitive limitations of decision makers, very complex problems will tend to be solved in a decentralized fashion (Astley et al., 1982). This type of decision making is similar to distributed computing that is used in modern computer systems. When the amount of information that needs to be processed exceeds the capacities of a single computer, engineers can program several computers working in parallel so that each one of them will solve part of the problem. An obvious complication of using this approach in organizations is the need for subsequent integration of individually obtained solutions. It may happen that the individual decision makers have come up with incompatible or conflicting solutions. The problem of dealing with this type of complexity is conceptually similar to the problem of integration of knowledge dispersed throughout the organization that was discussed earlier.

The second type of complexity that exists in organizations and alliances arises because of the presence of multiple simultaneous interactions among the various decisions and activities. This type of complexity was first treated in substantial detail by Herbert Simon (1962). He suggested that the presence of multiple interactions among parts of the system complicated the task of management. Each change in the organization may have multiple consequences in other parts of the organization that are not always obvious. Thus, managing a complex system such as a firm or a combined venture will usually entail managing interactions of the resources as well as the resources themselves.

One approach to dealing with complexity is modularizing the organization. The concept of modularizing refers to containing most interactions within relatively compact modules and minimizing interactions among modules. Baldwin (2008) suggests that modularity of the organization will generally mirror modularity of the production technology. Decentralization of decision making is possible if the technology itself is modular. Then the firm or combined venture can break up the task into a series of subtasks and assign each of these subtasks to divisional managers or managers of each individual party in the combined venture. However, if the overall task cannot be broken apart into modules, the management of the entire firm or combined venture will have to have a much more active role in the coordination of efforts of the divisions or parties. The hypothesis that the structure of the organization will generally mirror the structure of the technology was suggested by Henderson and Clark (1990). Colfer and Baldwin (2010) surveyed the literature and found that the mirroring hypothesis has received good empirical support. In particular, within-firms tests found support for the mirroring hypothesis in 68 percent of all empirical tests, with another five percent of all tests providing partial support. Support was lower in across-firm studies (mostly alliances and joint ventures). 47

percent of all across-firm tests supported the mirroring hypothesis, with another 23 percent providing partial support. Notably, a total of 26 percent of all across-firm tests provided results that were contrary to the mirroring hypothesis (this number was 23 percent for within-firm tests). Overall, it could be noted that there is some evidence suggesting that organizational structure does mirror the structure of the problem that needs to be solved; however, this evidence is far from conclusive.

A similar approach to the problem of complexity was taken by Nickerson and Zenger (2004). They suggested that decomposability of the task will affect the optimal governance mode choice. If the task is decomposable, which means that it can be broken up into a series of independent subtasks, the optimal governance mode for solving this task will be market contracting with independent decision making by each party involved. If the task is nearly decomposable, which means that there are some non-trivial interactions among the sub-tasks, but their number is not too large, the optimal governance mode will be the authority-based hierarchy. Centralized decision making that is a characteristic of authority-based hierarchies will facilitate coordination of activities among the interdependent parts. Finally, if the problem is non-decomposable, which means that the sub-tasks interact very significantly, the optimal governance mode will be the consensus-based hierarchy. The main difference between consensus-based and authority-based hierarchies is the mode of decision making. In the authority-based hierarchy, decisions are made centrally by the top management of the firm or alliance. In the consensus-based hierarchy, decisions are made via agreement of all the parties involved. The conceptual arguments of Nickerson and Zenger (2004) are based upon the need for communication as a function of interdependence. If interdependence is very low or non-existent, the parties do not need to communicate and decisions can be made in a fully decentralized

fashion. If interdependence is present but not very high, the central management may play the role of an information-processing center that gathers information from all parties and makes decisions based upon it. The centralized decision making characterizing an authority-based hierarchy will serve to mitigate the problem of externalities that interdependent agents may impose on one another. Finally, when interdependence is very high, fully centralized decision making is likely to break down because the top management will be overloaded with information. The most obvious solution to this problem is partial decentralization of information processing (Radner, 1992) while decision making is done via consensus.

Summary of DMS choice as a function of various factors

In order to summarize the findings and arguments of the various streams of research, I would like to present the following table.

Table 1
Decision-making structure choice from the point of view of existing theories

Theory	Factors that affect DMS choice	Main predictions and findings	Representative papers
Transaction cost economics	Opportunism Bounded rationality	Decision making will be centralized when opportunism hazards are significant	Hennart (1988) Hennart (1993) Arrunada, Garicano, & Vazquez (2001)
Knowledge-based view	Knowledge substitution effect	Decisions will be made by one party if this party has valuable knowledge that is difficult to transfer to other parties.	Conner (1996) Conner and Prahalad (1996)
Decision making under uncertainty	Quality of proposals Risk tolerance	Decision making will be decentralized if making a mistake is not very costly and if the average quality of proposals is high.	Sah and Stiglitz (1986, 1988) Kim & Burton (2002)

	Uncertainty Quality of problem definition	Decisions will be centralized if the problem is ill-defined and when there is a lot of uncertainty	Macher (2006) Lerner & Malmendier (2010)
Decision making in changing environments	Speed and pattern of market change	Decisions will be centralized if high speed of decision making is important. Decisions will be centralized if the market is stable or changes unpredictably.	Eisenhardt & Bourgeois (1988) Wally & Baum (1994) Marengo (1992)
Integration of knowledge	The locus of knowledge in the organization	Decision making will be decentralized if the managers of the firm (alliance) do not possess information and knowledge necessary to make decisions.	Grant (1996) Breshanan, Brynjolfsson, & Hitt (2002) Acemoglu et al. (2007) Dewitt & Jones (2001)
Complexity theory	Cognitive limitations; the number of items to consider	Cognitive limitations of decision makers will necessitate decentralized problem solving; the problem of coordination and integration emerges.	Thompson (1967) Astley et al. (1982)
	Interactions among sub-problems	Increasing interactions among sub-problems will drive centralization of decision making.	Simon (1962) Nickerson & Zenger (2004) Colfer & Baldwin (2010) Aggarwal, Siggelkow, & Singh (2011)

Based on Table 1, the antecedents of centralized decision making can be classified into three

groups according to their locus:

(1) General environmental factors:

    a. Adverse environment that increases the probability of making mistakes and raises

       the cost of making a mistake

    b. A need for quick decision making (e.g. a fast-changing environment)

      c. High environmental uncertainty

(2) Transaction-specific factors:

      a. An ill-defined problem that the parties are trying to solve

      b. Many interactions among the sub-problems that need to be solved

      c. Relatively few decisions need to be made

      d. Opportunism hazards caused by the characteristics of the transaction (e.g. transaction-specific investments need to be made)

(3) Subjective, personal characteristics of the participants in the transaction

      a. Valuable, difficult-to-transfer knowledge that is owned by one party

      b. Opportunism hazards caused by characteristics of the parties (e.g. propensity of one of the parties to engage in opportunistic behavior)

      c. Low risk tolerance of the parties

According to this classification, centralized decision making can help solve or alleviate many different problems. All of these factors are based on the assumption of bounded rationality of the transacting parties that does not allow them to write and enforce a complete contingent claims contract in a cost- and time-efficient manner. As a result, a centralized authority that has the power to make decisions not specified in the contract might be beneficial.

As noted previously, the importance of a decision-making structure stems from contract incompleteness. If contracts were complete, a decision-making structure would not matter because the contract would specify every possible situation with every duty unambiguously

assigned to specific parties. An incomplete contract makes DMS choice important. As a result, the more incomplete the contract, the more important the DMS choice becomes.

What conditions lead to contract incompleteness? In general, incomplete contracts are an outcome of bounded rationality of humans. The more severe the problems imposed by bounded rationality, the more incomplete the contract will be. Bounded rationality itself is a result of complexity and uncertainty that exceed the capacities of the human brain. Table 1 presented the factors that affect DMS choice. Most of those factors are related to uncertainty and complexity. According to Table 1, centralization of decision making will be beneficial if there is a lot of uncertainty and complexity in the environment, the transaction, and the knowledge of the participants. These same factors affect the extent of bounded rationality and contract incompleteness. In addition, as Nickerson & Zenger (2004) argued, complexity and uncertainty affect the chances of opportunistic behavior by affecting the appropriability regime. As a result, we would expect to see more opportunistic behavior under severe uncertainty and complexity. Individual-level characteristics of the parties will affect opportunism (due to the varying propensities of different parties to engage in opportunistic behavior) and the extent of bounded rationality (due to the varying capabilities of different parties to process information and write effective contracts).

Based on the previous discussion, the following conceptual model can be drawn:

Figure 1: Theoretical model

Uncertainty (environmental, transactional)

Extent of bounded rationality

Incomplete contracting

The choice or a decision making structure

Individual party characteristics

Opportunism

Complexity (environmental, transactional)

The choice of an incentive structure
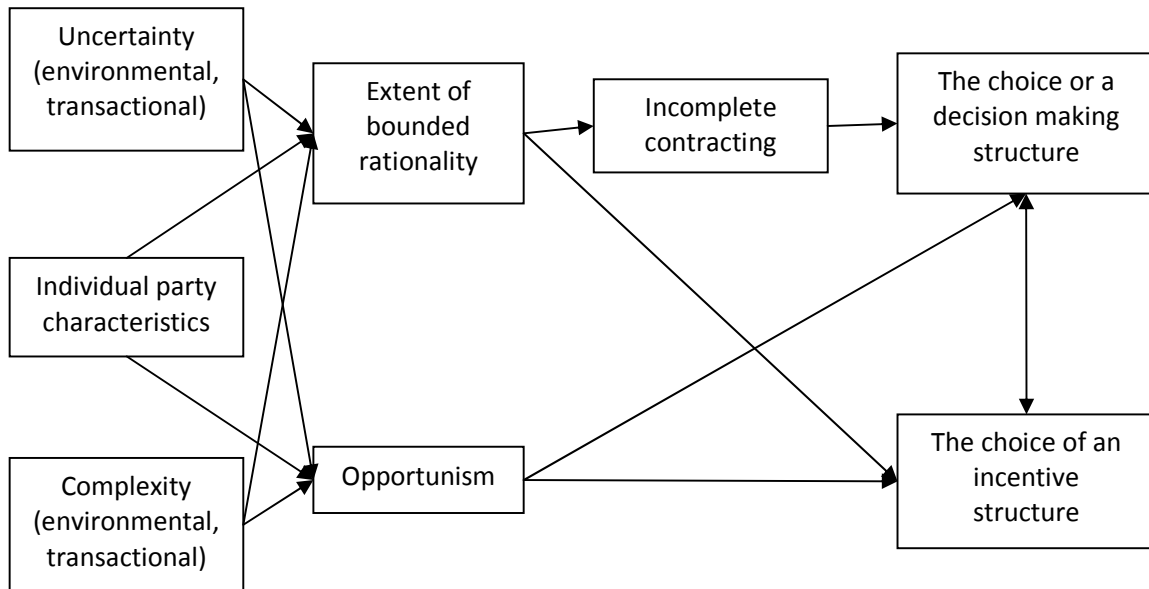
Discussion: Summary and future directions

The previous discussion has provided various reasons why decision making matters in firms and alliances. Some theories, such as transaction cost economics and property rights theory, suggest that centralized decision making combined with an appropriate incentive structure may help contain opportunism. Other theories, such as the knowledge-based view of the firm, complexity theory, and environmental analysis, suggest that decision making may be important for reasons unrelated to opportunism. While none of these theories explain centralized ownership of assets, which is at the heart of the modern theory of the firm (Foss, 1996b), they help predict an important aspect of governance mode choice which the modern theory of the firm does not explain adequately. Having covered the conceptual arguments and empirical findings of the

various non-opportunism-based theories of DMS choice, I would like to outline the existing blind spots and suggest areas for future research in these theories.

Empirical testing of theory is a vital part of scientific inquiry. However, the theories outlined above have not received adequate testing. There are various reasons for that. One reason is that governance has traditionally been associated with asset ownership modes. Much existing research has been devoted to determining when an alliance is likely to be equity-based. While equity investments are important, they are not the only governance mechanism available to alliance parties. Other governance mechanisms are contracts and relational governance. All of these mechanisms can be used to align incentives and set up a decision-making structure (Stiglitz, 1989, 1991). This dual role of governance mechanisms may complicate empirical testing. In the world where opportunism exists, the use of centralization of ownership and more detailed contracts as means to align incentives may correlate with centralized decision making. Future researchers will need to separate decision making and incentive alignment as reasons for choosing a specific governance mechanism.

The second reason for limited empirical testing of non-opportunism-based theories is difficulty in measurement of certain key constructs. For example, according to the knowledge-based view, centralization of decision making is likely if one party possesses critical knowledge that is difficult to transfer to other parties. It may be difficult to measure possession of such knowledge given the fact that such knowledge is likely to be tacit. Likewise, complexity of the problem that the alliance is facing is not easy to measure. The concept of complexity is based on the existence of multiple interactions. Observing all interactions in a complex system is an almost impossible task. Many of those interactions are unclear even to specialists. Thus, researchers would have to resort to proxies, many of which are far removed from the

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phenomenon of complexity. Much existing research that uses the concept of complexity is based on formal modeling and simulations because these methods allow researchers to capture the relationships without the need to measure the constructs and control for multiple confounding factors (e.g. Levinthal, 1997; Rivkin and Siggelkow, 2003; Ganco and Agarwal, 2009; Aggarwal, Siggelkow, & Singh, 2011).

The goal of governance mode choice is improved efficiency and increased performance (Williamson, 1991b, 1999). One weakness of existing research on decision making structures is the relative lack of attention to performance consequences of DMS choice. While we may know when centralization of decision making makes sense, we do not know what happens when DMS choice differs from theory prescriptions. How much does overcentralization of decision making damage the performance of a combined venture? What about insufficient centralization? Which deviation from the optimal degree of centralization is more damaging? Future researchers should address these questions in the same way as previous researchers have addressed costs of misalignment of ownership structures and exchange characteristics (e.g. Nickerson & Silverman, 2003; Sampson, 2004).

An important difference between combined ventures and single firms is the fact that alliance performance is not as easy to measure. While performance metrics are fairy well-established for single firms (e.g. ROA, ROE, operating margin, etc.), no such commonly accepted metrics exist for alliances and other similar combined ventures (see Arino, 2003; Lunnan & Haugland, 2008 for examples of measures of alliance performance). In particular, performance may be measured at the individual firm level or the whole combined venture level. While performance at the level of the whole combined venture is important, managers of the individual parties will also want to know how the alliance contributes to the performance of their

firms. Thus, researchers will be well advised to study performance differences between the partners as a result of adopting certain DMS. In addition, researchers will need to find structural characteristics of combined ventures and the partnering firms that affect the relative performance of the parties (Hennart, 2006).

One way to approach the problem of performance is by constructing formal computer simulations of combined ventures. This approach was successfully used to study performance of individual firms as a function of complexity and other structural characteristics (e.g. Levinthal, 1997; Gavetti & Levinthal, 2000; Siggelkow & Rivkin, 2006). However, studies of alliances using computer simulations are yet to be developed (a notable exception is Aggawal, Siggelkow, & Singh, 2011). Nickerson & Zenger (2004) offered a knowledge-based theory of the firm and of optimal governance mode choice largely based on the findings of single-firm studies (e.g. Rivkin & Siggelkow, 2003). Their theory has not been tested in either the simulation framework or empirically. Simulation research is valuable because it may offer unique insights into behavior of complex systems such as alliances. Based on predictions derived from simulations, researchers may create more precise empirical models.

To sum up, the following topics need to be addressed in future research on decision-making structures:

1. Empirical testing of various antecedents of DMS choice. It is important to test for both opportunism-related and non-opportunism-related factors simultaneously so as to obtain more precise estimates of the effects of each.

2. Development of good measures of such constructs as complexity and criticality of knowledge.

3. Testing of consequences of DMS choice and of the misfit between the optimal DMS and the actual choice of the alliance participants.

4. Testing for performance consequences of DMS choice both at the level of the whole alliance and the individual firm level.

5. Developing simulation models to derive empirically testable predictions.

Conclusion

The choice of a decision-making structure in inter-organizational relationships does not always depend on the presence of opportunism. Existing modeling and empirical research supports the idea that centralization or decentralization of decision making may be affected by other factors such as uncertainty, complexity of the problem, risk tolerance, or the locus of critical knowledge in the organization. Transaction cost theory has traditionally concentrated on provision of incentives in the presence of opportunism as the primary goal of governance mode choice. The surveyed theories suggest that the choice of a decision-making structure, which is the other part of a governance mode choice, is also affected by factors unrelated to opportunism. Further research is needed to investigate when certain decision-making structures are optimal and how deviations from the optimal choice affect organizational performance.

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Essay 2: Performance of various decision-making structures in combined ventures as a function of firm complexity and asymmetric interdependence: Insights from a simulation study

Introduction

When the managers of two initially autonomous firms consider collaboration, they face the problem of choosing a governance mode. The two firms may have various reasons to seek collaboration, including (but not limited to) resource and activity sharing, synergies among their existing resources, developing new resources, etc. Many forms of collaboration give rise to interdependence between the parties (Gulati & Singh, 1998). I will call a combination of two previously autonomous firms a '*combined venture'* between the two parties. Examples of combined ventures are alliances, joint ventures, and mergers and acquisitions. The two parties in a combined venture have to use a certain combination of governance mechanisms to structure the collaboration toward the achievement of certain goals. Examples of governance mechanisms are equity investments (e.g. Hennart, 1988; 1991), contracts (e.g. Parkhe, 1993; Poppo & Zenger, 2002; Reuer & Arino, 2007), and relational governance (e.g. Zaheer & Venkatraman, 1995; Poppo & Zenger, 2002; Lee & Cavusgil, 2006).

