INTER-ORGANIZATIONAL COORDINATION:
STRUCTURE, PROCESS, INFORMATION TECHNOLOGY

An Empirical Study of Buyer-Supplier Relationships
in the US/Japanese Automobile Industries

by

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Submitted to the Alfred P. Sloan School of
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the requirements for the degree of

DOCTOR OF PHILOSOPHY IN MANAGEMENT
at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
February 1992

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# Table of Contents

Table of Contents 2

Abstract 5

Chapter I: The Research Question 8

Emerging Importance of Inter-Organizational Coordination 8
The Role for Information Technology 8
Structure of the dissertation 11

Chapter II: A Conceptual Model for Inter-Organizational Coordination 17

*Dominant Theoretical Perspectives* 17
  Organization Theory 17
  Transaction Cost Economics 18
  Political Economy 20

*An Information Processing View of Inter-Organizational Coordination* 21

*The Proposed Conceptual Model* 23

Uncertainty States 23
  Environmental Uncertainty 23
  Partnership Uncertainty 25
  Task Uncertainty 26

Coordination Mechanisms 27
  Structural Mechanisms 27
  Process Mechanisms 28
  Technological Mechanisms 28
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linking Theory Building and Theory Testing</td>
<td>29</td>
</tr>
<tr>
<td>Towards a Program of Research on Inter-Organizational Coordination</td>
<td>32</td>
</tr>
<tr>
<td>Bivariate Relationships</td>
<td>32</td>
</tr>
<tr>
<td>Multivariate Configurations</td>
<td>32</td>
</tr>
<tr>
<td>Chapter III: Research Design and Threats to Validity</td>
<td>36</td>
</tr>
<tr>
<td>Research Design</td>
<td>36</td>
</tr>
<tr>
<td>The Operational Model</td>
<td>41</td>
</tr>
<tr>
<td>Threats to Validity</td>
<td>43</td>
</tr>
<tr>
<td>Appendix: Measurement Issues in Cross-Cultural Studies</td>
<td>62</td>
</tr>
<tr>
<td>a LISREL two group analysis across US and Japan</td>
<td></td>
</tr>
<tr>
<td>Chapter IV: The Empirical Study and Results</td>
<td>66</td>
</tr>
<tr>
<td>Two Models of Supplier Coordination</td>
<td>69</td>
</tr>
<tr>
<td>Uncertainty and Coordination: Bivariate Relationships</td>
<td>83</td>
</tr>
<tr>
<td>Uncertainty and Coordination: Multivariate Relationships</td>
<td>84</td>
</tr>
<tr>
<td>Uncertainty and Coordination: Uncovering Configurations</td>
<td>88</td>
</tr>
<tr>
<td>Calinski and Harabasz Variance Ratio Criterion</td>
<td>93</td>
</tr>
<tr>
<td>Uncertainty Configurations</td>
<td>98</td>
</tr>
<tr>
<td>Configurations of Uncertainty-Coordination Fit</td>
<td>98</td>
</tr>
<tr>
<td>Partnership Control</td>
<td>103</td>
</tr>
<tr>
<td>Structural Relationships</td>
<td>107</td>
</tr>
<tr>
<td>Remote Control</td>
<td>111</td>
</tr>
</tbody>
</table>
Electronic Integration 116
Electronic Coordination 122
Arms Length Relationship 125
Electronic Control 129
Quasi-Integration 132
Mutual Adjustment 135

Chapter V: Contributions, Implications and Extensions 139
Theoretical Contribution 139
Empirical Contribution 140
Methodological Contribution 142
Implications 143
Limitations and Extensions 145

References 147
INTER-ORGANIZATIONAL COORDINATION:
STRUCTURE, PROCESS, INFORMATION TECHNOLOGY

An Empirical Study of Buyer-Supplier Relationships
in the US/Japanese Automobile Industries

ABSTRACT

In response to the new strategic challenges of global competition many firms are undergoing profound organizational transformations, typically moving away from traditional vertical integration towards more external contracting of activities. These emerging inter-organizational arrangements imply much higher levels of inter-dependence between a focal firm and its growing network of business partners. The input of any member firm significantly and directly affects the value-adding process as well as the performance of the focal firm. In addition, Information technology (IT) is increasingly playing a critical role in the economy, affecting the nature and structure of competition. This ability to use information and technology as strategic resources is also becoming more widespread. In particular, the massive increase in use of IT across organizational boundaries has lead some to argue that information technology has become a new coordination mechanism capable of changing the way information is exchanged across organizational boundaries, and in turn changing the nature and governance of these relationships.

The Research Question

Despite the importance of these phenomena, managers and researchers alike still have little understanding of what new organizational, managerial and technological skills become necessary for the effective coordination of these emerging relationships. We need therefore to better understand how do organizations in general coordinate across their organizational boundaries. In this thesis, I in particular address three key related issues:

1. What are the dominant sources of uncertainty which affect the need for organizations to coordinate across their organizational boundaries?
2. Given their needs for coordination, how do firms best manage their relationship, and effectively leverage the individual and collective coordination capabilities of (i) the structure of their relationship, (ii) the socio-political processes within which the relationship is embedded, and (iii) inter-organizational applications of IT?
3. How does the relationship between sources of uncertainty and coordination mechanisms reflect on the coordinative performance of the relationship?