Regardless of the chosen combination of mechanisms, any governance mode has to solve two separate problems: (1) alignment of incentives of the two previously autonomous parties; (2) setting up a decision-making structure (DMS) that will determine who will make decisions and how those decisions will be made (Stiglitz, 1989, 1991). The problem of incentive alignment arises because of the potential difference in the parties' objectives exacerbated by the threat of opportunism (Foss, 1996a). A DMS is important because of contract incompleteness (Anderson

& Dekker, 2005): a DMS will determine how decisions will be made in situations when contract boundaries are reached.

Previous research has started to show that the performance of a combined venture depends on the alignment between the chosen governance mode and the characteristics of the transaction (Sampson, 2004; Aggarwal, Siggelkow, & Singh, 2011). In light of the previous discussion, a governance mode choice affects the performance of a combined venture via (1) incentive alignment mechanisms; (2) the chosen DMS. Imperfect incentive alignment may lead to opportunism-related hazards such as shirking (Hennart, 1993; Madhok, 1996) or hold-up (Williamson, 1985). The optimal level of incentive alignment will thus depend on the divergence between the parties' goals and their propensities to engage in opportunistic behavior. An improper DMS choice may result in insufficient coordination between the parties (Gulati & Singh, 1998; Aggarwal, Siggelkow, & Singh, 2011). Determining antecedents of optimal DMS choice is a goal of this paper.

While it has been suggested that incentive alignment and DMS choice are closely related (e.g. Nickerson & Zenger, 2004), conceptually they are separate. Incentive alignment would not matter in a moral utopia characterized by absence of opportunism (Foss, 1996a). The importance of decision making structures ultimately stems from the existence of bounded rationality of the decision makers and contract incompleteness that do not allow the parties to specify all possible contingencies in advance. Contract incompleteness is likely to be a function of the complexity of the problem that the two parties are trying to solve (Nickerson & Zenger, 2004). A highly complex problem characterized by multiple simultaneous interactions among the parties' resources and activities may require greater integration in the form of more coordinated or even centralized decision making. This intuitively clear proposition was formulated by Nickerson and

Zenger (2004) and supported by the simulation results of Aggarwal, Siggelkow, and Singh (2011). An important assumption that Aggarwal, Siggelkow, and Singh made in their simulation models was the symmetric interdependence between the parties. Another assumption that they made was the fixed internal complexity of the parties, defined as the density of resource interactions owned by one partner. Therefore, what remains unexplored is the potential impact of interdependence asymmetry and the internal complexities of the two parties on the choice of the DMS and governance mode. Asymmetric interdependence may arise out of the properties of the technology used by the partner or differentials in the bargaining power of the two parties (e.g. Gulati & Sytch, 2007). As an example, consider the interdependence between Ford and its suppliers. Arguably, Ford is less dependent on its suppliers than vice versa due to the differences in size and availability of alternative partners. Internal complexity of the parties is largely determined by the degree of sharing resources and activities across multiple departments and tasks inside each party (Simon, 1962). Some firms, such as those diversified in unrelated ways, are less complex because there is relatively little sharing of resources and activities among their business units. Other firms, such as those diversified in closely related ways, are more complex, because there is a lot of sharing of resources and activities among their business units. The questions that I would like to explore are: (1) Does a greater asymmetry in interdependence between the parties increase or decrease the need for coordinated or centralized decision making? (2) Does a greater internal complexity of the parties increase or decrease the need for coordinated or centralized decision making? For example, if two unrelatedly-diversified firms consider collaboration, does it make sense for them to set up a less centralized or a more centralized decision-making structure? What if these firms become asymmetrically dependent on

each other? Does it increase or decrease the need to centralize decision making? Answering questions like these is the main contribution of this paper.

In this essay, I use the theory of decision making under uncertainty (Sah & Stiglitz, 1986, 1988) and the complexity theory of firms and alliances (Levinthal, 1997; Nickerson & Zenger, 2004) to predict the benefits of centralization of decision making in combined ventures. I use agent-based simulations to show that both the degree of asymmetry in dependence between the parties and the internal complexities of the parties affect the benefits of centralization of decision making even when opportunism is absent. In the discussion section, I introduce opportunism back into the problem to show how my results would apply to the real world where opportunism hazards exist. My findings extend the work of Aggarwal, Siggelkow, and Singh (2011) and contribute to the theory of alliances and the theory of the firm.

Literature review and research questions

I would like to start my discussion of governance in combined ventures with two real-world examples. Doz (1996) described an alliance between Ciba-Geigy, a large Swiss-based pharmaceutical firm, and Alza, a small California-based biotechnology firm. The goal of the alliance was the development of advanced drug-delivery systems by Alza and their subsequent manufacturing and commercialization by Ciba. In order to align the interests of the two parties, Ciba took an equity stake in Alza. The two firms possessed complementary capabilities: Alza was an expert in drug discovery and initial testing while Ciba had expertise in the manufacturing and commercialization of drugs. The presence of this complementarity meant that this alliance had significant potential promise due to possible synergies between the two firms' resources and

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capabilities (King, Slotegraaf, and Kesner, 2008). The equity stake in Alza, taken by Ciba, was supposed to ensure that the two parties' interests were aligned.

The outcome of this alliance, however, was far from ideal. While some new products were created and commercialized, the alliance was not nearly as successful as the partners had hoped. The main problem with this alliance was that there was no centralized decision making structure that should have solved problems and improved the alliance performance. The significant reciprocal interdependence (Gulati and Singh, 1998) between Ciba and Alza called for greater coordination of decisions. It turned out that potential synergy may be difficult to implement in practice because such implementation requires a number of coordinated actions and decisions to be made by both parties. If the number of actions and decisions to coordinate is sufficiently great and their consequences are not well known, the partners cannot always hope that coordination will happen automatically. They will need to set up some form of centralized decision-making structure (Nickerson and Zenger, 2004) which was lacking in the case of the Ciba-Alza alliance.

The second example is the alliance between Renault and Nissan, two large auto manufacturers (Burgelman and Leslie, 2008). One significant difference between the Renault-Nissan alliance and the Ciba-Alza alliance is the presence of centralized decision making in Renault-Nissan. Both companies have the same CEO, Carlos Ghosn. This unified leadership means that decisions are made in the best interests of the entire alliance, not only of one of the partners. Both partners trust each other and are willing to take small, temporary losses if there is promise of large gains to the entire alliance later. As a result, Renault-Nissan is a very successful alliance in terms of performance.

The two examples above show the critical importance of decision-making structures in combined ventures. Ownership structure is important but insufficient to explain the performance of a combined venture. Both Renault-Nissan and Ciba-Alza are equity alliances. However, Ciba-Alza used decentralized decision making while Renault-Nissan used centralized decision making. The difference in outcomes of these alliances may have been partially determined by the difference in the decision-making structures used.

Governance mode choice in combined ventures

The question of governance mode choice in combined ventures is closely related to the theory of the firm. Going back to Coase (1937), scholars have sought answers to the question "why do firms exist as islands of conscious power in a sea of markets?" and the related question "what explains the choice of a governance mode used to combine several productive resources?" These questions have traditionally been answered with the use of the concept of transaction costs. When costs of organizing an activity in the market exceed internal organization costs, the transaction will be internalized (Coase, 1937; Williamson, 1985, 1991). Another argument was presented by knowledge-based theorists (e.g. Conner, 1991; Conner & Prahalad, 1996; Kogut & Zander, 1992) who suggested that coordination of complex knowledge is another function of the firm and that this function goes beyond cost minimization. While knowledge-based arguments have been unable to explain centralized ownership of assets that characterizes modern firms (see Foss, 1996a, 1996b) and even the existence of long-term employment-like contracts (see Essay 1 of this Dissertation), they have been helpful in explaining why firms need more centralized decision-making structures (DMS). In particular, knowledge-based arguments lay at the core of

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the study by Nickerson and Zenger (2004) who suggested that coordination of complex knowledge and activities may be a reason why transacting parties may choose a more integrated governance mode.

The essence of the argument by Nickerson and Zenger (2004) is as follows. Increased interdependence of the parties in a transaction results in non-decomposability of the problem that the parties are trying to solve. Non-decomposability means that the problem cannot be divided into sub-problems that can be solved separately. The existence of a non-decomposable problem necessitates close coordination between the parties to make sure that the parties maximize joint gains and minimize negative externalities that uncoordinated action might generate. Nickerson and Zenger (2004) hypothesized that market-like governance with little coordination would only work when there was little interdependence between the parties. When there is significant interdependence, the parties will have to move toward authority-based, hierarchical governance to mitigate negative externalities. Finally, when interdependence is very high, the parties will have to collaborate within a consensus-based hierarchy to tap into the knowledge and expertise of all participants in the transaction.

This line of reasoning received support in the simulation model developed by by Aggarwal, Siggelkow, and Singh (2011). Using agent-based simulation, they found that increased interdependence between the two parties increased benefits of centralized governance. The idea of Nickerson and Zenger (2004) that very high levels of interdependence would require consensus-based hierarchy did not receive support. Aggarwal, Siggelkow, and Singh (2011) found that the centralized decision-making authority performed best at the very high levels of interdependence while intermediate forms based on consensus were optimal at moderate levels

of interdependence. This finding necessitates reconsideration of interdependence and complexity as factors that affect the optimal degree of centralization.

Interdependence within and between parties

Interdependence between the transacting parties is not the only type of interdependence in combined ventures. The other type concerns interactions between resources and activities within each party. In order to differentiate between these two types, I will refer to interactions of resources and activities within one firm or party as the "complexity" of that firm or party, while the term "interdependence" will be reserved for the inter-party interactions within the framework of a combined venture. It is worth noting here that complexity of a firm is an internal property that exists separately from any combined venture while interdependence is a feature of a specific combined venture.

Herbert Simon (1962) was one of the first researchers who examined the concept of complexity. He stated that the presence of multiple interactions among the firm's resources and activities makes the task of managing such a firm complex (hence the term "complexity"). In order to decrease complexity, firms can adopt more modular structures in which most interactions will be contained within compact modules while interactions across module boundaries are minimized. The prevalence of modular design in modern organizations, according to Simon (1962), is a means of making organizations more manageable. One implication of modular design is the reduction of the density of interactions across organizational units. Each unit in a modular organization becomes a separate profit center that has all the necessary resources. A modular organization is forced to implement a strategy of unrelated diversification

or a strategy of inter-temporal economies in which resources and activities are not shared across module boundaries (Helfat & Eisenhardt, 2004). This also means that related diversification strategies will use organizational designs that are not strictly modular. While this opens up opportunities for resource and activity sharing and resulting economies of scale and scope, it also means that management of such an organization becomes a more complex task.

What happens when internally complex organizations form a combined venture? There could be two approaches to answering this question. One will evoke ideas from transaction cost theory. According to this line of reasoning, a complex organization may be subject to greater transaction costs in a combined venture due to a greater risk of disruption of its intricate system of interacting resources and activities. It may be the case that complex parties will require more centralized governance and decision making. According to the other approach, internally complex parties may be well-equipped to deal with the added interdependence that the combined venture brings. Managers in such organizations are likely to be used to coordinating interacting resources and activities. Besides, the interdependence added by the combined venture may be relatively small compared to the existing internal complexity of the parties. In this case, the parties may not require much centralization of decision making (Villalonga & McGahan, 2005).

The existence of rival predictions from two different theories allows us to formulate my first research question:

Question 1: How does the internal complexity of the parties affect the need to centralize decision making in a combined venture?

Another factor that may affect the need to centralize decision making in a combined venture is asymmetry of interdependence. The conceptual model of Nickerson and Zenger (2004) and the simulation model of Aggarwal, Siggelkow, and Singh (2011) only considered

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situations of symmetric interdependence. However, combined ventures may be characterized by asymmetric interdependence. In situations of asymmetric interdependence, one party's actions may affect the other party's performance more significantly than the other way around. Such asymmetric interdependence may arise out of unequal options that the parties have outside the combined venture (e.g. one party may have many more potential partners) or out of the existing technology (e.g. a manufacturer may be affected much more by the demands of the distributor than the other way around). Transaction cost theory predicts that asymmetric interdependence may generate hold-up hazards, which would require greater integration between the parties (Pearce, 1997). In addition to hold-up, one party may have greater power over the other because it can impose greater externalities on the other party. Under arms-length market contracting, such power differentials may result in the less dependent party appropriating most of the returns from the combined venture. Going into a combined venture, the more dependent party may require greater integration to prevent such appropriation of returns[4]. On the other hand, asymmetric interdependence may create a "leader-follower" effect under which the more dependent party will simply have to adjust its strategy to the actions taken by the less dependent party. Such one-sided adjustment may obviate the need for centralized coordination and decision making because coordination may happen almost automatically.

As I have shown, there exist rival predictions based on previous research and theorizing. I can formulate my second research question:

Question 2: How does the degree of asymmetry in interdependence between the parties affect the need to centralize decision making in a combined venture?

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[4] It is a separate question whether the less dependent party will agree to integrate. Casciaro and Piskorski (2006) found that less dependent parties often successfully resist integration in order to preserve the power relationship that asymmetric interdependence brings.

Decision-making structures (DMS) in combined ventures: the Sah and Stiglitz typology

The importance of decision-making structures was formally studied by Sah and Stiglitz (1986, 1988). They modeled the impact of different structures on the performance of a firm in the presence of multiple potential projects whose values were uncertain. Sah and Stiglitz (1986) showed that a low average quality of projects made hierarchical decision making beneficial. Hierarchical decision making in Sah and Stiglitz's papers meant that all decision makers had to approve of a decision before a project could be implemented. This process minimized the number of projects implemented but assured the highest quality of those projects that were in fact implemented. The reverse was true when the average quality of the projects was high. In this case, a polyarchy (a decentralized structure in which any decision maker could approve a project alone) resulted in the best performance because many good projects were implemented. Sah and Stiglitz (1988) extended this logic to the case of committees, which approved a decision if a certain percentage of decision makers agreed. Committees are a "hybrid" structure that is most useful at intermediate levels of expected project quality.

Thus, according to Sah and Stiglitz (1986, 1988), decision-making structures can be classified according to the degree of consensus that they require. Decentralized structures like polyarchies are at one end of the spectrum and fully hierarchical structures are at the other end of the spectrum. Committee-like structures which require some consensus among the parties are an intermediate form. According to previous research on alliances and other combined ventures (e.g. Gulati & Singh, 1998; Nickerson & Zenger, 2004), we would expect to see polyarchical structures (resembling the market) when the need of coordination is low. We would expect to see centralized and hierarchical structures (resembling mergers) when the need of coordination is

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high. When the need of coordination is intermediate, we would expect to see intermediate structures such as committees (resembling alliances or joint ventures).

The typology of decision-making structures offered by Sah and Stiglitz is more general than the one tested by Aggarwal, Siggelkow, and Singh (2011). In their study of governance modes in alliances, Aggarwal, Siggelkow, and Singh considered collaborating parties as consisting of the "alliance" part and the part that was not involved in the alliance. Some of their alliances were managed in a decentralized fashion with each party making its decisions without consulting with the other party. Other alliances were managed in a fully centralized structure similar to a merger. The intermediate governance forms that they modeled were a three-agent structure in which there was one agent running the aggregate "alliance" parts of the two parties (the alliance manager) and two agents running the rest of the two parties' operations (managers of each party). In the "Self-governing alliance", the alliance manager did not have to consult with the managers of the two parties. In the "Ratified alliance", the parties' managers had to approve the decisions of the alliance manager.

The Sah and Stiglitz typology does not concern itself only with alliances but is conceptually applicable to any forms of combined ventures, from spot market contracts to fully centralized mergers. The Sah and Stiglitz typology suggests that alliances may be governed by consensus of the parties without forming a separate structure such as a free-standing joint venture. One of the goals of this paper is to model the general structures introduced by Sah and Stiglitz and compare the results to those obtained by Aggarwal, Siggelkow, and Singh.

In Table 2 below, I summarize the main decision-making structures modeled in this essay.

Table 2: Decision-making structures modeled in Essay 2

DECISION-MAKING STRUCTURE	WHO GENERATES PROPOSALS?	CRITERIA FOR EVALUATING PROPOSALS	WHERE CAN IT BE USED MOST OFTEN?
Fully decentralized – no coordination between the parties	Individual parties	Performance of the proposing party	Market-based exchanges; contract-based alliances with little coordination
Consensus-based (two versions)	Individual parties	(1) Performance of the proposing party and the other party; (2) Performance of the proposing party and the combined venture	Strategic alliances with significant coordination between the partners
Divisional	Individual parties	Performance of the combined venture	Free-standing joint ventures; divisional mergers
Centralized	The combined venture	Performance of the combined venture	Mergers with fully centralized management

MODEL

Assumptions

In order to find answers to the stated research questions, I ran computer simulations based on a formal model. Before I describe the model and its implementation, I would like to discuss my assumptions. Any formal model is a simplification of reality. Even though the assumptions that my model makes are standard in this stream of research (e.g. Rivkin & Siggelkow, 2003; Ganco & Agarwal, 2009; Aggarwal, Siggelkow, & Singh, 2011), I would like to explain why my simplification of reality is likely to capture the important aspects of this reality.

The fist assumption that I make is the absence of opportunistic behavior. I assume that the partners always behave according to the "contract." For example, in consensus-based

structures, I assume that the partner that makes a proposal will never proceed with implementing this proposal if it is not approved by the other partner. I make this assumption to separate the effects of decision-making structures from those of ownership structures. Ownership structures matter precisely because they affect the incentives of the parties and the transaction costs. Ownership of assets and incentive alignment would not matter if opportunism-related transaction costs were zero (Foss, 1996a). However, coordination problems would still exist even in a world without opportunism (Conner and Prahalad, 1996). These coordination problems make decision-making structures important.

My second assumption is bounded rationality (March and Simon, 1958). The existence of coordination problems is explained by bounded rationality of decision makers. I assume that the decision makers in my models cannot evaluate all the possible decisions. The partners cannot simply identify the strategy that will yield the best performance and implement it. Thus they are forced to engage in local search (Cyert and March, 1963). The decision-making structure that they use will affect the strategy that they will be able to find and the performance of the combined venture. In addition to bounded rationality of their decision makers, firms are characterized by limited flexibility and imperfect dynamic capabilities (Teece, Pisano, and Shuen, 1997; Eisenhardt and Martin, 2000; Schreyogg and Kliesch-Eberl, 2007). Even if the decision makers were able to find the best-performing strategy, the firms may be unable to implement it because of limits to their flexibility. The effect of bounded rationality and limited flexibility are likely to be in the same direction, confining the firm to local search.

My third assumption is costless evaluation of proposals. I assume that the parties can easily and precisely evaluate the short-term effect of each new proposal on the performance of both parties and the combined venture. This assumption may seem unrealistic. In real life, firms

can rarely know the precise effect of a proposed decision on their performance. Effects of new decisions are often "contaminated" by effects of other decisions, changes in the environment, simultaneous actions of the partner, etc. However, I believe that this assumption is reasonable for the purpose of this study. It simplifies the model significantly while allowing for precise interpretation of its results. Managers of partnering firms often have a good idea about the likely short-term effect of the newly proposed decision. Their knowledge of the world often allows them to form good heuristics that guide the evaluation of proposals. In other words, the search process may be local but it is not necessarily blind. Finally, costless evaluation of proposals is an assumption built into much of the literature using formal computer modeling (e.g. Gavetti and Levinthal, 2000; Rivkin and Siggelkow, 2003; Siggelkow and Rivkin, 2006). Future researchers may want to look at the effect of relaxing this assumption.

Finally, I assume that the environment does not change. The mapping from the specific decision combinations to performance stays the same throughout the simulation. For example, if the parties were to find a certain combination of decisions A, then move to other combinations of decisions and then somehow come back to combination A, their performance during this second use of A would be the same as during their first use of A. While this assumption of a static environment may seem unrealistic, it does not mean that the parties are only concerned with static efficiency. Their search for better performing strategies is driven by considerations of dynamic combining of the resources controlled by the two parties (Teece, Pisano, and Shuen, 1997; Eisenhardt and Martin, 2000). Exploitation of complementarities will likely require multiple adjustments from each party and search for the best ways to use the resources jointly. Thus, even in situations of relatively stable markets, decision-making structures that I study in this paper are likely to affect the performance of the combined venture. Again, future researchers

may want to study the effect of environmental dynamism on the relative performance of the various decision-making structures in future.

Model specification

In order to find answers to my research questions, I ran a series of computer simulations using a variant of the NK[C] modeling technique (Kauffman, 1993; McKelvey, 1999; Ethiraj and Levinthal, 2004; Ganco and Agarwal, 2009). The choice of simulation as my research method was dictated by a few reasons. First, simulation-based research is a useful method of theory development (Davis, Eisenhardt, and Bingham, 2007). It is especially useful when data collection is difficult, measurement of the key constructs is problematic, and there is little theory to generate empirically testable hypotheses. Second, simulation methods allow researchers to isolate the phenomenon of interest and study its effects without contamination from confounding factors. Finally, simulation results can be compared to prior empirical findings. If simulation results allow researchers to explain previously unexplained phenomena, their value is enhanced.

My implementation of the NK[C] model is similar to the previous implementations in the literature with a few differences. I will describe my implementation of the model and highlight its differences from the previous implementations.

NK[C] models represent firms as vectors of interdependent decisions. This aspect of NK[C] models makes them especially suitable for studying interactions within and between firms, which is the main theme of my paper. K and C are the most important parameters of the model. Varying these parameters, I am able to model differences in the firms' internal complexity and interdependence. Below is a description of all parameters of the model.

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Parameter N denotes the number of decisions facing the combined venture, which is sometimes referred to as the *size* of the firm. For example, if party 1 controls six decisions and party 2 controls six decisions, the size of the combined venture is therefore $N = 12$. The sizes of the two parties can be equal or non-equal. I modeled both equal and non-equal sizes to make sure that my results are robust. The overall size of the combined venture in the model (the value of N) is not very important. Even small values (for example, six – see Rivkin and Siggelkow, 2003) provide for meaningful variation and overall complexity of the model. Therefore, I chose to model the combined venture of size $N = 12$. This value of N is in line with the majority of research that has used NK[C] models in the past (e.g. Gavetti and Levinthal, 2000; Siggelkow and Rivkin, 2006; Ganco and Agarwal, 2009; Aggarwal, Siggelkow, & Singh, 2011). Much greater values of N reduce variation in the performance of the decision-making structures and exponentially increase the computing time without providing substantial new insights.

The decisions that each party controls are assumed to be binary. This assumption can represent many aspects of reality in business and management. Managers often decide whether to switch suppliers or not; whether to introduce a new compensation scheme or leave the old scheme in place; whether to buy a new technology or develop it internally; whether to use the new technology at all or keep perfecting the old technology; etc. In addition, the binary nature of decisions does not limit the generalizability of results of NK[C] simulations (Levinthal, 1997).

Parameter K represents the internal complexity of the firm. Formally, K is the number of internal decisions of the firm that affect the payoff to any particular decision. For example, if the payoff from every decision is totally independent of any other decision, the value of K is zero. I will call such a firm "simple." When the value of K rises from zero, the firm becomes more complex. For example, when K equals two, each decision's payoff depends not only on the

decision itself, but also on two other decisions that the focal firm has to make. The greatest possible value of K is N-1. When K = N-1, the payoff to every decision depends on all the other decisions that the firm has to make and the complexity of the firm is the highest possible for a firm of this size. The intuition behind calling the firm "simple" or "complex" depending on the value of K is as follows. Low values of K mean that decisions of the firm are largely independent. When K equals zero, the firm's managers can make each decision separately from the others because none of the decisions affect each other's payoffs. The task of managing such a firm becomes relatively simple. When K is greater than zero, interactions among decisions are present. In order to make one optimal decision, managers have to optimize K other decisions simultaneously. The problem of finding optimal decisions quickly becomes mathematically intractable even at relatively small values of K (Rivkin, 2000). Thus, managers face much more complex problems when K increases. Decision making becomes the most complex when K reaches the maximum possible value of N-1. If one decision's payoff depends on how the managers have resolved all other decisions, optimization of firm performance becomes virtually impossible.

Figure 2 shows three examples of firms (size of the firm N = 4) at various levels of complexity. The X's represent the interdependencies within the firm and the "minus" signs represent independent decisions. Each row represents one decision. The way to read these charts is as follows: go along a row from left to right. If there is an X in position [row, column], the payoff to the decision corresponding to the row depends on the decision corresponding to the column. By definition, the payoff to any decision always depends on how the firm has resolved this decision. Thus, there will always be X's on the main diagonal.

Figure 2: Examples of firms of various internal complexity.

(a) Structure of the simplest possible firm (K = 0). There are four decisions in total (N = 4). Each decision's payoff only depends on how the firm has resolved this decision but not on any other decisions. "X": decisions are interdependent; "-": decisions are independent.

[X - - -]
[- X - -]
[- - X -]
[- - - X]

(b) Structure of a moderately complex firm (K = 1). There are four decisions in total (N = 4). Each decision's payoff depends on how the firm has resolved this decision and one other decision. Remember that dependence is read horizontally (e.g. row 1: payoff to decision 1 depends on itself and decision 3). This is one of many possible structures of a firm with N=4 and K=1.

[X - X -]
[X X - -]
[X - X -]
[- X - X]

(c) Structure of a firm of the highest possible complexity (K = 3). There are four decisions in total (N = 4). Each decision's payoff depends on how the firm has resolved this decision and all other decisions.

[X X X X]
[X X X X]
[X X X X]
[X X X X]

Considering the fact that there are two initially autonomous firms in my model, I use two values of K: K_1 and K_2. They correspond to internal complexities of party 1 and party 2, correspondingly.

Parameter C represents the interdependence between the parties after they form a combined venture. Here I depart from the ways C was operationalized in Kauffman (1993) or Ganco and Agarwal (2009). In order to simplify the model and still capture all the possible variation, I let C denote the total number of interdependences of payoffs of decisions of one

party on the decisions of the other party. For example, if C equals two, it means that there are two different instances when a decision of partner 2 affects the payoff to some decision(s) of partner 1. To illustrate the parameter C, let us turn to Figure 3.

Figure 3: An example of a combined venture consisting of two interdependent parties. The size of the combined venture is $N = 8$. Each party is size $N_1 = N_2 = 4$. Each party is simple ($K_1 = K_2 = 0$) – there are no internal interactions of decisions within the parties. The value of C is two: there are two total cases of payoffs to decisions of each party being affected by decisions of the other party. The upper left quadrant in Figure 2 is party 1; the lower right quadrant in Figure 2 is party 2. The upper right quadrant in Figure 2 is the dependence of payoffs to decisions of party 1 on decisions of party 2. The lower left quadrant in Figure 2 is the dependence of payoffs to decisions of party 2 on decisions of party 1.

```
[ X - - - | - - - - ]
[ - X - - | - - X - ]
[ - - X - | - - - - ]
[ - - - X | X - - - ]
-----------------------
[ - - - - | X - - - ]
[ - - - - | - X - - ]
[ - X X - | - - X - ]
[ - - - - | - - - X ]
```

Figure 3 tells us that each party is simple ($K1 = K2 = 0$) as evidenced by X's on the main diagonal only. Also, according to Figure 2, the payoff to decision 2 of party 1 depends on decision 3 of party 2; the payoff to decision 4 of party 1 depends on decision 1 of party 2. Finally, the payoff to decision 3 of party 2 depends on decisions 2 and 3 of party 1.

Figure 3 also shows us that the maximum value of parameter C is N_1 times N_2. In addition, there could be two different values of C: C_1 and C_2. C_1 is the number of dependences of payoffs to decisions of party 1 on decisions of party 2 (upper right quadrant); C_2 is the number of dependences of payoffs to decisions of party 2 on decisions of party 1 (lower left quadrant). In general, C_1 and C_2 do not have to be equal. If C_1 is greater than C_2, it means that the performance

of partner 1 is relatively more dependent on decisions of partner 2 than vice versa. The minimum possible value of C_1 and C_2 is zero, which would mean that one party's performance is completely independent of anything that the other party does. I model the values of C_1 and C_2 from 1 to N_1 times N_2.

In my simulations, I allowed each parameter (K_1, K_2, C_1, C_2, N_1, and N_2) to vary over the entire range of possible values. N_1 and N_2 vary from 2 to 10 (to exclude the trivial cases of a party the size of one). K_1 (K_2) varies from 0 to N_1-1 (N_2-1). C_1 and C_2 vary from 0 to N_1*N_2. My simulations thus cover all possible parameter combinations.

Now I would like to show how my parameters correspond to the research questions that I formulated earlier. In order to compare my results with those reported by Aggarwal, Siggelkow, and Singh (2011), I will be looking at the effect of the sum of C_1 and C_2 on the relative performance of the decision-making structures. Research Question 1 asked how the internal complexity of the parties affected the relative performance of the decision-making structures. To answer this question, I will be looking at the effect of the sum of K_1 and K_2 on the performance of decision-making structures (alone and in interaction with the sum of C_1 and C_2). Finally, Research Question 2 asked how the asymmetry of interdependence between the parties affects the relative performance of decision-making structures. To answer this question, I will be looking at the effect of the absolute difference between C_1 and C_2 on the relative performance of decision-making structures.

Table 3 provides a summary of the parameters of the model.

Table 3: Parameters of the model

Parameter	Meaning	Assigned value or range of values	Relevance to Research Question
N	The size of the combined venture	12	n/a
N_1	The size of party 1	From 2 to 10 $(N_1+N_2=N)$	n/a
N_2	The size of party 2	From 10 to 2 $(N_1+N_2=N)$	n/a
K_1	The complexity of party 1	From 0 to N_1-1	1
K_2	The complexity of party 2	From 0 to N_2-1	1
C_1	Dependence of party 1 on party 2	From 1 to N_1*N_2	2
C_2	Dependence of party 2 on party 1	From 1 to N_1*N_2	2
INTERDEPEND	Total amount of interdependence between the parties	From 0 to N_1*N_2*2	
COMPLEXITY	The sum of complexities of the parties	From 0 to K_1+K_2	1
ASYMMETRY	$\mid C_1 - C_2 \mid$	From 0 to N_1*N_2	2

Implementation

Calculation of the performance of each party and the combined venture

Following previous research (e.g. Levinthal, 1997, Rivkin, 2000; Rivkin and Siggelkow, 2003), I

calculated the performance of the parties and the combined venture as follows. At the start of

each simulation run, I assigned a random value from the uniform distribution U[0,1] to each

possible combination of decisions of the two parties. These values were stored in a large array.

During simulation runs, the performance contribution of each decision was taken from this array.

Consider the situation in Fig. 2. The payoff to decision 3 of party 2 depends on this decision as

well as on decisions 2 and 3 of party 1. Given the binary nature of the decisions, there are $2^3 = 8$

possible combinations of those decisions. Thus, the program accessed one of 8 randomly generated numbers depending on the values of the decisions. The resulting number was the payoff to decision 3 of party 2 considering the values of decisions 2 and 3 of party 1. Payoffs to all the decisions of each party were computed in this manner. The program always explicitly considered all interactions of decisions. The performance of each party was calculated as the simple average of payoffs to all decisions. Formally, $P_j = [\Sigma_{ij}D_{ij} (D_{11}, \ldots D_{N1,1}, D_{12}, \ldots, D_{N2,2})]/Nj$, where P_j is the performance of party j; D_{ij} is the payoff to decision i of party j considering its dependence on the decisions of both parties; Nj is the size of party j.

The performance of the combined venture was calculated similarly. The program calculated the performance of the combined venture as if it were one big firm. Mathematically, the performance of the combined venture was a weighted average of the performance values of the two partners considering their size.

Search strategies

When there are multiple interactions of decisions within and between the parties, the best-performing combination of decisions is difficult to find (Levinthal, 1997; Gavetti and Levinthal, 2000). Based on the notion of bounded rationality (Simon, 1947), the parties were assumed to engage in local search (Cyert and March, 1963). Local search was implemented as varying one decision at a time. At each step of the search process, the parties took turns performing the following procedure. One party chose one decision at random and flipped this decision's value (from zero to one or from one to zero). Then the program calculated the performance of each party and of the combined venture after this change. Depending on the decision-making structure adopted for this simulation run, the change was either accepted or rejected. In the latter case, the

change was reversed. The parties took turns in offering such proposals of change. After a number of steps, when the performance of the parties and the combined venture had stopped improving, the program recorded this achieved performance value.

The program performed five simulation runs with each possible set of parameter values: one for each decision-making structure. In order to equalize the conditions for each decision-making structure as much as possible, I did the following. For each new set of parameters, the program randomly generated a new starting combination of decisions. All five decision-making structures started their search from this position. I did this to ensure that the only performance variation among the decision-making structures was attributable to the different ways they evaluated proposals. The total number of simulation runs with all parameter value combinations was over 253 thousand.

Specification of decision-making structures

I followed Table 2 in implementing the decision-making structures. Each decision-making structure was implemented as a set of rules that specified how the decision was allowed to affect the performance of the parties and the combined venture.

In the decentralized decision-making structure, the parties took turns offering proposals. A proposed change was accepted if it improved the performance of the proposing party without regard to its effect on the performance of the other party.

In consensus-based decision-making structures, the parties took turns offering proposals. A proposed change was accepted if it improved the performance of the proposing party and either (1) did not decrease the performance of the other party, or (2) did not decrease the

performance of the combined venture. Thus, I implemented two versions of consensus-based decision-making structures. I called variant (1) "restrictive structure" because it placed the most severe restrictions on the actions of the parties. I called variant (2) "consensus structure" because it allowed the parties more latitude than the restrictive structure but still less than the decentralized structure.

In the divisional decision-making structure, the parties took turns offering proposals. A proposed change was accepted if it improved the performance of the combined venture.