The Conceptual Model

In this dissertation, I am concerned especially with the phenomenon of inter-organizational coordination that explicitly leverages IT capabilities. From a research
perspective, two categories are therefore important: (a) a general concern with changes in the pattern of relationships among firms, especially the emergence of hybrid forms; and (b) the specific concern with the comparative coordination role of IT in enabling and facilitating these new forms of relationships. Within the second category, researchers have been more concerned with developing frameworks linking IT and competitive strategy or based on new institutional theories of economics (e.g. agency and transaction costs). However, inter-organizational relationships have had a rich research tradition from an organization theory perspective that has not been well-integrated within the context of emerging IT capabilities. In this dissertation, I therefore extend the information processing view of organization from an intra-organizational focus to an inter-organizational level of analysis. I argue that an information-processing view of inter-organizational coordination provides us with the rationale to integrate three dominant perspectives applied to IT-mediated relationships: organization theory; transaction costs economics; and political economy. I specifically develop a conceptual model that articulates the fit between sources of uncertainty (i.e. environmental, partnership, and task) and coordination mechanisms (i.e. structural, process, and information technology) as a critical condition for improved performance of the dyadic relationship.

The empirical study

To bridge the requirements of theory building and theory testing I apply this conceptual model to the specific context of buyer-supplier relationships, which have been undergoing dramatic organizational transformations in the US and Japanese automobile industries. The empirical study employed both qualitative and quantitative methodologies. Questionnaires in English (140 collected) and in Japanese (307 collected) were administered to two types of boundary roles, i.e. purchasing agents and engineers, to provide me with measures of the seven key constructs in the conceptual model. The characteristics of (1) the environment surrounding the relationship, (2) the climate of the relationship, and (3) the nature of boundary tasks are measured as sources of uncertainty. Further, (4) the use of structural mechanisms for information exchange, (5) the use of inter-organizational information systems and (6) the characteristics of the socio-political processes within the relationship are measured as three generic coordination mechanisms which may increase or reduce the coordination capabilities of the relationship. Finally, the questionnaires provide for each supplier-manufacturer relationship a (7) measure of the performance of and the satisfaction with inter-organizational coordination.

All three US (GM, Chrysler and Ford) and all eleven Japanese (Toyota, Nissan, Honda, Mazda, Mitsubishi, Isuzu, Daihatsu, Fuji [Subaru], Suzuki, Yamaha, Hino) auto manufacturers agreed to participate (data is kept confidential). The large data set (447) represents a wide cross-section of supplier relations in both countries across a variety of car components (e.g. tires, trims, shock absorbers, gaskets, anti-lock brakes, cruise control systems...).

Results and Contributions

Theoretical. The theoretical contribution stems from the development and validation of a conceptual model which bring together three dominant research perspective usually considered separately. The model argues for an interaction view of the relationship between structure, process and information technology, under the strong contingency effect of sources of uncertainty. This integrative model provides a rich conceptual tool to better understand and describe the determinants and components of inter-organizational coordination. In addition, it not only predicts the existence of a wide range of hybrid arrangements between the two extreme pure forms of market and hierarchy proposed by transaction cost economics, but also offers a conceptual framework to understand and describe their characteristics and differences.
Empirical. The results derived from statistical analyses conducted on a highly reliable and valid data set collected from US and Japanese manufacturers (447 data points) provide insights about:

(i) differences in supplier relations coordination across the US and Japan, testifying to the existence of two general models of supplier coordination,

(ii) but also differences within each country supply system. In particular,
(1) I uncover distinct configurations of uncertainty in the US and Japan,
(2) I uncover distinct patterns of coordination across these uncertainty configurations,
(3) I observe performance variations across these uncertainty configurations.
(4) I uncover nine configurations of fit between uncertainty and coordination. These configurations also display performance variations.

I also demonstrate that a configurational approach to uncovering patterns of coordination is more insightful than sets of bivariate and multivariate reductionist analyses (the two sets of multiple regressions).

Methodological. The two original methodological contributions consists of:
(1) a LISREL two group analysis across the two countries which reveals a set of critical measurement issues for cross-cultural studies,
(2) the first application of the Calinski and Harabasz (1974) Variance Ratio Criterion index to a empirical data set for the identification of the best number of clusters.

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Chapter I
The Research Question

Emerging Importance of Inter-Organizational Coordination

In response to the new strategic challenges of global competition many firms are undergoing profound organizational transformations. They are streamlining their operations, typically moving away from traditional vertical integration towards more external contracting of activities (Industry Week, 1989; Piore, 1986; Wall Street Journal, 1988). These emerging inter-organizational arrangements imply much higher levels of inter-dependence between a focal firm and its growing network of business partners. The input of any member firm (e.g. its product design, quality, or cost structure) significantly and directly affects the value-adding process as well as the performance of the focal firm (e.g. the final product time to market, price structure, design and manufacturing quality, delivery and inventory constraints).

The Role for Information Technology

In addition, Information technology (IT), i.e. tools and techniques based upon computer and telecommunication technologies (e.g. computers, software, telecoms, professional workstations, robots, and chips), is increasingly playing a critical role in the economy, affecting the nature and structure of competition (Walton, 1990). This ability to use information and technology as strategic resources is also becoming more widespread (Clemons

In particular, the massive increase in use of IT across organizational boundaries has led some to argue that information technology has become a new coordination mechanism capable of changing the way information is exchanged across organizational boundaries, and in turn changing the nature and governance of these relationships. A question among IS practitioners today is: "How best to leverage information technology (IT) capabilities to restructure business relationships with external business partners to obtain firm-level strategic advantage." The corresponding question for the IS and organization studies researchers is: "How best to develop a research framework that guides research efforts systematically as well as offer insights for management practice."

Despite the importance of these issues, managers and researchers alike still have little understanding of what new organizational, managerial and technological skills become necessary for the effective coordination of these emerging relationships. I need therefore to better understand how do organizations in general coordinate across their organizational boundaries. This implies addressing three key related issues in particular:

(1) What are the dominant sources of uncertainty which affect the need for organizations to coordinate across their organizational boundaries?