Finally, in the centralized decision-making structure, the combined venture offered proposals. A proposal was accepted if it improved the performance of the combined venture.

Specification of the regression model

In order to find the answers to my research questions, I performed linear regression analysis of the data generated by my program. The dependent variable, DIFF_PERFORM was the difference in performance between two specific decision-making structures (e.g. the difference in performance between centralized and decentralized decision-making structures). The dependent variable was calculated for each possible pair of decision-making structures. The independent variables were: (1) INTERDEPEND: the sum of interdependence values of the two parties (C_1+C_2); (2) COMPLEXITY: the sum of complexity values of the two parties (K_1+K_2); (3) INTERACTION: the product of parameters (1) and (2) representing their interaction effect; (4) ASYMMETRY: the absolute difference between the interdependence values of the two parties $(abs(C_1-C_2))$. I also included SIZE_DIFF as a control variable: the absolute difference in size

between the two parties ($abs(N_1-N_2)$). Finally, I tested for possible non-linear effects of party complexity. I included the variable COMPLEXITY_SQUARED in the regression model.

The formal specification of the model is as follows:

DIFF_PERFORM = b0 + b1*INTERDEPEND + b2*COMPLEXITY + b3*INTERACTION_INTERDEPENT_COMPLEXITY + b4*ASYMMETRY + b5*SIZE_DIFF +b6*COMPLEXITY_SQUARED + error

In order to avoid multicollinearity problems caused by introducing a product of two independent variables, I orthogonalized it by regressing the product on both terms and storing the residuals. These residuals were used as the new value of the product term. I also orthogonalized the COMPLEXITY_SQUARED term this way. However, it made interpretation of the results difficult. This is why I report the results for COMPLEXITY_SQUARED in the original (non-orthogonalized) metric and show the non-linear effect.

RESULTS

In order to illustrate the answers to the research questions, I will use the difference in performance between centralized and decentralized decision-making structures (see Table 3). I will provide the similar detailed data for other dependent variables in the appendix.

In order to test the conceptualizing in Nickerson and Zenger (2004) and compare my results to those reported in Aggarwal, Siggelkow, and Singh (2011), I would like to discuss the effect of interdependence between the parties on the relative performance of the centralized structure. The coefficient for INTERDEPEND in Table 3 is positive and significant (B = 0.799, p < 0.001). It means that combined ventures characterized by significant interdependence between the parties

benefit more from centralization of decision making than combined venture characterized by low interdependence between the parties. This result suggests that highly interdependent parties may see additional benefits to centralization of decision making even when opportunism is not an issue. This result is similar to the findings of Aggarwal, Siggelkow, and Singh (2011).

Question 1: How does the internal complexity of the parties affect the need to centralize decision making in a combined venture?

Part of the answer to this question is provided by the coefficient for the variable COMPLEXITY. Its value is negative and significant (B = -3.586, $p < 0.001$). It means that parties with higher internal complexity experience lower benefits from centralization of decision making regarding the joint use of their resources compared to parties with low internal complexity. The other part of the answer is provided by the coefficients for the variable INTERACTION_COMPLEXITY_INTERDEPENDENCE. It is negative and significant (B = -0.225, $p < 0.001$). It means that the even though high interdependence between the two parties has a positive effect on the benefits of centralization, its effect is weakened when the two parties are internally complex.

To facilitate interpretation of the interaction between internal complexity of the parties and interdependence between the parties, I have provided the following graph (Fig. 4):

Figure 4: Interaction between firm complexity and interdependence between the parties.
The dependent variable is the performance difference between centralized and decentralized decision-making structures. The independent variable is the combined degree of interdependence between the parties. The moderator is the combined complexity of the parties.
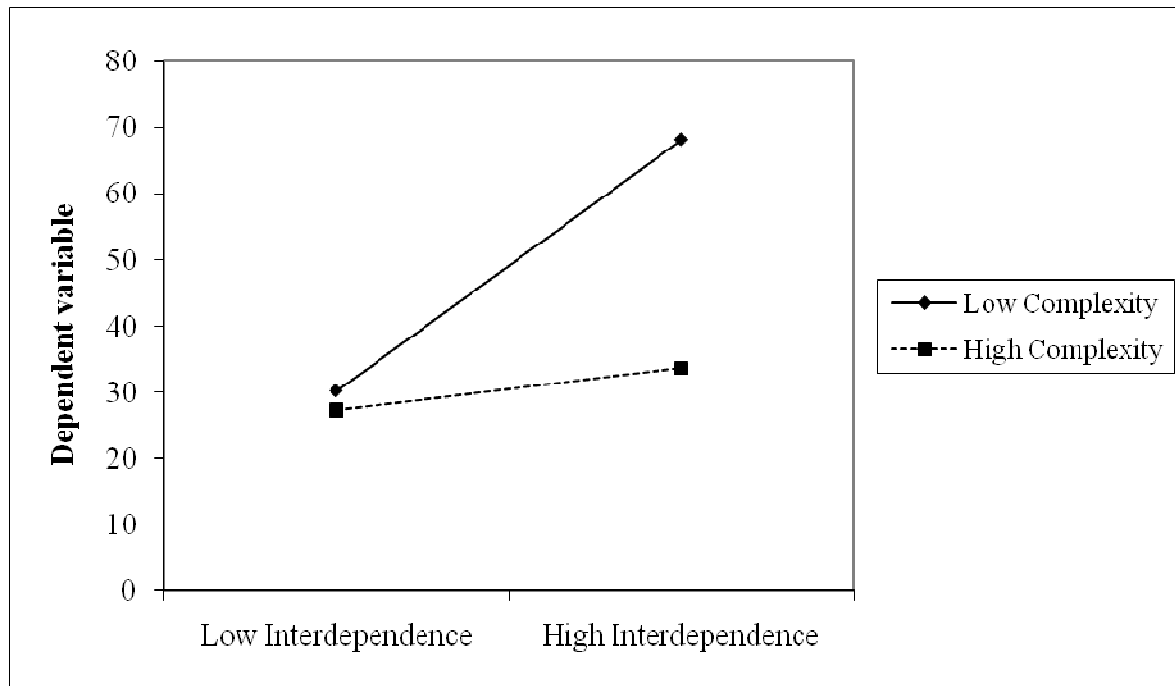
We can see that parties of low internal complexity gain much more from centralization when they are highly interdependent. This gain greatly diminishes when the parties are of high internal complexity.

In order to investigate a possible nonlinear or non-monotonic effect of internal complexity, I included the squared complexity term in the regression equation. We can see that the coefficient for the squared term is positive and significant (0.818, $p < 0.001$). In order to facilitate interpretation of the quadratic term, I have drawn the following graph:

Figure 5

The difference in performance between centralized and decentralized decision-making structures as a function of the combined complexity of the parties.
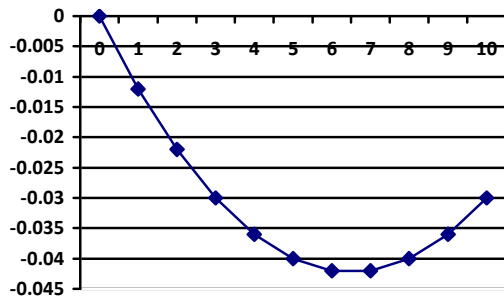
Thus, we can see that combined internal complexity has a negative effect on the performance advantage of the centralized decision-making structure. This effect is most pronounced at 6 and 7 and actually starts to diminish at higher values of combined internal complexity.

In order to explain the effect of internal complexity of the parties on the benefits of centralization, let us first consider the case of simple parties with no internal interactions of decisions and activities. If such two parties are significantly interdependent, each of them may impose potentially significant externalities on each other under decentralized decision making. One change in the strategy of Party 1 may affect the payoffs to many or all decisions of Party 2. However, since each party engages in local search by altering one decision at a time, it has only a limited ability to correct the negative consequences of the other party's strategizing. As a result, simple parties have the greatest need to centralize decision making when they are significantly interdependent.

When each party is moderately complex, each decision by this party may affect the performance of some other decisions. In general, this performance effect may be negative when the party engages in local search. However, if the performance of one party has just been negatively affected by the other party, changing one decision may in fact positively affect the

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performance contributions of some other decisions that have been affected by the previous move by the other party. As a result, parties of moderate complexity will experience smaller performance benefits from centralizing their decision making.

Why does this effect level off and even reverse at high complexities of the parties? Highly complex parties experience the greatest problems with local search due to the presence of multiple simultaneous interactions of activities and decisions (Gavetti and Levinthal, 2000). In a very complex firm, changing one decision affects the payoffs to nearly all other decisions. As a result, highly complex firms may "overcompensate" when trying to respond to externalities imposed by the other party. For example, suppose that Party 1 has affected payoffs to two decisions of Party 2. In an attempt to correct the external shock to its performance, Party 2 tries to change one decision of its own. However, this change in one decision affects payoffs to most other decisions of Party 2. As a result, the performance effect of the change may be negligible or even negative for Party 2. Thus, highly complex parties may need more centralization compared to firms of moderate complexity.

Question 2: How does the degree of asymmetry in interdependence between the parties affect the need to centralize decision making in a combined venture?

The answer to this question is provided by the coefficient for the variable ASYMMETRY. It is negative and significant (B = -0.704, p < 0.001). It means that combined ventures characterized by high asymmetry of interdependence benefit less from centralization than combined ventures in which the two parties are symmetrically interdependent. This result is explained by the presence of a "leader-follower" effect. Suppose that the venture has chosen the decentralized decision-making structure. It means that each party is free to do anything. When the less

dependent party takes an action, it is likely to affect the performance of the more dependent

party. The more dependent party responds by taking an action of its own. However, the less

dependent party is less likely to "feel" the effect of its party's action and less likely to respond.

Thus, the less dependent party plays the role of a leader while the more dependent party plays the

role of a follower. Successful adaptation and search in this case happen almost automatically,

without much need for centralized decision making.

Table 4: Difference in performance of centralized and decentralized decision-making structures as a function of independent variables.

Independent variables	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	31.263	.516		55.219	.000
INTERDEPEND	.799	.010	.160	79.687	.000
COMPLEXITY	-3.586	.053	-.131	-68.154	.000
ASYMMETRY	-.704	.017	-.079	-40.439	.000
INTERACTION_INTERDEPEND _COMPLEXITY	-.225	.004	-.114	-59.445	.000
DIFF_SIZE	.349	.062	.011	5.591	.000
COMPLEXITY_SQUARED	.818	.019	.082	42.763	.000

DISCUSSION

One of the contributions of this paper is to extend the findings of Aggarwal, Siggelkow, and Singh (2011). I would like to start the discussion with explaining their main findings and relating their results to what I did. Aggarwal, Siggelkow, and Singh (2011) used a similar computer simulation methodology to study the relationship between interdependence and optimal governance mode choice. The way they modeled an alliance was as follows: they divided each firm into the "alliance" part (the part of the firm that is directly involved in an alliance) and the "non-alliance" part (the part of the firm not directly involved in an alliance). They also modeled firms that did not separate the "alliance" parts from the rest of the firms' operations as well as completely centralized entities representing two merged firms. The question that they investigated was the performance implications of various governance modes (ranging from no coordination to complete centralization) depending on the degree of interdependence between the two parties. The findings reported in Aggarwal, Siggelkow, and Singh (2011) indicate that more interdependence between the parties increased the benefits of more centralized governance. However, their study made two important assumptions: (1) the firms are symmetrically interdependent and their "alliance parts" are of equal size; (2) the firms have equal internal complexity (maximum possible for the firms of a given size). I believe that these assumptions are not merely technical details but represent important structural characteristics of the firms and the resulting combined venture. Therefore, the motivation behind this study was to tease out the effects of asymmetric interdependence and internal complexity on the optimal choice of a decision-making structure in the absence of opportunism.

My computer simulations show that centralization of decision-making tends to bring positive performance benefits when there is higher interdependence between the two parties.

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However, the size of these benefits depends on the complexity of the parties. When the parties are internally complex, they benefit less from centralization compared to internally simple parties. While high interdependence between the parties generally has a positive effect on the performance advantage of centralized decision-making structures, its effect is diminished by increased asymmetry of interdependence. These results were obtained by running relatively simple models that made certain assumptions. Now I would like to discuss the likely effects of relaxing some of those assumptions.

A key assumption that I made is the absence of opportunism. I made this assumption in order to isolate the effects of interdependence and complexity on the optimal choice of a decision-making structure. My results do not say anything about the optimal ownership structures in which those decision-making structures should be organized. If opportunism-related transaction costs are zero, the partners can set up any decision-making structure under any ownership structure. For example, firms contracting in the market could set up a centralized decision-making structure, and firms that decided to merge could use a fully decentralized decision-making structure. The choice of an optimal decision-making structure would become completely independent from the choice of an optimal ownership structure. In fact, the choice of an ownership mode would not matter at all if there were no opportunism-related transaction costs (Foss, 1996a). However, the choice of a decision-making structure would still be important even in the absence of opportunism, as my simulations show. Thus, my results formally demonstrate that the study of governance mode choice benefits from integrating ideas from knowledge-based theories (e.g. Kogut and Zander, 1992; Conner and Prahalad, 1996; Madhok, 1996, 2002) with ideas from organizational economics theories. I would like to stress that my results do not disconfirm the arguments and findings of either theoretical perspective. Knowledge-based

theories emphasize the role of the decision-making structure in the absence of opportunism while organizational economics theories emphasize the role of ownership structures and formal contracts in mitigating transaction costs that arise from opportunism. My findings contribute to the emerging integration of knowledge-based and organizational economics theories on the boundary of the firm. A combination of the two theoretical perspectives can potentially provide a fuller understanding of the choice among different governance modes.

Role of Opportunism

What happens if I relax the assumption of zero opportunism? Implementing centralized decision-making structures becomes more costly if the assets are owned separately. Without opportunism, the parties could agree to maximize the performance of the combined venture and then divide the profits equitably. However, if one party can opportunistically appropriate most of the benefits from the combined venture, the other party will be wary of entering such a combined venture. It will likely demand additional safeguards in the form of equity investments that align their interests and/or costly monitoring mechanisms. In the extreme cases, merging the assets of the two partners may be the only way to implement a centralized decision-making structure. The two parties may attempt to implement a centralized decision-making structure in a contract-based alliance as well. However, they would have to set up a costly system of monitoring which is also likely to be highly imperfect. It may be less costly for the two partners to arrange for some form of common ownership of assets (e.g. an equity joint venture) to implement a joint decision-making structure.

Thus, in real life, the choice of a decision-making structure will be related to the choice of an ownership structure. For example, if asset specificity is high, the parties are more likely to merge or use significant equity investments (Williamson, 1985; Hennart, 1991). This centralization of asset ownership may allow them to implement a more centralized decision-making structure. We have seen that more centralized decision-making structures tend to outperform less centralized decision-making structures if the parties are significantly interdependent. It may make sense for the parties to centralize decision making as well. Thus, we would expect to see more centralized decision-making structures in combined ventures characterized by significant equity investments. On the other hand, the optimal decision-making structure choice might drive the choice of an ownership structure. If the task of combining the parties' resources calls for highly centralized decision making, they may want to merge or form an equity joint venture because such an ownership choice is likely to economize on transaction costs. The goal of centralization of decision making is to create value for the combined venture, not for either individual party. Centralized ownership of assets largely eliminates private interests and subjugates the individual players to the interests of the combined venture. Therefore, the need to choose a more centralized decision-making structure may drive common ownership of assets.

My findings formally confirm some theoretical insights of Nickerson and Zenger (2004). In particular, I found that when interdependence between the parties is low (corresponding to Nickerson and Zenger's "decomposable problem"), decentralized decision-making structures work well. This result is in line with Nickerson and Zenger's prediction that decomposable problems can be solved in market-like structures. However, when interdependence between the partners increases, my results depart from those predicted by Nickerson and Zenger. They

predicted that "nearly decomposable problems" (corresponding to moderate degrees of interdependence between the partners in my terminology) would lead to authority-based hierarchy while "nondecomposable problems" (corresponding to high degrees of interdependence between the partners in my terminology) would lead to consensus-based hierarchy. My results show that when interdependence between the parties is high, centralized decision-making structures outperform consensus-based decision-making structures. Part of the reason why my results diverge from Nickerson and Zenger's (2004) predictions is that I studied "pure" decision-making structures while Nickerson and Zenger conceptualized on the governance form in general (thus subsuming both the decision-making structure and the ownership structure). Their conceptualization focuses on the negative consequences from opportunistic behavior in highly interdependent relationships, while my conceptualization takes into account both the damages and opportunities created by the "external" shocks from the actions of the two parties in the absence of opportunism.

It might be tempting to argue that Nickerson and Zenger's (2004) "nondecomposable problem" refers to both the high interdependence between the partners and the high internal partner complexity. If that is the case, my results contradict Nickerson and Zenger's predictions. I find that greater internal complexity of the partners actually decreases the benefits of centralization. Moreover, it decreases the positive effect of greater interdependence on the benefits of centralization. I suggest that interdependence between the parties alone is a better fit to Nickerson and Zenger's concept of decomposability. When the two parties contemplate the choice of the governance form, they do not usually consider changes to their internal governance forms that are already in use. The governance form choice usually refers to the choice of a decision-making structure and ownership structure that will govern the relationship *between* the

parties. Therefore, a party's internal complexity is conceptually distinct from "decomposability" that Nickerson and Zenger (2004) used as a predictor of governance choice. However, I found that internal complexity of the parties affects the benefits of centralization and thereby affects the optimal governance mode choice.

Another result of my simulations has not been predicted before. I found that asymmetry of interdependence actually decreases benefits of centralization of decision-making. This may seem counterintuitive because usually asymmetric interdependence is seen as a condition for high transaction costs and thus a factor that should *increase* centralization. This discrepancy between my findings and the usual predictions is easily explained. As I have argued earlier, asymmetric interdependence between the partners gives rise to the "leader-follower" effect. This means that coordination between the asymmetrically dependent parties happens almost automatically without the need for centralized decision making. Also, I use the term "dependence" differently from its conventional meaning. "Dependence" is often used to mean "resource dependence" (Pfeffer and Nowak, 1976), "supply chain dependence" (Harland, 1996), or, in an extended sense, dependence of the party that makes a transaction-specific investment on the other party's honesty (Williamson, 1985). My use of the term "dependence" refers to the dependence of performance of one party on the actions of the other party. This kind of dependence includes, but is not limited to, resource dependence, supply chain dependence, or dependence due to transaction-specific investments. For example, R&D alliances, in which the parties pool resources to create a new product or technology, are usually characterized by reciprocal interdependence (Gulati and Singh, 1998). This interdependence is a result of complex complementarities between the resources and activities of the parties. However, it does not necessarily give rise to high transaction costs in Williamsonian sense. I have found that such

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interdependence positively affects centralization of decision making, but only when the parties are relatively symmetrically dependent on each other. With an increase in the asymmetry of interdependence, the benefits of centralization diminish.

When transaction costs are positive and significant, the asymmetry of interdependence may contribute to the increase of transaction costs. This is particularly likely when one party can use its lower dependence to threaten actions that will hurt the other party's performance. Thus, predictions based on asymmetry of interdependence are not as straightforward. While asymmetry will decrease benefits to centralization of decision making, it may increase benefits to centralization of asset ownership. Since an asset ownership structure needs to be compatible with the decision-making structure, the optimal governance mode structure will depend on the overall risk of opportunism as well. Under low risk of opportunism, asymmetry of interdependence is likely to have a negative effect on centralization of governance. Under high risk of opportunism, asymmetry of interdependence is likely to have a positive effect on centralization of governance.

My contribution in this essay is the simultaneous consideration of inter-party dependence and intra-party complexity as determinants of the optimal decision-making structure. I would like to sum up the predictions of my models in Table 5. For convenience, I compare my results with those predicted by Nickerson and Zenger (2004).

Table 5: My results compared to theoretical predictions by Nickerson & Zenger (2004)

Factor	Prediction by Nickerson and Zenger (2004)	Prediction of my model without transaction costs	Prediction of my model with transaction costs
The degree of interdependence between the parties (defined as dependence of performance of one party on the actions of the other party)	Low interdependence: market governance. Medium interdependence: authority-based hierarchy. High interdependence: consensus-based hierarchy	Higher interdependence increases benefits of centralized decision making.	Higher interdependence increases the probability of using more centralized governance modes (e.g. equity joint ventures or mergers)
Internal complexity of the parties	No prediction	Higher internal complexity of the parties (1) decreases benefits of centralized decision making; (2) decreases the positive effect of interdependence on benefits of centralization.	More internally complex parties will be more likely to use decentralized governance modes (e.g. market contracting or non-equity alliances).
Asymmetry of interdependence between the parties	No prediction	Higher asymmetry of interdependence between the parties decreases the benefits of centralized decision making.	When opportunism threat is low, asymmetric interdependence will be related to less centralized governance (e.g. market contracting or non-equity alliances). When opportunism threat is high, asymmetric interdependence will be related to more centralized governance (e.g. equity joint ventures or mergers).

Relevance to Existing Empirical Work

Finally, I would like to discuss how my results help explain empirical phenomena. According to Davis, Eisenhardt, and Bingham (2007), using simulation results to "predict" well-known empirical findings is a standard way of validating simulation research in economics. The key issue here is whether the simulation offers any new theoretical insight to explain the well-known empirical results.

As an example, I will use some of the findings by Villalonga and McGahan (2005) on the relation between the degree of diversification and the preference of acquisitions over alliances. Villalonga and McGahan (2005) found that highly diversified firms were much more likely to use acquisitions than alliances. They explained this finding by the fact that highly diversified firms were likely to have used acquisitions to become diversified. As a result, these firms are more likely to use acquisitions again because they have accumulated acquisition experience and may have build up capabilities to acquire and successfully integrate other firms (Laamanen and Keil, 2008; Zollo and Singh, 2004). This line of reasoning suggests that controlling for the previous acquisition experience should have eliminated or at least greatly reduced the effect of diversification on the preference for acquisitions. However, this was not the case: the effect of diversification on the preference for acquisitions and other centralized governance forms remains highly significant (e.g. Villalonga and McGahan (2005), Table 6 on p. 1199: coefficients for diversification are positive and highly significant with t-values around 24 even when controlling for the previous acquisition experience).

How can my findings explain the phenomenon reported by Villalonga and McGahan (2005)? The way Villalonga and McGahan (2005) operationalized diversification was the "[n]umber of segments in different SIC codes reported by the focal firm." (p. 1197). Their

measure was in effect capturing lack of relatedness of diversification: if one firm is active in many different SIC codes, it is not likely to be using a related diversification strategy. Using my terminology, a firm that is highly diversified in unrelated ways is a firm with relatively few internal interactions. Divisions of such a firm are likely to operate as independent units, and the need for coordination among them is likely to be low. On the other hand, a firm that is diversified in related ways will need more coordination because its units will exhibit resource complementarity. Thus, if we compare firms of equal size, relatedly-diversified firms will have more internal interactions among their divisions than firms using unrelated diversification.

My findings predict that firms with relatively many internal interactions of resources will be less likely to use centralization than firms with relatively few internal interactions of resources. This is exactly what Villalonga and McGahan (2005) reported. My predictions of this effect are not based on the previous acquisition experience of the firm. Thus, my findings help predict and explain a real-world empirical phenomenon that was not adequately explained before.

Limitations and Implications for Future Research

The main limitation of my study relates to the chosen method of research. Computer simulations are based upon abstract models that simplify the reality. While I have explained that my model is an acceptable approximation of reality for the purpose of my study, it is nevertheless quite simple. The only factor that determined performance of combined ventures in my study was the specific combination of decisions that the combined venture was able to find. This is a common weakness of all studies that use NK[C] modeling. In reality, the performance of combined

ventures is determined by many other factors as well, including resource characteristics (Das and Teng, 2000), interpersonal dynamics (de Rond and Bouchikhi, 2004), the level of interpartner trust (Gulati, 1995; Krishnan, Martin, and Noorderhaven, 2006), experience with the chosen governance form (Villalonga and McGahan, 2005), and many others. Choosing decision making as the only factor affecting the performance of the combined venture was necessary to isolate the effects of decision-making structures. Investigating the choice of decision-making structures in the context of other factors that affect combined ventures is the next step in this area of research.

The present study is most applicable to combined ventures in which significant learning and adaptation takes place. Thus, for example, it is less applicable to supply agreements that involve the exchange of a clearly defined product or service for a predetermined payment. The results of this study are most applicable to R&D alliances, joint ventures that are formed to penetrate new markets, mergers that hope to exploit potential synergies of resources and capabilities, and other similar combined ventures. One of the main assumptions that I made in this paper is bounded rationality which does not allow managers to write complete contracts. The effects of bounded rationality will be much more severe in the case of an R&D alliance than in the case of a supply agreement. By definition, R&D alliances engage in exploration of new, previously undiscovered opportunities. Such alliances are likely to be characterized by significant ambiguity and lack of *ex ante* knowledge about the course of action that will bring the desired benefits. Similarly, the ways to integrate two firms' resources into one company are difficult to predict in advance. Thus, these combined ventures will likely result in lengthy and complicated search and adaptation with unpredictable results.

CONCLUSION

The present paper was motivated to study the effects of interfirm dependence and intrafirm complexity on the optimal choice of decision-making structure in the absence of opportunism, I found that the internal complexity of the parties and the degree and asymmetry of interdependence between the parties affect the performance benefits of centralization of decision making. In particular, I found that more centralization is optimal when there is significant interdependence between the parties. However, performance benefits of centralization are more limited when this interdependence between the parties is asymmetrical or when the parties are internally complex. My study is based on formal computer simulations. Its validity is enhanced by the fact that it predicts and explains the relationship between broad diversification and tighter governance structures. This study also contributes to the theory of the firm by showing how interdependence between the two initially autonomous firms affects centralization of decision making even in the absence of opportunism.

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Essay 3: Interdependence, coordination, and firm performance in alliances: Insights from a simulation study

Introduction

Firms that enter a strategic alliance[5] can often choose how much they will coordinate their actions. Coordination can bring benefits such as better use of the partners' resources and capabilities and lower negative externalities (damage to each other's performance) that the partners might impose on each other. Closer coordination may also mean that one firm will have to forego some opportunities to improve its performance at the expense of its partner's performance. On the other hand, if the partners act largely independently and do not coordinate their actions much, they may be less likely to find a well-performing joint strategy and utilize their combined resources to the fullest. Lack of coordination may also result in significant negative externalities that the partners will impose on each other. Meanwhile, each firm will be relatively free to pursue any activities without being constrained by having to coordinate them with its partner or seek its partner's approval. This independence in decision making may result in better use of individual opportunities that the firm encounters. Therefore, alliance partners face tradeoffs when they decide on the amount and nature of coordination of their actions.

When will more coordination or more independent action be beneficial to a specific firm in an alliance? This question is often studied from the point of view of the whole alliance (e.g. Gulati & Singh, 1998; Gulati, 1998; Ireland, Hitt, & Vaidyanath, 2002; Gerwin, 2004; Aggarwal,

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[5] I chose to talk about alliances in Essay 3, not about combined ventures for the following reason. Essay 3 is about benefits at the level of individual parties while Essay 2 (where I used the term "combined ventures") is about benefits at the aggregate level. Arguably, parties in an alliance will be more interested in individual-level benefits than divisions in a single firm. This is why Essay 3 is most applicable to alliances. It may also be applicable to divisions in a single firm if the divisional managers' compensation is based on divisional performance.

Siggelkow, & Singh, 2011). More coordination is usually beneficial to the alliance as a whole because it allows for better use of the partners' resources and capabilities (Grant, 1991; Gulati, 1999) and greater value creation at the alliance level. More coordination may not be beneficial to an individual partner if this partner has to bear significant one-sided costs of coordination. Existing research does not say much about when coordination or independent action in alliances will be beneficial to a specific partner. Studying performance implications of coordination at the alliance level is important; however, managers of individual firms will also want to know the relative benefits of coordinated decision making vs. independent decision making for their firms.

Coordination in alliances is necessary because of interdependence of the partners. Interdependence is defined here as a situation when one partner's actions may affect the other partner's performance and vice versa. Intuitively, it seems clear that an alliance with more interdependence between the partners will require more centralized coordination, ceteris paribus (Nickerson and Zenger, 2004; Aggarwal, Siggelkow, & Singh, 2011). It is not as clear what conditions lead to greater benefits for the specific partner. Interdependence in alliances is not always symmetric. Does it benefit the focal firm to ally with a partner that is greatly dependent on the focal firm? Does the chosen mode of coordination between the partners affect the relationship? Existing theories do not provide answers to these questions.

This paper is an attempt to fill this theoretical void. Using agent-based simulations, I study an alliance between two interdependent firms. I am not concerned with why the firms enter the alliance and become interdependent. I treat interdependence as a given and study the process of interaction and search for strategies between two interdependent partners. I assume that the partners are boundedly rational (March and Simon, 1958) and engage in local search (Cyert and March, 1963) for a relatively long period of time in order to find a well-performing joint

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strategy. I model various decision-making structures (Sah and Stiglitz, 1986, 1988) as ways to coordinate the actions of the two partners. In this paper, a decision-making structure is defined as a set of rules that determine (1) who makes proposals and (2) the criteria to evaluate those proposals. The parameters of the model are the degree of dependence of the partners on each other and the various levels of internal partner complexity (Levinthal, 1997; Rivkin, 2000; Ganco and Agarwal, 2009). Internal complexity of a firm is defined as the number of interactions of its resources and activities. As stated earlier, partner dependence on each other refers to the extent to which their actions affect each other's performance. Partner complexity accounts for different possible internal structures of the partners. The dependent variable of the model is the performance of the focal firm as a function of partner dependence on the focal firm and the partner's internal complexity. The decision-making structure (DMS) is assumed to be a policy choice of the managers of the allying firms.

The findings show that the focal firm's performance under every DMS is negatively affected by the greater dependence of the partner on the focal firm. The effect of partner internal complexity on the performance of the focal firm is more complicated and depends on the chosen DMS. Finally, the effect of the DMS choice on the focal firm's performance depends on the structure of interdependence in the alliance and the internal complexities of the partners. In general, centralized decision making is the most beneficial for the focal firm; however, in some cases, it results in the worst performance of the focal firm.

Overall, the results suggest that there is a group of factors affecting firm performance in alliances that have not been studied before. These factors are rooted in the process of collaboration and search for a well-performing joint strategy under conditions of

interdependence. The results of this study are empirically testable and can be used as a first step in the program of research that will investigate the effects of those factors.

Dependence and interdependence in alliances

Many alliances are characterized by significant interdependence between the partners. Before proceeding with the analysis of performance implications of coordination, I would like to consider the concept of dependence and interdependence in greater detail.

According to Emerson (1962, p. 32), "A depends upon B if he aspires to goals or gratifications whose achievement is facilitated by appropriate actions on B's part." This definition makes three important assumptions: (1) A's goals are clear; (2) it is clear what actions B needs to take in order to facilitate or hinder the achievement of A's goals; (3) B can hurt A's performance without hurting its own performance. For example, if A needs a resource that B has and if this resource is difficult to substitute or obtain elsewhere, A will depend on B in the Emersonian sense. If B withholds the resource from A, it will complicate A's achievement of its goals. If B cannot sell the resource to anyone else but A, the situation becomes one of mutual dependence and the power differential diminishes or disappears.

The situation with resource dependence described above is an example of relatively simple dependence. Many modern alliances are much more complex. For example, the partners may form an alliance to develop a new product or technology. Such alliances are often characterized by significant reciprocal interdependence between the partners (Gulati and Singh, 1998). This interdependence means that each partner's actions may affect the other partner's immediate and or/long-term performance. However, this performance effect may be positive or

negative, so there is no clear-cut power relationship even if this interdependence is asymmetric. Each partner will have certain goals whose achievement may be facilitated by some actions of the other partner. It is usually unclear at the beginning precisely what actions need to be taken by each partner to achieve those goals. Emersonian power-dependence relationships can only exist when one partner knows what it needs to do to hurt the other partner without hurting itself as much in the process. Modern technologies and business systems are often very complex, with many interacting resources, activities, and decisions needed to achieve the goals of the alliance and of each partner. The complexity of the interactions in many alliances may present many situations in which it is unclear what one partner needs to do to improve or damage the performance of the other partner. While the partners may be interdependent, they may not have clearly defined means to improve or damage each other's performance. Thus, power differentials may not exist even when the alliance is characterized by asymmetric interdependence.

An example of different approaches to interdependence is provided by the U.S. auto manufacturers vs. Toyota. Traditionally, U.S. auto manufacturers have used many suppliers while maintaining low dependence on any one of them. The goal of such an arrangement was to play the suppliers against one another to squeeze profits from them. Since the U.S. auto manufacturers have low dependence on any one supplier, they can easily switch suppliers. Toyota, on the other hand, has traditionally worked with just a few suppliers. As a result, Toyota is much more dependent on its suppliers. Nevertheless, Toyota's relationships with its suppliers are quite successful. Working more closely with its suppliers, Toyota is better positioned to address quality issues and make sure that the suppliers have the right parts necessary for Toyota's new vehicles.

Individual costs and benefits

An alliance in which the partners are strongly interdependent is likely to be characterized by significant coordination needs (Nickerson and Zenger, 2004). When the partners have to coordinate their actions, each one of them may incur individual costs or enjoy individual benefits. These costs and benefits are side-effects of coordination under interdependence. They are conceptually different from private benefits (Khanna, Gulati, & Nohria, 1998). Private benefits exist when one firm picks up knowledge and skills from its partner and applies them to activities unrelated to the alliance. Individual costs and benefits of coordination occur when one partner's actions affect the other's performance or when one partner has to forego some opportunities because the other partner vetoes some of its proposals.