(2) Given their needs for coordination, how do two firms (a dyad) best manage their relationship, and effectively leverage the individual and
collective coordination capabilities of (i) the structure of their relationship, (ii) the socio-political processes within which the relationship is embedded, and (iii) inter-organizational applications of information technology?

(3) How does the relationship between sources of uncertainty and coordination mechanisms reflect on the coordinative performance of the relationship?

In this thesis, I am concerned especially with the phenomenon of inter-organizational coordination that explicitly leverages IT capabilities -- that has been variously described as: 'value-adding partnerships' (Johnston and Lawrence 1988; Henderson, 1990) 'inter-organizational systems' (Barrett and Konsynski, 1982; Cash and Konsynski, 1985), 'information partnerships' (Konsynski and McFarlan, 1990) and 'electronic integration' (Venkatraman and Kambil 1991) within a broader continuum of electronic markets and electronic hierarchies (Malone, Yates, and Benjamin, 1986).

From a research perspective, two categories are therefore important: (a) a general concern with changes in the pattern of relationships among firms, especially the emergence of hybrid forms (Williamson, 1990) or networks (Piore and Sabel, 1984; Powell, 1990); and (b) the specific concern with the comparative coordination role of IT in enabling and facilitating these new forms of relationships. Within the second category, researchers have been more concerned with developing frameworks linking IT and competitive strategy (see for instance: Porter and Millar, 1985; Johnston and Vitale, 1988) or based on new institutional theories (such as: agency and transaction costs)
of economics (see for instance, Malone et al, 1986; and Gurbaxani and Whang, 1991)

However, inter-organizational relationships have had a rich research tradition from an organization theory perspective (see for instance, Hall, 1977; Schmidt and Kochan 1977; Van de Ven, 1976) that has not been well-integrated within the context of emerging IT capabilities. In this thesis, I therefore extend the information processing view of organization from an intra-organizational focus (Galbraith, 1977; Daft and Lengel, 1986; Tushman and Nadler, 1978) to an inter-organizational level of analysis. I argue that an information-processing view of inter-organizational coordination provides us with the rationale to integrate the different dominant perspectives applied to IT-mediated relationships.

Structure of the dissertation

This document is divided into five chapters. This first chapter, primarily poses the research question, and highlights its importance to theory and practice. The second chapter discussed the following dominant theoretical perspectives -- organization theory; transaction costs economics; and political economy -- and develops the logic for an information processing view of inter-organizational coordination. This theoretical discussion leads to the formulation of a conceptual model that articulates the fit between uncertainty and coordination as a critical condition for improved performance of the dyadic relationship.

Chapter three describes how I employed this conceptual model to bridge the requirements of theory building and theory testing. Specifically, I
apply the model to the specific context of buyer-supplier relationships in the US and Japanese automobile industries. These represent a class of dyadic relationships that have been undergoing dramatic organizational transformations, and have become models of the effective use of inter-organizational information systems and EDI (electronic data interchange) in the manufacturing sector (as opposed to the frequently cited cases of strategic uses of I.T. in the service sector, where after all information is the key resource and output). I describe in detail the research design and the operationalization of the constructs, and explicitly review the choices and trade-offs I made in order to deal with the various threats to validity. In particular, chapter three concludes with a two group LISREL analysis across the two countries and hints to some critical measurement issues generally overlooked in international comparative studies.

In summary, the empirical study employed both qualitative and quantitative methodologies. Questionnaires in English (140 collected) and in Japanese (307 collected) were administered to two types of boundary roles, i.e. purchasing agents and engineers, to provide with measures of the following seven key constructs of the conceptual model. The characteristics of (1) the environment surrounding the relationship, (2) the relationship with a given supplier, and (3) the task executed by boundary spanning roles (such as purchasing and engineering functions) are measured as surrogates for uncertainty, one dominant determinant of the requirements for inter-organizational coordination. Further, (4) the use of structural mechanisms for information exchange, (5) the use of inter-organizational information systems and (6) the characteristics of the socio-political processes within which the relationship operates are measured as three mechanisms which
can increase or reduce the coordination capacity of the relationship. Finally, the completed questionnaires provide for each supplier-manufacturer relationship a (7) measure of the performance of and the satisfaction with inter-organizational coordination.

All three US (i.e. GM, Chrysler and Ford) and all eleven Japanese (Toyota, Nissan, Honda, Mazda, Mitsubishi, Isuzu, Daihastu, Fuji [Subaru], Suzuki, Yamaha, Hino) assemblers agreed to participate (each individual respondent's answers and each firm data is kept confidential). The total data set of 447 completed questionnaires represents a wide cross-section of distinct supplier relations in both countries across a variety of components with different technological and market characteristics (e.g. tires, trims, shock absorbers, gaskets, anti-lock brakes, cruise control systems...).

In chapter four I report the key findings of the empirical study. First, I present the analysis conducted at the most aggregate level across the two country and I show the existence of two distinct logics of supplier management and coordination in the two countries. I then specifically test the conceptual model and explored each of the bivariate relationships (regression analyses) between each source of uncertainty and each coordination mechanisms. Multiple stepwise regressions are also executed to further understand the relative effect of the three sources of uncertainty on each type of coordination mechanisms. Some of these tests constitute replication of previous empirical tests done at the intra-organizational level, thus providing strong nomological validity to the research design and operationalization of the constructs. The remaining set of multiple regression analyses (in particular those involving partnership uncertainty,
process and I.T. mechanisms) represent the first empirical test of the corresponding bivariate relationship.