While it is intuitively clear how such individual costs and benefits may occur, it is more difficult to predict based on extant theories when they will be positive or negative. Existing theories of alliances are silent about the effects of asymmetric interdependence without power differentials on the performance of the focal firm. Such theories as resource dependence theory (RDT; Pfeffer & Salancik, 1978; Casciaro & Piskorski, 2005) and transaction cost economics (TCE; Williamson, 1985; Hennart, 1988) do not apply to cases when there are no power differentials or opportunism. As has been argued before, asymmetric interdependence may not necessarily entail power differentials; besides, not all alliances are characterized by deliberate use of power differentials or opportunism. The asymmetric gains to alliance partners caused by asymmetries in dependence or internal complexity may exist independently of the problems of resource dependence or transaction costs. The cause of asymmetric gains studied in this paper is bounded rationality of the decision makers (March & Simon, 1958). Trust and relational governance may remedy some problems of resource dependence and transaction costs but not the

coordination problems caused by bounded rationality of the decision makers and great complexity of modern business systems and technology.

Performance effects of partner complexity

Another factor that may affect the performance of the focal firm in an alliance is the internal complexity of its partner. The idea of firm complexity was developed by Herbert Simon (1962). Simon suggested that the presence of multiple interactions of resources and activities within the firm makes the problem of managing this firm complicated. Modifying one resource or activity may affect many other resources or activities, which would in turn necessitate their adjustment. A firm with multiple interactions among its resources and activities is called complex. A firm of the same size with few interactions among its resources and activities is called simple.

The importance of partner complexity for the performance of the focal firm in an alliance stems from the following condition. Firms participating in an alliance may be unable to separate their "alliance" parts from the rest of their operations. Such separation was suggested by Hennart (2006) as a way to make an alliance more stable and manageable[6]. The likelihood of a successful separation diminishes with the growing complexity of the firm. If a firm's resources and activities interact densely to create value, its "alliance" part may be connected to the rest of the firm with many links. Breaking these links would be impossible without severely impairing the firm's capabilities (Collis, 1994). An action or decision of the focal firm may affect only a small part of the activities within its partner. If these activities are densely interconnected with the rest

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[6] It could be argued that firm A could simply sell its assets to firm B if those assets were independent from the rest of firm A's operations. This course of action assumes that the transaction costs of selling the assets will be negligible. If the transaction costs are significant (e.g. due to the tacitness of these assets), it may be optimal for the firms to form a joint venture instead of selling the assets.

of the partner's operations, it will have to reorganize a lot of its other activities and resources. This reorganization may in turn affect the performance of the focal firm because of interdependence between the partners. Such a chain reaction of adjustments may not occur if the partner is simple. Thus, the complexity of the partner may affect the focal firm's performance.

There is no theory that would suggest how the partner's complexity might affect the focal firm's performance. The growing literature on complexity and its effects on optimal search strategies (e.g. Levinthal, 1997; Rivkin, 2000; Rivkin & Siggelkow, 2003; Ethiraj & Levinthal, 2004) has made significant discoveries about the effects of firm complexity on its own performance. However, no studies have investigated the effect of firm complexity on its partner's performance. The study of this effect is the second goal of this paper.

Decision-making structures in alliances

The partners in an alliance can choose the degree and mode of coordination by choosing a specific decision-making structure (DMS; Sah and Stiglitz, 1986, 1988). A DMS is a set of rules that determine who makes decisions and how those decisions are made (Stiglitz, 1989, 1991). In this essay, a DMS is defined as the rules that determine (1) who makes proposals and (2) the criteria for evaluating these proposals. Conceptually, all decision-making structures can be placed along a continuum whose extreme ends are fully decentralized decision making and fully centralized decision making. Some alliances may use decentralized decision making, in which the proposals are evaluated based on their impact on the performance of the proposing firm without regard to the performance of the other partner or the entire alliance. Other alliances may use an alliance-centric (centralized) DMS which will evaluate proposals based on the performance of the entire alliance, ignoring the immediate interests of the partners (such a

decision-making structure is likely to be based on mutual forbearance and trust). Still other alliances may use a combined DMS, in which the proposed action will be evaluated based both on the performance of the proposing firm and the performance of the entire alliance.

While it is intuitively clear that employing different DMS will likely affect the performance of the focal firm in different ways, it is more difficult to predict the effects of DMS choice on the focal firm's performance based on theoretical reasoning. Maximizing individual gains may come at the price of lower alliance performance. Maximizing alliance performance may restrict the focal firm's independent actions and impose opportunity costs on the focal firm. It is worth noting here that DMS choice is not synonymous with the choice of a communication structure. The partners may communicate and share information freely under a decentralized DMS. Yet when it is the time to take action, each one of them may consider its own performance as the sole criterion. If the partners trust each other, they may allow each other to take such independent action. As the results of my simulations will suggest, it may be rational for the partners not to consider each other's immediate interests when making decisions. Arguably, such a DMS needs plenty of trust to function smoothly.

The effect of the chosen DMS on the performance of the focal firm will likely depend on the structural characteristics of the alliance (Hennart, 2006). The degree and asymmetry of interdependence between the partners will affect the costs and benefits of independent vs. coordinated action. The partners' internal complexity will affect their behavior (Levinthal, 1997) which in turn will affect the focal firm's performance if it is dependent on the partner. As in the case of DMS choice, it is difficult to predict conceptually the effects of interdependence and partner complexity on the focal firm's performance. Let us consider the following hypothetical example.

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Firm A needs a partner in developing a new computer game. Both firms B and C have computer graphics technologies that could be used in the development process. B's technology is simple: it consists of a few modules that weakly interact with one another. C's technology is complex: it consists of many modules that densely interact with one another. If A chooses B as the partner, A's actions may result in less "radical" responses by B because B will be able to fine-tune its technology module-by-module. If A chooses C as a partner, C may have to engage in broader system redesign following some of A's actions. Such "radical" responses by C may affect A's performance in negative ways if A is greatly dependent on C. Uncovering these effects of partner complexity and dependence on the focal firm is the goal of this paper. Complex systems such as alliances often exhibit surprising behavior even when they follow a few simple rules (Holland, 1992). This unpredictability of outcomes in alliances may be one reason why so many alliances fail (Park and Ungson, 2001). Thus, obtaining some results concerning the effects of these three factors may be a first step toward incorporating complexity into the theory of alliances.

Research questions

In this study, I am aiming to find answers to the following questions:

1. How does the partner's dependence on the focal firm affect the focal firm's performance?

2. How does the partner's complexity affect the focal firm's performance?

3. How does the choice of a DMS affect the focal firm's performance? In particular, how does DMS choice affect the relationships in questions (1) and (2)?

The model

In order to find answers to the research questions, I ran a series of computer simulations using a variant of the NK[C] modeling technique (Kauffman, 1993; Ethiraj & Levinthal, 2004; Ganco & Agarwal, 2009). The choice of simulations as my research method was dictated by a few reasons. First, simulation-based research is a useful method of theory development (Davis, Eisenhardt, & Bingham, 2007). It is especially useful when data collection is difficult, measurement of the key constructs is a problem, and there is little theory to generate empirically testable hypotheses. Second, simulation methods allow researchers to isolate the phenomenon of interest and study its effects without contamination from confounding factors. Finally, simulation results can be compared to prior empirical findings. If simulation results allow researchers to explain previously unexplained phenomena, their value is enhanced.

My implementation of the NK[C] model is similar to the previous implementations in the literature with a few differences. I will describe my implementation of the model and highlight its differences from the previous implementations.

NK[C] models represent firms as vectors of interdependent decisions. This aspect of NK[C] models makes them especially suitable for studying interactions of decisions within and between firms, which is the main theme of this paper. K and C are the most important parameters of the model. Varying these parameters, I was able to model differences in the firms' interdependence and internal complexity. Below is a description of all parameters of the model.

Parameter N represents the size of the entire alliance. In my models, the size of a firm is the number of decisions that this firm controls. For example, if partner 1 controls six decisions and partner 2 controls six decisions, the size of the alliance is therefore N = 12. The sizes of the two partners can be equal or non-equal. I modeled both equal and non-equal sizes to make sure

that my results are robust to differences in firm sizes. The overall size of the alliance in the

model (the value of N) is not very important. Even small values (for example, six – see Rivkin &

Siggelkow, 2003) provide for meaningful variation and overall complexity of the model.

Therefore, I chose to model the alliance of size N = 12. This value of N is in line with the

majority of research that has used NK[C] models in the past (e.g. Gavetti & Levinthal, 2000;

Siggelkow & Rivkin, 2006; Ganco & Agarwal, 2009). Much greater values of N reduce variation

in the performance of the firms and exponentially increase computing time without providing

any substantial new insights.

The decisions that each partner controls are assumed to be binary. This assumption is a

realistic representation of reality. Managers often decide whether to switch suppliers or not;

whether to introduce a new compensation scheme or leave the old scheme in place; whether to

buy a new technology or develop it internally; whether to use the new technology at all or keep

perfecting the old technology; etc. In addition, the binary nature of decisions does not limit the

generalizability of the results of NK[C] simulations (Levinthal, 1997).

Parameter K represents the internal complexity of a firm. Formally, K is the number of

internal decisions of the firm that affect the payoff to any particular decision. For example, if the

payoff to a decision is not affected by any other decisions, the value of K is zero. I called such a

firm "simple." When the value of K is greater than zero, the firm is more complex. For example,

when K equals two, each decision's payoff depends not only on the decision itself, but also on

two other decisions that the focal firm has made. The greatest possible value of K is N-1. When

K = N-1, the payoff to each decision depends on all the decisions that the firm has made. When

K = N-1, the complexity of the firm is the highest possible for a firm of this size. The intuition

behind calling the firm "simple" or "complex" depending on the value of K is as follows. Low

values of K mean that decisions are largely independent. When K equals zero, the firm's managers can make each decision separately because none of the decisions affect each other's payoffs. The task of managing such a firm becomes relatively simple. When K is greater than zero, interactions among decisions are present. In order to make one optimal decision, managers have to optimize K other decisions simultaneously. The problem of finding optimal decisions quickly becomes mathematically intractable even at relatively small values of K (Rivkin, 2000). Thus, managers face much more complex problems when K increases. Decision making becomes the most complex when K reaches the maximum possible value of N-1.

Considering the fact that there are two firms in my models, I used two values of K: K_1 and K_2. They correspond to internal complexities of partner 1 and partner 2, correspondingly.

Parameter C represents the interdependence between the partners after they form an alliance. Here I depart from the ways C was operationalized in Kauffman (1993) or Ganco & Agarwal (2009). In order to simplify the model and capture all the possible variation, I let C denote the total number of dependences of payoffs of the decisions of one partner on the decisions of the other partner. For example, if C equals two, it means that there are two different instances when some decision of partner 2 affects the payoff to some decision(s) of partner 1.

There could be two different values of C: C_1 and C_2. C_1 is the number of dependences of payoffs to decisions of firm 1 on decisions of firm 2 (upper right quadrant); C_2 is the number of dependences of payoffs to decisions of firm 2 on decisions of firm 1 (lower left quadrant). In general, C_1 and C_2 do not have to be equal. If C_1 is greater than C_2, it means that partner 1 is relatively more dependent on partner 2 than vice versa. The minimum possible value of C_1 and C_2 is zero, which would mean that one partner's performance is completely independent of

anything that the other partner does. I modeled the values of C_1 and C_2 from 1 to N_1 times N_2

(the maximum possible value of C_1 and C_2).

In my simulations, I allowed each parameter (K_1, K_2, C_1, C_2) to vary over the entire range

of possible values. K_1 (K_2) varies from 0 to N_1-1 (N_2-1). C_1 and C_2 vary from 0 to N_1*N_2. My

simulations thus cover all possible parameter combinations.

Now I would like to show how the parameters correspond to the research questions that I

formulated earlier. Research Question 1 asked how the degree of dependence of partner 2 on the

focal firm affected the performance of the focal firm. To answer this question, I will be looking

at the effect of parameter C_2 on the performance of the focal firm. Research Question 2 asked

how the internal complexity of partner 2 affected the performance of the focal firm. To answer

this question, I will be looking at the effect of parameter K_2 on the performance of the focal firm.

Finally, Research Question 3 asked how the chosen decision-making structure affected the

performance of the focal firm. To answer this question, I will vary the chosen DMS and observe

its effect on the performance of the focal firm.

Calculation of the performance of the partners and the alliance

Following previous research (e.g. Levinthal, 1997, Rivkin, 2000; Rivkin & Siggelkow, 2003), I

calculated the performance of the partners and the alliance as follows. At the start of each

simulation run, I assigned a random value from the uniform distribution U[0,1] to each possible

combination of decisions of the two partners. These values were stored in a large array. During

simulation runs, the performance contribution of each decision was taken from this array.

Consider the situation in Fig. 2. The payoff to decision 3 of partner 2 depends on this decision as

well as on decisions 2 and 3 of partner 1. Given the binary nature of the decisions, there are eight

(2^3) possible combinations of those decisions. Thus, the program accessed one of eight randomly

generated numbers depending on the values of the decisions. The resulting number was the

payoff to decision 3 of partner 2 considering the values of decisions 2 and 3 of partner 1. Payoffs

to all the decisions of each firm were computed in this manner. The program always explicitly

considered all interactions of decisions. The performance of each partner was calculated as a

simple average of payoffs to all decisions. Formally, $P_j = (\Sigma_{ij}D_{ij} (D_{11}, \ldots D_{N1,1}, D_{12}, \ldots, D_{N2,2}))/Nj$, where P_j is the performance of partner j; D_{ij} is the payoff to decision i of partner j

considering its dependence on other decisions made by the partners; Nj is the size of partner j.

The performance of the alliance was calculated similarly. The program calculated the

performance of the combined venture as if it were one big firm. Mathematically, the performance

of the combined venture was a weighted average of the performance values of the two partners

considering their size.

The behavior of the partners and search for strategies

When there are multiple interactions of decisions within and between the partners, the best-

performing combination of decisions is difficult to find (Levinthal, 1997; Gavetti and Levinthal,

2000). Given my assumption of bounded rationality of the decision makers, the partners were

forced to engage in local search. Local search was implemented as varying one decision at a

time. At each step of the search process, the partners took turns performing the following

procedure. One partner chose one decision at random and flipped this decision's value (from

zero to one or from one to zero). Then the program calculated the performance of each partner

and of the entire alliance after this change. Depending on the decision-making structure adopted for this simulation run, the change was either accepted or rejected. The partners took turns in offering such proposals of change. When the performance of the partners and the alliance had stopped improving, the program recorded this achieved long-term performance value. The program performed 10,000 simulation runs with each possible set of parameter values.

Implementation of decision-making structures

Each decision-making structure was implemented as a set of rules that specified how the decision was allowed to affect the performance of the partners and the alliance. In the decentralized decision-making structure, the partners took turns offering proposals. A proposed change was accepted if it improved the performance of the proposing partner without regard to its effect on the performance of the other partner. In consensus-based decision-making structures, the partners took turns offering proposals. A proposed change was accepted if it improved the performance of the proposing partner and did not decrease the performance of the alliance. In the centralized decision-making structure, the partners took turns offering proposals. A proposed change was accepted if it improved the performance of the alliance. The difference between the consensus-based structure and the centralized structure lies in their treatment of the performance of individual partners. The centralized structure does not concern itself with the performance of either partner: the only criterion for evaluating proposals is the performance of the entire alliance. Under the consensus-based structure, the performance of the proposing firm is an important criterion for evaluating a proposal. Under the centralized structure, the proposing firm may suggest an action that hurts its own immediate performance. Such altruism may seem

improbable outside a merger, yet it is still possible. For example, in the case of an equity joint venture, the partners may be chiefly concerned with maximizing the performance of the entire venture. It may be rational for each one to be willing to take small, temporary losses if they lead to large, long-term gains. In addition, the partners may have developed significant trust in each other, e.g. as a result of repeated collaboration (Gulati, 1995). Not only might they be willing to sacrifice their immediate performance for large long-term gain of the whole alliance, but they might also have the means of coordinating their actions via more complete contracts (Poppo and Zenger, 2002). As a result, the partners may have the contractual means of ensuring that one partner's sacrifice for the common gain will be compensated.

Results

In order to answer the research questions, let us examine the following graphs. In each graph presented in this paper, the potential performance values of the focal firm run from 0 to 1000. Each graph only shows part of this range in order to make the result more visually salient.

Each graph is to be interpreted as follows: the graphs show expected long-run performance of the focal firm under different scenarios. Each bar in the graphs represents a different alliance with a specific set of parameters.
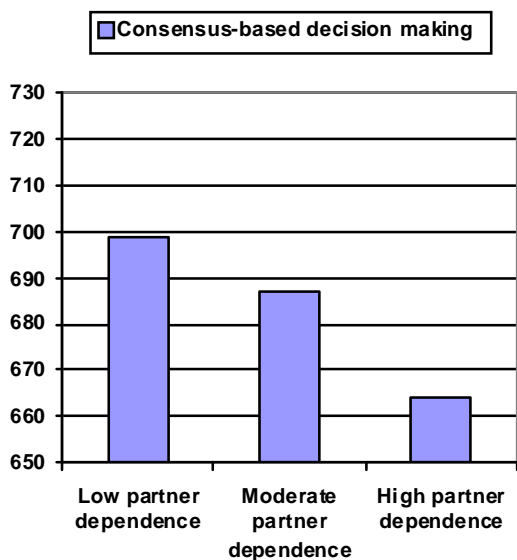
## The effects of partner dependence on the focal firm's performance

Figure 6: Performance of the focal firm as a function of partner dependence in the case of decentralized decision making. Each firm is moderately complex (K1 = K2 = 2). The focal firm is moderately dependent on its partner (C1 = 10). The parameter that changes is the dependence of the partner on the focal firm.
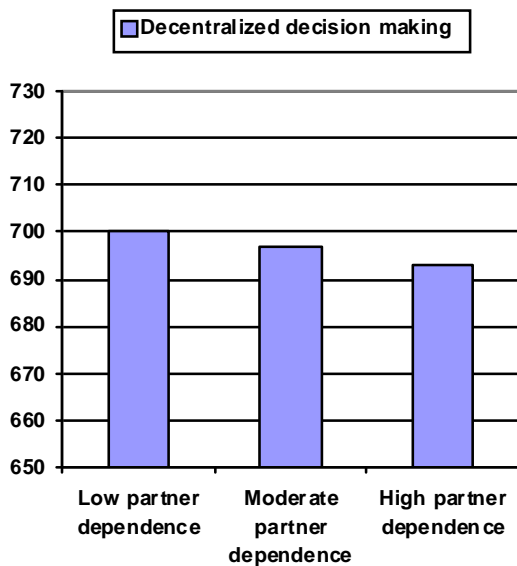
Figure 7: Performance of the focal firm as a function of partner dependence in the case of consensus-based decision making. Each firm is moderately complex (K1 = K2 = 2). The focal firm is moderately dependent on its partner (C1 = 10). The parameter that changes is the dependence of the partner on the focal firm.

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Figure 8: Performance of the focal firm as a function of partner dependence in the case of centralized decision making. Each firm is moderately complex (K1 = K2 = 2). The focal firm is moderately dependent on its partner (C1 = 10). The parameter that changes is the dependence of the partner on the focal firm.
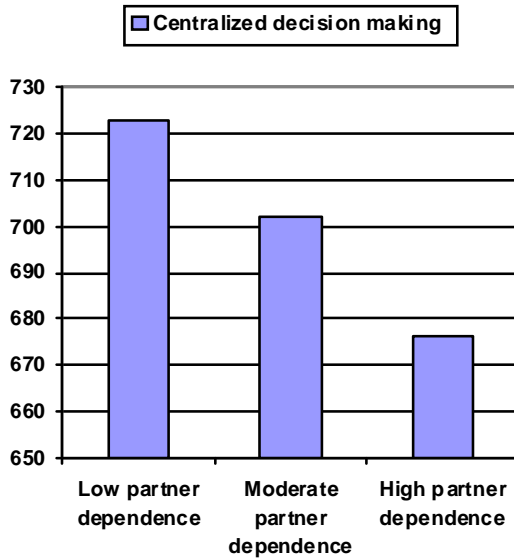
In all three graphs, the performance of the focal firm declines when the partner's dependence on the focal firm grows. For example, in Fig. 6, the focal firm's performance is 700 when its partner's dependence on the focal firm is low. When the partner's dependence on the focal firm is moderate, the focal firm's performance declines to 697 (a small but significant decline). And when the same focal firm allies with a partner that is significantly dependent on the focal firm, its performance is only 693. Thus, allying with more dependent partners under decentralized decision making, the focal firm loses up to seven points in performance, ceteris paribus. Similar but more pronounced dynamics are observable under other decision-making structures. According to Fig. 7, this difference in performance increases to 35 points when the alliance is using the consensus-based decision-making structure. Finally, in the case of a centralized decision-making structure, the focal firm loses 47 points allying with a partner that is highly

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dependent on the focal firm compared to the baseline case of allying with a partner that has low dependence on the focal firm (Fig. 8).

This result is unexpected from the point of view of existing theories. Neither RDT nor TCE can explain it. In fact, we might expect increased performance of the focal firm as a result of increased partner dependence on the focal firm. The negative effect of partner dependence on the focal firm's performance requires an explanation within the theoretical framework of complexity used in this paper.

I would like to begin the explanation with the most straightforward case: the consensus-based decision-making structure (Fig. 7). It will be recalled that under consensus-based decision making, each proposal was evaluated according to two criteria: (1) its effect on the performance of the proposing partner; (2) its effect on the performance of the entire alliance. The performance of the entire alliance was conceptualized as the sum total of the performance values of both partners. Thus, according to criteria (1) and (2), any proposal was accepted if it improved the performance of the proposing partner by more than the loss to the other partner. Weak partner dependence on the focal firm meant that the focal firm's actions did not affect the partner's performance much. In this case, the focal firm was relatively free to make decisions without consulting with its partner. If the focal firm allied with a partner that was significantly dependent on the focal firm, the partner's performance was often affected when the focal firm proposed an action. Quite often, the partner's performance would be negatively affected by the focal firm's actions, and the size of this loss would be greater than the gain to the focal firm. Thus, such proposals were vetoed and the focal firm suffered opportunity costs because it had to forego an opportunity to improve its performance. The more dependent its partner became, the more often

such a situation occurred and the more often the focal firm suffered opportunity costs. Thus, the focal firm's performance was lower when the partner was more dependent on the focal firm.

A similar logic applies in the case of centralized decision making (Fig. 8). Under centralized decision making, a proposal was accepted if it improved the performance of the entire alliance regardless of its effects on the performance of the individual partners. If the partner had low dependence on the focal firm, it was often possible to improve the performance of the focal firm without affecting the performance of the partner much. As a result, the performance of the entire alliance improved and the proposed change was implemented. When the partner was significantly dependent on the focal firm, many decisions that would have resulted in performance gains for the focal firm would also have decreased the partner's performance by a significant value. Often, this drop in the partner's performance was greater than the gain in the performance of the focal firm, and the performance of the entire alliance would suffer. As a result, such a change was vetoed and the focal firm suffered an opportunity cost. The greater the partner's dependence on the focal firm, the more often the focal firm suffered opportunity costs and the lower was its performance.

Now let us consider the most challenging case: the decentralized DMS. As Fig. 6 shows, the focal firm's performance was negatively affected by allying with a partner that was heavily dependent on the focal firm. The principal difference between the decentralized DMS and the other DMS's is the lack of coordination between the partners in the decentralized structure. Under decentralized decision making, each firm was free to make any decisions and take any actions. This means that each firm only tried to improve its own performance without regard to the externalities it would impose on its partner. The logic that I used to explain performance drops in the case of consensus-based and centralized DMS does not apply here. Each firm was

free to pursue any opportunity without consulting with its partner. Thus, there were no opportunity costs. When the focal firm made a decision that affected its partner's performance, this action forced the partner to react and adjust its strategy and operations. The more dependent the partner was on the focal firm, the more it was affected by the focal firm's actions and the more it had to do to compensate for those actions. Considering the fact that the focal firm was also dependent on its partner, the partner's response also affected the focal firm's performance. This effect was more often negative than positive because the firms were in essence disrupting each other's adaptation. Thus, the focal firm's long-run performance suffered when its partner was heavily dependent on the focal firm.

To test this logic, let us conduct the following experiment. The focal firm's performance was negatively affected by its partner's dependence because the focal firm was also significantly dependent on the partner. Following this logic, we would expect this effect to diminish or disappear if the focal firm's dependence on its partner was minimal. To illustrate this effect, let us consider Fig. 9 where the focal firm's dependence on its partner is low.

Figure 9: Performance of the focal firm as a function of partner dependence in the case of decentralized decision making. Each firm is moderately complex ($K1 = K2 = 2$). The focal firm's dependence on its partner is low ($C1 = 2$). The parameter that changes is the dependence of the partner on the focal firm.
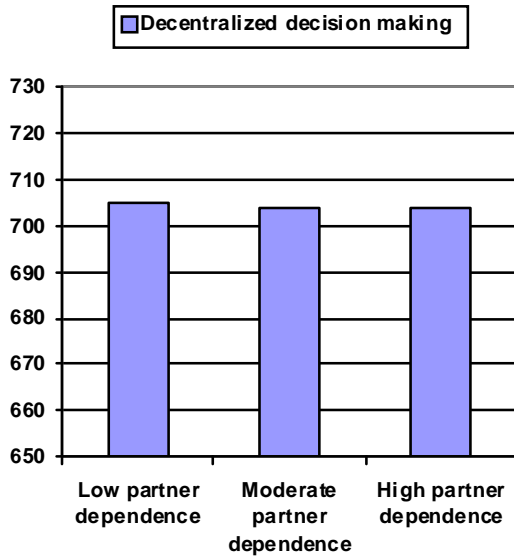

Fig. 9 confirms the reasoning provided previously. The main cause of diminished performance of the focal firm under decentralized decision making when its partner is highly dependent on the focal firm is the dependence of the focal firm on the partner.

Interestingly, another confirmation of this logic comes from Fig. 10. In Fig. 10, the focal firm also has low dependence on its partner. The difference between Figs. 9 and 10 is the DMS: In Fig. 9, the partners employ decentralized decision making while in Fig. 10 they employ consensus-based decision making. We can see that in Fig. 10 the focal firm's performance follows the now familiar pattern, declining with an increase in its partner's dependence on the focal firm. The performance of the focal firm when its partner has low dependence on the focal firm is 703. The performance of the focal firm when its partner is highly dependent on the focal firm is 682. Thus, the focal firm loses 21 points in performance from allying with a highly dependent partner compared to the baseline case of allying with a low-dependent partner. It will

be recalled that this difference was 35 points when the focal firm was moderately but significantly dependent on its partner (see Fig. 8). Thus, the negative effect of partner dependence on the focal firm's performance is a sum of two separate effects: (1) The opportunity costs stemming from the fact that the focal firm often foregoes opportunities to improve its performance due to their negative impact on the partner's performance; (2) The negative externalities that the partner's actions impose on the focal firm's performance.

Figure 10: Performance of the focal firm as a function of partner dependence in the case of consensus-based decision making. Each firm is moderately complex (K1 = K2 = 2). The focal firm's dependence on its partner is low (C1 = 2). The parameter that changes is the dependence of the partner on the focal firm.
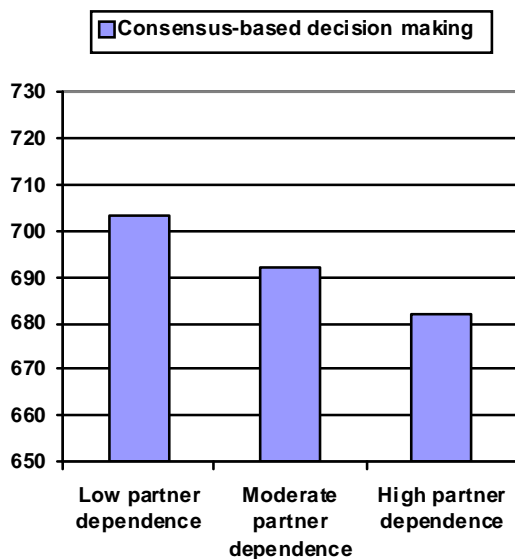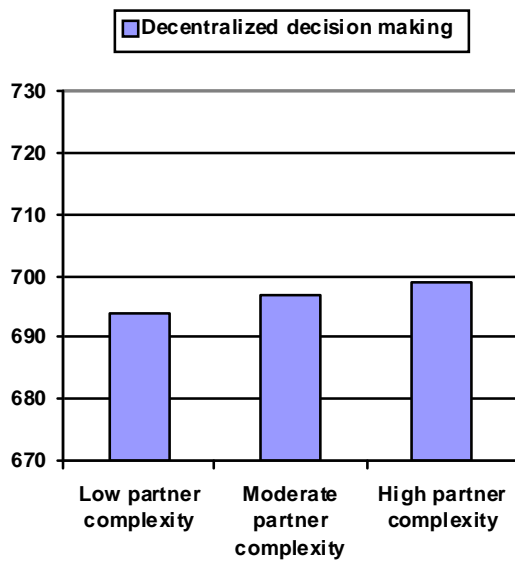

The effects of partner complexity on the focal firm's performance

In order to answer Research Question 2, let us examine the following graphs. Each one shows the performance of the focal firm as a function of its partner's complexity while keeping

interdependence between the partners constant. It will be recalled that each bar represents a

separate alliance with a specific set of parameters.

Figure 11: Performance of the focal firm as a function of partner complexity in the case of decentralized decision making. The focal firm is moderately complex ($K1 = 2$). Both partners are moderately dependent on each other ($C1 = C2 = 10$). The parameter that changes is the internal complexity of the partner.

Figure 12: Performance of the focal firm as a function of partner complexity in the case of consensus-based decision making. The focal firm is moderately complex (K1 = 2). Both partners are moderately dependent on each other (C1 = C2 = 10). The parameter that changes is the internal complexity of the partner.
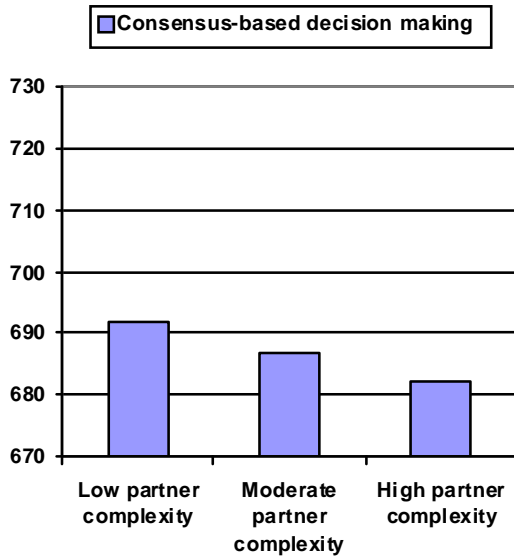
Figure 13: Performance of the focal firm as a function of partner complexity in the case of centralized decision making. The focal firm is moderately complex (K1 = 2). Both partners are moderately dependent on each other (C1 = C2 = 10). The parameter that changes is the internal complexity of the partner.
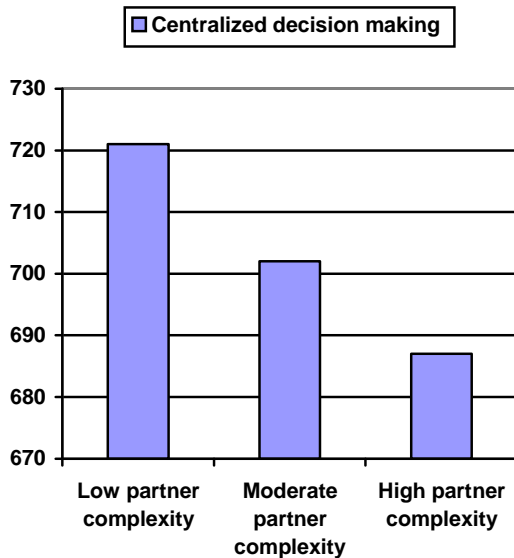
Figs. 11-13 show that the performance of the focal firm is affected by its partner's complexity. However, the direction and magnitude of this effect depend on the chosen decision-making structure. In the case of a decentralized DMS (Fig. 11), the performance of the focal firm is positively affected by its partner's complexity. In the case of a consensus-based DMS and centralized DMS (Figs. 12 and 13, respectively), the performance of the focal firm is negatively affected by its partner's complexity. The negative effect is most pronounced in the case of a centralized DMS (34 points in Fig. 13). The negative effect in the case of a consensus-based DMS is ten points (Fig. 12).

The difference in the sign and magnitude of the effect of partner complexity on the performance of the focal firm deserves an explanation. I would like to start with explaining the highly negative effect under a centralized DMS (Fig. 13). It will be recalled that under centralized decision making, all decisions were made in the interests of the entire alliance without any regard to the effect of those decisions on the individual performance of either partner. Greater internal complexity of the partner means that it has a larger number of potentially high-performing combinations of activities and decisions (Levinthal, 1997). Also, the performance differences among those combinations of decisions tend to be greater in a highly complex partner (Levinthal, 1997). As a result, it makes sense to concentrate the search for well-performing strategies on the more complex partner. The less complex focal firm serves as an assistant in this process and bears individual costs of coordination, which tend to be lower than the gains of the more complex partner. The question of whether the focal firm will be compensated for this sacrifice is beyond the results of these simulations[7].

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[7] For example, the partners may agree on side payments to compensate one another for temporary losses in individual performance. It may be difficult to set up such a compensation scheme if the gains and losses of each party are not perfectly measurable. Firms may also enter an alliance with the goal of maximizing their own performance, not the joint gains.

Next, let us consider the case of a consensus-based DMS (Fig. 12). It will be recalled that under consensus-based decision-making, each partner can only proceed with an action if it (1) improves the performance of the focal firm and (2) does not damage the performance of the entire alliance. If the partner is highly complex, it can often find a change that will improve its own performance significantly while decreasing the performance of the focal firm by a smaller margin. According to the rules of the consensus-based DMS, the partner will proceed with this action. Thus, the focal firm will bear the cost of coordination while allowing its partner to improve the partner's performance.