However, our objective in this research is to push beyond, and demonstrate how a configurational approach to uncovering patterns of fit between uncertainty and coordination is more insightful than sets of bivariate reductionist and highly deterministic analyses. I conducted on the data set a series of cluster analyses, using for the first time in an empirical setting a systematic and objective procedure to determine the "best number" of clusters) and uncovered the dominant configurations of uncertainty, coordination, and uncertainty-coordination fit.

Finally, in chapter five I draw the conclusions of the study, highlight its contributions, discuss some of its the limitations and propose an agenda for future research.

Theoretical. The theoretical contribution stems from the development and validation of a conceptual model which bring together three dominant research perspective usually considered separately. The model argues for an interaction view of the relationship between structure, process and information technology, under the strong contingency effect of sources of uncertainty. This integrative model provides a rich conceptual tool to better understand and describe the determinants and components of inter-organizational coordination. In addition, it not only predicts the existence of a wide range of hybrid arrangements between the two extreme pure forms of market and hierarchy proposed by transaction cost economics, but also offers a
conceptual framework to understand and describe their characteristics and differences.

**Empirical.** The results derived from statistical analyses conducted on a highly reliable and valid data set collected from US and Japanese manufacturers (447 data points) provide insights about:

(i) differences in supplier relations coordination *across* the US and Japan, testifying to the existence of two general models of supplier coordination,

(ii) but also differences within each country supply system. In particular,

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I also demonstrate that a configurational approach to uncovering patterns of coordination is more insightful than sets of bivariate and multivariate reductionist analyses (the two sets of multiple regressions).

**Methodological.** The two original methodological contributions consist of:
(1) a LISREL two group analysis across the two countries which reveals a set of critical measurement issues for cross-cultural studies, (described in chapter 3)

(2) the first application of the Calinski and Harabasz (1974) Variance Ratio Criterion index to a empirical data set for the identification of the best number of clusters (described in chapter 4).
Chapter II
A Conceptual Model for Inter-Organizational Coordination

This chapter presents a conceptual basis to guide research in the area of inter-organizational coordination strategies, in particular those that explicitly leverage IT capabilities. The proposed conceptual model develops the logic for an information processing view of inter-organizational coordination which allows to bring together three dominant theoretical perspectives typically applied separately: organization theory, transaction cost economics, and political economy.

Specifically, I argue that three types of uncertainty -- environmental, partnership, and task -- give rise to a set of information-processing requirements which are appropriately balanced by a set of coordination mechanisms -- structure, process and information technology -- that reflect the total available capabilities to process information. I further outline at the end of the chapter, specific research directions and approaches to employing this conceptual model and bridge the requirements of theory building and theory testing. The remainder of the document then proceeds with the implementation and results derived from the pursuit of one such research direction and approach.

Dominant Theoretical Perspectives

Organization Theory
The inter-organizational relations framework (Clark 1965, Evan 1966, Guetzkow 1966, Warren, et al. 1971) and early marketing channels literature (Etgar 1976, Hunt and Nevin 1974) represent the first attempts by researchers to conceptualize the relationship between two or more independent organizations as a separate, and important level of analysis. This level is described in terms of its structural characteristics, such as: centralization, formalization, and complexity, (Aiken and Hage 1968, Paulson, 1971), or its behavioral or process characteristics, such as: power, influence, conflict (Gaski 1984, Marrett 1971, Schmidt and Kochan 1977). The relevance of this perspective to the present context is that IT could potentially affect and be affected by these structural and behavioral characteristics (Markus and Robey, 1988).

While this stream developed some useful insights (see for instance, Van de Ven, 1976), a major limitation is that researchers have simply extended or adapted constructs from a within-organization setting to an across-organization level without articulating their distinct role or benefits in the new level of analysis. Further, the empirical work has been predominantly restricted to relationships between public sector organizations (Clark 1965; Warren et al. 1971) with the exception of the early literature on marketing channels (see Gaski 1984 for a review). In addition, this is weak in terms of clarifying the determinants of structural and behavioral characteristics of inter-organizational relations. Despite these limitations, I argue that this perspective, in combination with other perspectives discussed below, could contribute to our understanding of IT-mediated relationships.

Transaction Cost Economics
The second perspective, on the other hand, offers a set of determinants of the [governance] structure of inter-organizational relations. Based on a rational, economic argument, this theory specifies the comparative efficiency of various forms of governance under different conditions (see Williamson, 1975, 1979, 1985). Briefly, it relates the [governance] structure of a relationship to the presence of transaction-specific assets required to support the transaction, and which could be potentially exploited by the other member of the dyad. The core concern, then, is how to develop efficient safeguards strategies, namely, how to "... organize transactions [to] safeguard them against the hazard of opportunism" (Williamson 1985 p. 32). The relevance of this perspective to the present context has been well articulated by Malone et al (1986) and Clemons and Row (1989).

The empirical research on this general theoretical perspective has been steadily increasing in recent times. While some studies have provided empirical support for the relationship between asset specificity and vertical integration (Joskow, 1987; Klein, Crawford and Alchian, 1978; Masten, 1984; Monteverde and Teece 1982; Walker and Weber 1984), others have reported the absence of such a relationship (Masten, Meehan and Snyder, 1991; Klein, Frazier and Roth, 1990). The empirical work in the area of IT-mediated patterns of integration and IT-induced asset specificity has been absent with the possible exception of Venkatraman and Zaheer (1990), who did not find the expected relationship.

Nevertheless, this perspective suffers from some limitations (see Robins, 1987; Perrow, 1986). For instance, inter-organizational relationships may serve non-economic purposes in general (Eccles and White 1988,
Granovetter 1985, Macaulay 1963. Dore, 1983) as well as in specific setting like Japan (Aoki, 1988). In addition, it is concerned with discrete and static transactions, while I argue that the entire relationship embedded in its history and anticipated future may need to be recognized.