Finally, let us consider the case of a decentralized DMS (Fig. 11). Under this DMS, each firm is free to take any action that improves its own performance without regard to the performance of its partner. According to Fig. 8, the focal firm actually gains from allying with a highly complex partner, as opposed to the cases of consensus-based and centralized decision making. This gain is small (five points) but significant. Let us compare the performance of the focal firm under the decentralized and consensus-based DMS (Figs. 11 and 12). When its partner's complexity is low, the focal firm's performance is virtually equal under both DMS: 694 under the decentralized DMS and 692 under the consensus-based DMS. When the partner is moderately complex, the focal firm performs better under the decentralized DMS than under the consensus-based DMS (697 vs. 687). Finally, when the partner is highly complex, the focal firm under the decentralized DMS performs much better than the focal firm under the consensus-based DMS (699 vs. 682). These performance differentials hold a clue to the answer. When the partner is complex, it faces potentially many different well-performing combinations of activities and decisions. As a result, such a partner will engage in more intensive search for a well-performing strategy and will often make changes to its activities. The focal firm is dependent on

its partner, which means that its performance will be affected by its partner's search. The partner's actions may disrupt the focal firm's short-term performance but at the same time they may open up new opportunities for development and thereby help the focal firm improve its long-term performance. This effect is similar to escape from a competency trap (Siggelkow and Levinthal, 2005). A competency trap is a situation in which the firm has converged on a locally optimal strategy that is globally suboptimal. The focal firm will be unable to break out of the competency trap until its structure of payoffs changes. Such a change may occur due to environmental changes or actions of its partner. Escapes from competency traps will be more limited under the consensus-based DMS. Many of the partner's proposals under consensus-based decision making will be rejected by the focal firm precisely because they lead to significant 0short-term declines in the performance of the focal firm. This result resolves a seeming paradox and presents one more reason why relational, trust-based governance in alliance is beneficial (Krishnan, Martin, & Noorderhaven, 2006). When the partners trust each other, they may be willing to take small temporary losses because they know that a larger long-term gain will likely follow.

The effects of the chosen DMS on the focal firm's performance

The previous discussion has shown how the chosen DMS affects the relationships between the partner's complexity and the focal firm's performance and between the partner's dependence on the focal firm and the focal firm's performance. I would like to present the main effect of the chosen DMS on the focal firm's performance. Let us consider the graphs in Figs. 14-16.

Figure 14: Performance of the focal firm as a function of the chosen DMS. The focal firm and its partner are moderately complex ($K1 = K2 = 2$). Both partners are moderately dependent on each other ($C1 = C2 = 10$). The parameter that changes is the chosen DMS.

Moderate complexity; moderate interdependence
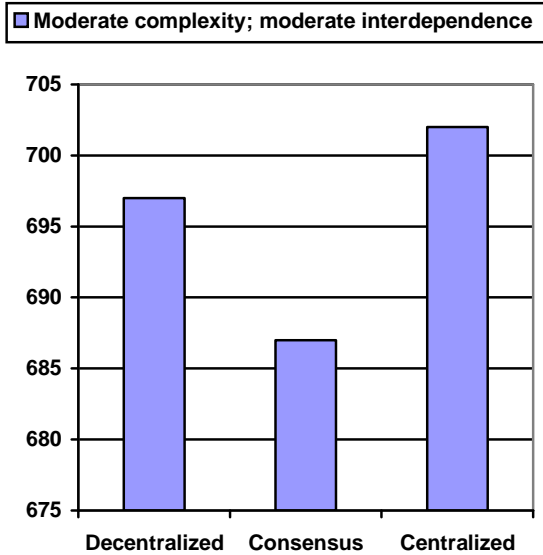
Figure 15: Performance of the focal firm as a function of the chosen DMS. The focal firm and its partner are moderately complex ($K1 = K2 = 2$). Both partners have low dependence on each other ($C1 = C2 = 2$). The parameter that changes is the chosen DMS.
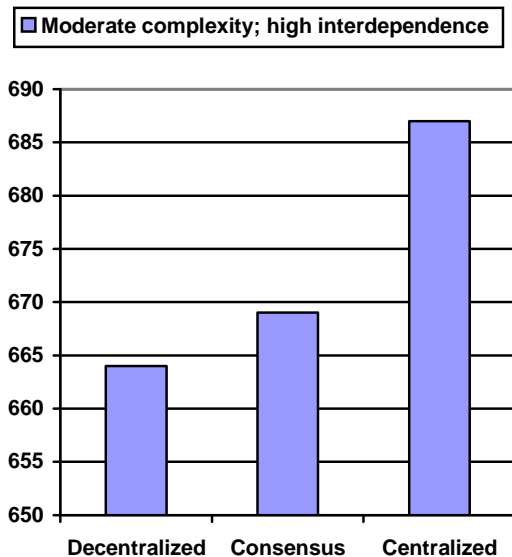

Moderate complexity; low interdependence
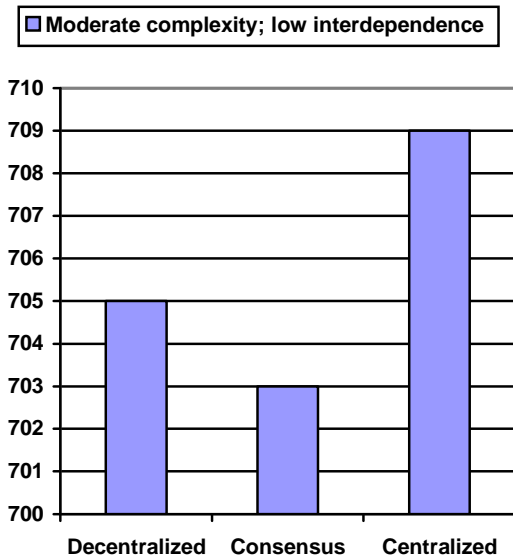
Figure 16: Performance of the focal firm as a function of the chosen DMS. The focal firm and its partner are moderately complex ($K1 = K2 = 2$). Both partners are strongly dependent on each other ($C1 = C2 = 25$). The parameter that changes is the chosen DMS.

Figs. 14-16 demonstrate non-linear effects of DMS choice. Under moderate and low interdependence (Figs. 14 and 15), the focal firm performs the worst under a consensus-based DMS. The decentralized DMS brings small but positive performance benefits to the focal firm, while the centralized DMS brings the best performance to the focal firm. When the two partners are highly interdependent (Fig. 16), the focal firm performs the worst under the decentralized DMS, somewhat better under the consensus-based DMS, and much better under the centralized DMS. These results show the contingent benefits of consensus-seeking and decentralization. In many alliances where the partners are not very strongly interdependent, decentralization may be better for the focal firm than consensus-based coordination. However, if the partners are strongly interdependent, the best they can do is forego any individual interests and concentrate on the performance of the entire alliance.

Robustness of the results

In order to check whether the results hold over a wide variety of parameters, I ran the simulations with all possible combinations of values of parameters K1, K2, C1, C2, and DMS. Table 1 shows the long-run performance of the focal firm for various parameter combinations under different DMS. Overall, the pattern of the results is the same as reported above. The effect size tends to be the strongest at high levels of dependence between the partners and low levels of complexity of the focal firm.

Table 6: Long-run performance of the focal firm. First number in each cell: Decentralized DMS. Second number in each cell: Consensus-based DMS. Third number in each cell: Centralized DMS.

	C1=2 C2=2	C1=2 C2=10	C1=2 C2=25	C1=10 C2=2	C1=10 C2=10	C1=10 C2=25	C1=25 C2=2	C1=25 C2=10	C1=25 C2=25
K1=0 K2=0	668 666 673	665 663 649	661 658 635	664 666 717	655 659 695	645 647 673	658 671 739	635 672 718	609 666 701
K1=0 K2=2	666 665 667	667 662 640	665 652 628	664 666 698	664 655 670	658 629 647	663 671 720	649 664 695	628 640 673
K1=0 K2=5	665 666 663	666 658 635	667 647 622	666 664 682	665 649 647	665 618 623	665 669 700	661 655 668	649 625 644
K1=2 K2=0	705 702 717	704 695 697	702 688 675	699 699 739	694 692 721	685 674 698	695 701 741	676 697 729	647 685 709
K1=2 K2=2	705 703 709	704 692 689	704 682 668	700 699 723	697 687 702	693 664 676	697 700 728	685 691 710	664 669 687
K1=2 K2=5	703 701 705	706 693 686	703 678 665	702 699 710	699 682 687	696 658 658	698 699 716	692 683 693	681 658 665
K1=5 K2=0	686 684 702	687 681 692	687 675 673	677 679 722	678 680 717	676 672 701	676 680 719	669 681 716	656 678 706
K1=5 K2=2	686 684 693	685 679 685	688 669 667	680 680 705	679 676 697	679 662 678	677 679 705	670 678 700	664 664 687
K1=5 K2=5	684 685 691	687 678 681	688 669 663	678 679 694	679 670 682	680 655 661	676 679 694	672 671 685	669 656 666

Based on the results of the simulations, I can formulate the following propositions:

1. ***The focal firm's performance in an alliance is negatively affected by its partner's dependence on the focal firm.***

2. ***The focal firm's performance is negatively affected by its partner's complexity under centralized decision making.***

3. ***The focal firm's performance is negatively affected by its partner's complexity under consensus-based decision making when the partner is significantly dependent on the focal firm.***

4. ***The focal firm's performance is positively affected by its partner's complexity under decentralized decision making. This effect is strongest when the focal firm is simple and greatly dependent on its partner.***

Discussion

The results of the simulations suggest that the process of coordination in alliances may affect the firms' performance in ways that can be predicted in advance. In particular, the results show that greater partner dependence on the focal firm results in lower performance of the focal firm. The effect of partner complexity on the focal firm's performance is more varied: under decentralized decision making, the focal firm tends to benefits from high complexity of its partner while under consensus-based and centralized decision making the focal firm's performance tends to suffer from high partner complexity. Finally, the results suggest that the decision-making structure chosen for the alliance affects the performance of the focal firm.

The results reported here suggest that there may be another group of factors affecting firm performance in alliances that has not been studied before. Previous research has found that firm performance in alliances depends on private and common benefits (Khanna, Gulati, & Nohria, 1998), network diversity (Goerzen & Beamish, 2005), technological diversity (Sampson, 2007), partner's reputation and technological resources (Stuart, 2000), etc. No previous studies have explicitly considered individual performance effects of coordination under interdependence.

The results reported in this paper suggest that firm performance in an alliance may also depend on the structure of interdependence between the partners, the structure of resource interactions within the partners' organizations, and the chosen decision-making structure. Firms may bear individual costs and enjoy individual benefits during long-term collaboration. Some of these costs and benefits in an alliance cannot be written into a contract. Moreover, their gradual emergence in the long process of coordination suggests that partners may have trouble sharing them even when there is full trust and goodwill.

External validity of the results: Explanation of the findings of Gulati and Sytch (2007)

Simulation research is often seen as unrealistic due to its simplifying assumptions and models that only capture a few aspects of reality. In order to demonstrate the external validity of the results, I would like to show how these results predict and explain findings of existing empirical research (as suggested by Davis, Eisenhardt, & Bingham, 2007). In a study of the U.S. auto industry, Gulati & Sytch (2007) found that the performance of the auto manufacturers declined when their suppliers were greatly dependent on them. This result contradicts the logic of power-dependence proposed by Emerson (1962). According to this logic, the less dependent side in a relationship enjoys a power advantage. This advantage can be used to bargain for more advantageous terms and therefore should positively affect the performance of the less dependent side. However, Gulati & Sytch (2007) found the opposite result. In order to explain this result, Gulati and Sytch used the concept of cohesion (Emerson, 1962) which refers to close collaboration between greatly interdependent partners. One problem with this explanation is that a relationship will exhibit cohesion when both partners are significantly and equally dependent

on each other. Besides, cohesion is a desirable quality if it results in greater collaboration. A possible agency theory explanation of this phenomenon is that the highly dependent supplier might enjoy free-riding benefits at the expense of the auto manufacturer. However, the auto manufacturer should be able to switch suppliers easily when this happens. Besides, Gulati and Sytch (2007) found no evidence of free-riding on the part of the suppliers. Thus, existing theories do not adequately explain the phenomenon reported by Gulati & Sytch (2007). The present study suggests that the negative performance effect of greater supplier dependence might have been a side effect of coordination under interdependence. As shown in Figs. 3-5, greater partner dependence results in lower performance of the focal firm under all decision-making structures. In fact, greater coordination between the partners may have exacerbated the problem.

Theoretical significance of the present study is in its novel approach to the investigation of factors that affect firm performance in alliances. The present study shows that coordination under complex interdependence in alliances may have unexpected side effects. The following findings are a contribution to the theory of alliances:

(1) Some costs and benefits in alliances are never shared yet they do not result from knowledge leaks (thus they cannot be called private benefits in the sense proposed by Khanna, Gulati, & Nohria, 1998). These costs and benefits result from long-term externalities that the partners impose on each other due to their interdependence. Decreasing interdependence between the partners is the only way to solve this problem. However, it would come at a cost. Interdependence is the outcome of sharing of resources and activities. The partners cannot share resources and activities yet remain independent. Thus, the partners face a tradeoff between greater potential side effects of interdependence and lower potential benefits from collaboration when little resource and activity sharing takes place.

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(2) As the simulations show, the performance of the focal firm depends on the structural characteristics of interdependence and on the partner's internal complexity. Firms do not usually choose partners based on these characteristics. They are more likely to look at the value of the potential partner's resources (Stuart, 2000), the fit between the corporate cultures (Pothukuchi et al., 2002), the potential partner's reputation (Saxton, 1997), etc. However, once the partner has been chosen, its internal complexity will affect the performance of the focal firm. In addition, the nature of interdependence between the partners is likely to be determined by the technologies that the partners possess and the goals of the alliance. As a result, the focal firm may not have much choice regarding the structure of interdependence. However, the decision-making structure is a parameter that can be chosen. The results of this study suggest that DMS choice can affect the performance of the focal firm.

(3) Equity joint ventures are not always the answer to the problem of coordination and incentives because of individually experienced benefits and costs. Hennart (2006) suggested that separating all alliance activities and resources into a free standing joint venture is a good idea. However, the partners may be unable to create such a free-standing JV that will be isolated from the rest of their operations. The resources and activities needed in the JV may also be needed in other areas unrelated to the JV. Besides, some capabilities that are needed for the JV may be systemic and reside in complex interactions of each partner's resources. In this case, each partner will individually bear costs of coordination. The fact that the alliance is structured as an equity JV does not change the individual nature of those costs. The only way for one of the partners to fully internalize all the costs and benefits experienced by the other partner is to acquire it.

Limitations

The present study has a few limitations which set boundary conditions on the results and suggest opportunities for further research. One limitation is the chosen definition of dependence as the impact of one partner's actions on the other partner's performance. This kind of dependence is most likely in alliances in which there is significant sharing of resources, activities, operations, etc. These alliances are likely to involve joint development of new products or technologies. The results reported in this paper are probably less applicable to licensing alliances or partnerships involving the supply of well-defined resources and services over a set period of time.

The second limitation is assumption of lack of opportunism and power games. Both partners in the simulations were assumed to always follow the contract. While this assumption may seem unrealistic, it was necessary to show that there may exist individual costs and benefits that are not the result of opportunism but are side effects of coordination under interdependence. Future research will undoubtedly incorporate opportunism and power games into this model.

The choice of simulations as a research method is another limitation of the study. The NK[C] model is a simplification of reality. It was not created to capture all the nuances of collaboration in alliances. However, NK[C] models do capture one important aspect of alliances: interdependence of the partners. The strength of NK[C] models is in being able to study interdependence at a much finer-grained level than that which is often used in alliance research (e.g. the usual distinction among pooled, sequential, and reciprocal interdependence – see Gulati & Singh, 1998). The results generated by the simulations are empirically testable. During empirical testing, researchers will be able to set up more realistic models that will incorporate interdependence as one of the factors affecting firm performance.

Conclusion

The present study has shown that the performance of the focal firm may depend on such factors as the degree of partner dependence on the focal firm, the internal complexity of the partner, and the chosen decision-making structure. These results suggest that there is another group of factors that may affect the performance of firms in alliances. These results are empirically testable. One of the results (a negative effect of partner dependence on the focal firm's performance) predicts and explains an empirical phenomenon that has not been adequately explained before.

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APPENDIX: Performance differentials of various decision-making structures

Table 7

Difference in performance between divisional and decentralized structures

Coefficients[a]

Independent variables	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	25.699	.614		41.879	.000
INTERDEPEND	.642	.011	.119	59.124	.000
COMPLEXITY	-5.008	.057	-.169	-87.832	.000
ASYMMETRY	-.957	.019	-.099	-50.709	.000
INTERACTION_INTERDEPEND_ COMPLEXITY	-.214	.004	-.100	-52.198	.000
COMPLEXITY_SQUARED	.734	.021	.068	35.420	.000
DIFF_SIZE	.013	.068	.000	.196	.845

a. Dependent Variable: Difference in performance between Divisional and Decentralized

Table 8

Performance difference between consensus and decentralized structures

Coefficients[a]

Independent variables	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	9.430	.620		15.205	.000
INTERDEPEND	.402	.011	.075	36.590	.000
COMPLEXITY	-3.784	.058	-.128	-65.661	.000
ASYMMETRY	-.680	.019	-.071	-35.624	.000
INTERACTION_COMPLEXITY_INTERDEPEND	-.181	.004	-.085	-43.643	.000
COMPLEXITY_SQUARED	.678	.021	.063	32.350	.000
DIFF_SIZE	.481	.068	.015	7.030	.000

a. Dependent Variable: Difference in performance between consensus-based structure and decentralized structures