Political Economy

The third perspective (Benson 1975, Zald 1970) reflects a holistic approach, with an explicit recognition of the economic and political dimensions of the dyad. More specifically, it is concerned with (1) the external forces, (2) the internal, organizational dimensions, and (3) their interaction as they influence the nature of the relationship within the dyad. The external forces, i.e. the prevailing and prospective environment within which the dyad operates, affect and are themselves shaped by the internal structure and processes of the relationship through adaptation and interaction (Aldrich 1979; Emery and Trist 1965, Pfeffer and Salancik 1978).

Internal dimensions shape the governance structure of the dyad -- which may range from a market-like relationship with an independent firm, to a hierarchy-like relationship (Williamson 1975). Between these two extremes lies a wide range of coordination strategies where the market mechanism is modified through some kind of formal or informal contractual arrangements between the parties involved (Blois 1972). Moreover, structural arrangements are embedded within the socio-political processes of the dyad (Eccles and White 1988, Granovetter 1985) -- representing the allocation and use of power and control as well as corresponding sentiments and behaviors (e.g. conflict, conflict resolution mode, commitment and cooperation).
The contribution of the political economy paradigm to the present context is primarily due to its holistic approach to this level of analysis, whereby it explicitly addresses the whole relationship over time, i.e. in its history and anticipated future, and across its economic/political as well as structural/behavioral dimensions. Its weakness, though, resides in the lack of conceptual and operational definitions for these concepts and the relationships among them, so as to allow for empirical validation.

An Information Processing View
of Inter-Organizational Coordination

While these three perspectives contribute to our understanding of inter-organizational coordination, each is concerned with a part of the larger phenomenon. Collectively, they address the structural and process (behavioral) characteristics as well as their determinants within a holistic perspective. The value-added sought in this chapter is to provide an information-processing view that systematically integrates these three different perspectives. Specifically, I argue that when brought together along an information-processing view, they complement each other and provide insights into the determinants, components and implications of different strategies for inter-organizational coordination.

The Information Processing Model. The basic logic in this model (Figure 1) is that: (1) organizations can be conceptualized as information processing systems (March and Simon, 1958; Galbraith 1977); and (2) the basic
function of organizational design can be seen as to create the most appropriate configurations of structures, processes and information technologies to facilitate the collection, processing, exchange and distribution of information (Duncan 1972, Galbraith 1977, March and Simon 1958). The basic axiom is that the fit between information processing needs (or coordination needs for an inter-organizational level of analysis) and information processing (coordination) capabilities is a strong determinant of effectiveness, or performance (Galbraith, 1977).

![Figure 1: An Schematic Representation of the Information Processing Model](image_url)

Although empirical studies do not directly test this axiom, several streams of research support it. In the task-structure fit literature, Aiken and Hage (1968) found that psychiatric agencies (non-routine tasks) were more organismic that were case work agencies (routine tasks). Similarly, Woodward (1961) found that successful organizations with relatively complex tasks were less mechanistic than successful organizations with routine tasks. Other supportive results include Whitley and Frost (1973), Perrow (1972), Freeman (1973), and Hickson et al. (1969). Similarly, in the environment-structure fit literature, Duncan (1972) found that successful subunits in a
changing environment had organic structures while successful subunits facing stable environmental conditions had more mechanistic structures. Other studies with supportive results include Lawrence and Lorsch (1967), Burns and Stalker (1966), and Negandhi and Reinmann (1973). For an overview, see Drazin and Van de Ven (1985).

The Proposed Conceptual Model

In Figure 2, I present the proposed conceptual model with the coordination requirements derived from different types of uncertainty and the coordination capabilities derived from an array of coordination mechanisms.

Uncertainty States

The proposed model of inter-organizational coordination recognizes three generic sources of uncertainty leading to the coordination needs of a dyad: (1) environmental uncertainty about the general market conditions surrounding the relationship, (2) partnership uncertainty about a focal firm's perception regarding a partner's future behavior, and (3) task uncertainty about the specific task jointly accomplished. The greater each dimension of uncertainty, the greater are the coordination needs.

Environmental Uncertainty. Dill (1969), Duncan (1972) and Thompson (1967) define the determinants of this type of uncertainty in terms of two dimensions: (1) the homogeneity-heterogeneity of the environment or
A CONCEPTUAL MODEL OF INTER-ORGANIZATIONAL COORDINATION

Coordination Mechanisms

Structural
Process
Technological

Coordination
Capabilities

Fit

Performance

Coordination
Needs

Uncertainty

Environmental
Partnership
Task
the degree of similarity/dissimilarity of the elements of the population dealt with, and (2) stability-dynamism of the environment or the degree to which contingencies remain basically the same overtime or are in a continual process of change. Other researchers have also related the perception of environmental uncertainty to the concentration-capacity of the environment or the degree to which resources are controlled by a small number of relevant organizations (Pfeffer and Salancik, 1978; Williamson, 1975).

**Partnership Uncertainty.** I define partnership uncertainty as the uncertainty a dyad member experiences about its relationship with another member. This type of uncertainty has traditionally been subsumed under either the general environmental uncertainty or the specific task uncertainty. When there is a predominance of market-like transactions, environmental uncertainty is the critical thrust; for predominantly hierarchical transactions, task uncertainty is the relevant thrust. However, in view of the emergence of hybrids (Williamson, 1990) or partnership-like arrangements with independent firms as partners differing in their capabilities and goals (Gardner and Cooper, 1988), it is important to recognize this type of uncertainty as in between the broader environmental uncertainty and the narrower task uncertainty. More specifically, as I move away from arms-length market transactions towards newer types of strategic partnerships, the uncertainty due to each partner needs to be recognized separately.

From recent work in the MIS literature on partnership (Cooprider 1990; Henderson, 1990), and new applications of political economy and exchange theory to marketing channels research (Anderson and Weitz 1989, Gardner and Cooper 1988) I derive two primary classes of determinants of partnership
uncertainty. The first one reflects the degree to which the two dyad member depend upon each other. Mutual interdependency relates among others to the balance of power and influence among the two dyad members, their respective switching costs or economic dependency on each other’s business.

The climate of the relationship represents another set of factors which may reduce or increase the level and importance of uncertainty about the other partner’s future behavior. Goal compatibility, trust, history of the relationship are some of the components of a dyad’s climate. *Goal compatibility* represent the extent to which both dyad members perceive their relationship as a long term relationship which adds value and generates mutual benefits (Stern and Reve, 1986, Eliashberg and Michie 1984, Schmidt and Kochan 1977). *Trust* has been argued to contribute to the reduction of uncertainty about potential opportunistic behavior by the other dyad member (Axelrod 1984, Dore 1983, Ouchi 1980), thus reducing the need to monitor each other. The balance of *Power-Dependence* (Frazier 1983, Frazier and Summers 1984; Stern and El Ansary, 1972) affects the perceived uncertainty about potential recourse in case of opportunistic behavior by the other dyad member. In particular, specific investments made for a particular relationship may hold one member hostage of the other (Anderson 1985, Heide and John 1990).

**Task Uncertainty.** Organization theory distinguishes between two sources of task uncertainty: task analyzability, task variety. *Analyzability* refers to the extent to which there is a known procedure that specifies the sequence of steps to be followed in performing the task. It is similar to Thompson’s knowledge of cause-effect relationships (1967) as well as to Cyert
and March's search procedures (1963), which favour either programmed or unprogrammed organizational responses (March and Simon 1958). *Task variety* refers to the number of exceptions or the frequency of unanticipated and novel events which require different methods or procedures for doing the job. This definition is consistent with the various notions of task variability (Pugh et al., 1969; Van de Ven and Delbecq 1974); uniformity (Mohr, 1971); predictability (Galbraith 1973, March and Simon 1958); complexity (Duncan 1972), and sameness (Hall, 1962).

**Coordination Mechanisms**

To cope with these (t.ree) types of uncertainty, organizations employ a number of alternate coordination mechanisms which *independently* and *collectively* contribute to increasing the coordination capabilities of the dyad. In the paragraphs below, I discuss the roles of three types of mechanisms: structural, process, and information technology.

**Structural Coordination Mechanisms.** Daft and Lengel (1986), for instance, argue for a hierarchy of structural mechanisms with different information processing capabilities: rules and procedures, direct contacts, liaison roles, integrator roles, task forces, teams. These mechanisms establish a formal assignment of information roles among boundary spanners as well as a formal assignment of authority. I argue the following dimensions as key characteristics of structural mechanisms: (a) their level of *formalization* (which reflects either a control or a coordination emphasis), (b) *intensity*, of their use (c) *multiplicity*, (d) *asymmetry*. Coordination capabilities are
hypothesized to increase with higher intensity, higher multiplicity, and lower formalization and asymmetry of these structural mechanisms.

**Process Coordination Mechanisms.** Process coordination mechanisms represent the socio-political processes (Arrndt 1983, Benson 1975) within which the previously defined structural mechanisms are embedded. They range along a cooperative-conflictual continuum, and directly affect the extent to which information is freely exchanged between the dyad members because or in spite of the nature of the structural mechanisms (Reve and Stern, 1984). For instance, under the same dyad structure coordination capabilities will tend to decrease in a negative, conflictual, and non-cooperative context. I define these process mechanisms along three distinct dimensions: (a) conflict (Gaski 1984; Lusch, 1976), (b) cooperation (Robicheaux et al., 1976, Harry and Mcgrath, 1988), and (c) commitment (Gardner and Cooper 1988, Henderson 1990). Coordination capabilities are hypothesized to increase with higher cooperation, higher commitment, lower conflict, and collaborative (vs. adversarial) conflict resolution.

**Technological Coordination Mechanisms.** These represent the use of information technology for facilitating inter-organizational coordination as opposed to intra-organizational uses. These include electronic linkages between the two dyad members that could range from simple, asymmetric access to databases to a more integrated platform involving symmetric sharing of a deeper set of information elements such as: joint design and development as well as knowledge sharing. The nature of the technology, the structure of ownership and access policies (Barrett and Konsynski 1982, Konsynski and Warbelow 1990) all contribute to different coordination
capabilities. In the proposed conceptual model, I consider the following characteristics of these mechanisms: (a) intensity of use of electronic linkages, (b) asymmetry, (c) level of electronic integration of operational processes across the two firms, and (d) scope of use. Coordination capabilities are hypothesized to increase with intensity, symmetry, higher integration of processes, and scope.

Linking Theory Building and Theory Testing

The proposed conceptual model is intended to serve as a basis to guide research in the area of inter-organizational coordination strategies. Specifically, it argues that the three types of uncertainty -- environmental, partnership, and task -- give rise to a set of coordination requirements which are appropriately balanced by a set of mechanisms -- structure, process and IT -- that reflect the total available capabilities to coordinate in the dyad. This framework has three roles -- descriptive, empirical (analytical), and prescriptive -- discussed below:

Role as a Descriptive (Conceptual) Model. At a first level, this framework can be viewed as a framework that allows the researchers and managers to organize the complex set of factors that could potentially influence the nature of inter-organizational coordination. Thus, at a minimum, this model (Figure 2) identifies a parsimonious set of sources of uncertainty within a dyadic transaction as well as coordination mechanisms that can be used to resolve it. Assessing its role as a descriptive framework using criteria such as: parsimony, internal consistency, and domain-coverage I can argue that the framework serves this role. Beyond such theoretical and
Table 1: The Dimensions of the Proposed Conceptual Model and the Relevant Theoretical Anchors

<table>
<thead>
<tr>
<th>Types of Uncertainty</th>
<th>Organization theory</th>
<th>Transaction cost economics</th>
<th>Political economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Uncertainty</td>
<td>- homogeneity/heterogeneity</td>
<td>- concentration/capacity or small number of firms (Williamson, 1975)</td>
<td>- external economy and polity (Benson, 1975)</td>
</tr>
<tr>
<td></td>
<td>- stability/dynamism (Dill, 1969; Duncan, 1972; Khandwalla, 1977)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- concentration/capacity (Pfeffer &amp; Salancik, 1978)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Power/dependence (Pfeffer &amp; Salancik, 1978; Frazier, 1983)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task Uncertainty</td>
<td>- Task analyzability</td>
<td>- bounded rationality (Williamson, 1975)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Task variety (Perrow, 1967)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Coordination Mechanisms

<table>
<thead>
<tr>
<th>Structural Coordination Mechanisms</th>
<th>- Formalization, Centralization, standardization of the relationship (Van de Ven, 1976)</th>
<th>- market, hierarchy or hybrid governance structures (Williamson, 1975; 1990)</th>
<th>- internal economy (Benson, 1975)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Coordination Mechanisms</td>
<td>- Cooperation, commitment, conflict (Gardner and Cooper, 1988)</td>
<td>- trust (Williamson, 1985; Ouchi, 1980)</td>
<td>- internal polity (Benson, 1975)</td>
</tr>
<tr>
<td>Technological Coordination Mechanisms</td>
<td>- Information systems (Galbraith, 1974; Daft &amp; Lengel, 1986)</td>
<td>- information technology could mitigate transaction cost determinants (Malone et al, 1986)</td>
<td></td>
</tr>
</tbody>
</table>
researcher-oriented criteria, this model has been used to discuss the phenomenon of inter-organizational coordination in IT-mediated settings with managers in one industry -- automotive; our own subjective assessment is that it fulfills its role as a descriptive framework well.

**Role as a Empirical (Analytical) Model.** The next role pertains to its potential to guide empirical research. To the extent that the framework builds from diverse perspectives and offers an integrated view on the phenomenon of interest (see table 1), I believe that this could serve as a framework to empirically examine several research issues. This requires that the relevant constructs of uncertainty and coordination mechanisms be operationalized using observable and measurable indicators (Bagozzi, 1980). I show in the remaining chapters how the normal criteria for an empirical model can be met, since the constructs and the dimensions enumerated in Figure 2 have been derived from research disciplines that are known not only for their theoretical contribution but also for their body of empirical research and insights. Indeed, I demonstrate how all the six major constructs can be operationalized using observable indicators that satisfy the required measurement properties (Bagozzi, 1980) by extending and adapting an impressive array of research studies reviewed earlier in this chapter.

**Role as a Prescriptive (Normative) Model.** This is an important role for this model. Being an applied discipline, where researchers are concerned with the ability of studies to inform and guide management practice, it is important that the model has the inherent potential to offer normative
insights. In the following pages, I illustrate how the empirical research rooted in this model (chapter three) can offer important insights (chapter five) into areas such as: the relative importance of the various coordination mechanisms under different conditions of uncertainty; trade-offs (or substitutability of one type for another) among the various mechanisms; selection of partners for dyadic relationships given possible constraints under different conditions of uncertainty; and the selection of IT mechanisms and their implementation under given conditions of market and partner.

Towards a Program of Research on Inter-organizational Coordination

Bivariate Relationships Under ceteris Paribus Conditions. The most basic set of analyses that could be examined within this framework relates to bivariate relationships between a given type of uncertainty and a type of coordination mechanism. Thus, the extant research stream on environment-structure fit can be positioned within this framework if I consider only environmental uncertainty and structural mechanisms. Similarly, the task-structure fit research stream can be positioned. Extending such a logic, I can examine bivariate relationships between environmental or partnership uncertainty on IT mechanisms. However, such a bivariate approach is limited since it invokes ceteris paribus conditions on other factors that may be too stringent for representing reality (see Child, 1975; Venkatraman, 1989 for discussions on the relative advantages and limitations of bivariate versus multivariate approaches to fit).

Multivariate Patterns of Configurations. Thus, a promising avenue for leveraging the value from this research framework is to adopt a multivariate
or configurational approach (McKelvey, 1978). As Miller argued: "Instead of looking at a few variables or at linear associations among such variables, I should be trying to find frequently recurring clusters of attributes or gestalts." (1981; p 5). Along similar lines, Miller and Friesen noted, "Archetypes appear to represent a set of relationships which are in a temporary state of balance. The ..... situations which are described seem to form a number of gestalts. There is something holistic and ordered about the patterns of ..... attributes (1977; p.264) and as Venkatraman argued: "such a pattern could provide useful insights into powerful concepts of equifinality or the feasible sets of internally consistent and equally effective configurations" (1989; p 432).

We believe that the power of the proposed framework is best highlighted by using it to uncover these configurations or gestalts of the alignment between uncertainty types and coordination mechanisms. This is different from a theoretically-derived typology of possible combinations among the uncertainty types and coordination mechanisms since empirical delineation of configurations highlight actually occurring, feasible patterns in any given context. Such a research strategy could be powerful in linking theory and practice and has the capability of developing managerially relevant guidelines for the use of different IT mechanisms for inter-organizational coordination. In other words, while research in the area of inter-organizational information systems has adopted a bivariate perspective, which has been argued to be limited earlier, I believe that the multivariate logic where IT is embedded within a larger set of forces is more appropriate.

Thus the research approach I adopt in the empirical study is based upon a configurational conceptualization and operationalization of fit, inspired by
recent work in this area by Venkatraman (1984 and 1989; i.e. conception of fit as gestalt) and others (Miller and Friesen 1984; McKelvey, 1982; Drazin and Van de Ven 1985). In the configurational view, Organizations are treated as complex entities whose elements, such as structure, processes and technology, have a natural tendency to coalesce into patterns or "configurations." These configurations are composed of interdependent and mutually supportive elements such that the importance of each element can best be understood by making reference to the whole configuration.

In other words, the belief here is that, for instance, the use of information technology by a manufacturer with a supplier may be best understood within the whole context of the nature of its competitive environment (for that component involved), its strategy towards the supplier(s), as well as the structures and processes used to coordinate with the supplier. Dyadic structures, production processes, coordination mechanisms, strategies, and environments all tend to influence each other and give rise to a multitude of differentiable relations. A small number of configurations, however, may be used to characterize a large fraction of these relationships. A central objective of the empirical study is then to uncover the small number of dominant configurations within the sample of relationships collected.

In addition, this dissertation is the first study of inter-organizational coordination which includes constructs of structure, process and information technology, which justifies a configurational approach. Indeed, as outlined by (Miller and Friesen 1984), the configurational approach, compared to other perspectives, is a strong approach in the early stages of theory construction, since a larger set of constructs are studied simultaneously (e.g. (1))
environmental, (2) partnership, (3) task uncertainties, and (4) structural, (5) process, and (6) technological coordination mechanisms) in order to yield a detailed, holistic, integrated image of reality. Data analysis and theory building are typically geared to finding common natural clusters among the constructs studied. The objective of such research is to derive either theoretical typologies or empirical multivariate taxonomies that discriminate among different configurations of the constructs, each configuration revealing its own relationships among the constructs.

However, configurational approaches have the potential to be viewed as atheoretical (McKeevey 1975). More recent uses of the configurational approach take an intermediate approach between the "typology" and "taxonomy" approaches. In this dissertation, I adopt such an integrative stepwise approach, where the initial phase (described in the chapter) consists of a deductive process, a theoretically-based quest for the parsimonious set of generic dimensions for IOC (e.g. uncertainties, structure, process, technology mechanisms). In the second phase, an inductive one (described in the next two chapters), actual coordination configurations are uncovered in a systematic cross-sectional study of buyers-suppliers in the US/Japanese automotive industries. Here, causation is viewed in the broadest possible terms. The search is not simply for unidirectional "structural" causation between pairs of constructs or even necessarily for multiple forms of causation. The approach is the search for systems of causation. Each configuration is considered as a system in which each construct can influence many of the others by being an indispensable part of an integrated whole. There are no purely dependent or independent variables in such a system.
Chapter III
Research Design and Threats to Validity

Research Design

To examine the research question stated in chapter one I apply the conceptual model developed in chapter two to the specific context of buyer-supplier relationships in the automobile industry. These relationships have been described as undergoing major changes, indicating far reaching transformations in the way automobile production and automobile companies themselves are organized (Womack, et al. 1990; Nishiguchi, 1989; Helper, 1987; Lamming 1989). Traditionally, automakers designed the car, manufactured nearly all the necessary core components and coordinated final production. The trend, however, is towards a car company becoming the coordinator of an increasingly intricate production network, typically purchasing more core componentry, thus reducing its level of vertical integration and increasing the number and relative importance of relations with suppliers.

At the same time, the climate and governance of supplier relations seem to be changing, moving away from the traditional model where a large number of suppliers were competing for short term contracts, on the primary basis of price. The trend would be for the assembler to establish longer-term contracts, and work more closely with suppliers to ensure that problems of financing, design, quality, delivery and cost are tackled at the earliest opportunity and resolved cooperatively. Competition would then involve a smaller number of suppliers capable of providing a greater share of the value
of the product, and would be based upon quality, delivery, and engineering capabilities as well as price.

*A cross-sectional quantitative field study* was designed to collect questionnaire data from *purchasing managers* and *engineers* at US and Japanese automobile manufacturers. The data collected represents a wide sampling of *relationships* between an auto manufacturer and one of its component suppliers. All firms from both countries agreed to participate in the study. Table 2 depicts the response patterns for each country, company (kept anonymous) and organizational role. Each firm first selected a set of components from a stratified list provided by the researcher, then for each component a buyer and/or an engineer were identified. The final choice of *the* supplier was at the respondent's discretion. As figure # shows each data point represent a unique component-dyad-task triplet, where the sampling of different components provides the variance along environmental uncertainty, the ensuing sampling of different manufacturer-supplier dyads provide variance along partnership uncertainty, and finally the sampling of different key informants dealing with different products and suppliers is likely to give variance along task characteristics. In sum, I are testing the proposed conceptual model on the basis of a sample of 447 independent observations.

In *Cook and Campbell's (1979)* terminology, this research design is a post-test design with nonequivalent groups. The unit of analysis is the Buyer-Supplier relationship, but the unit of measurement is the individual level of the key informant, an engineer and/or a purchasing manager (also referred to as a buyer in some organizations). In addition, it is important to
note that the data collected corresponds to only one side of the dyadic relationship, i.e. the manufacturer's perceptions of the relationship and its coordination. Also, no data was collected from the Japanese transplants in the US.

*A series of qualitative field studies* were conducted (primarily in the Detroit and Tokyo areas) at both US and Japanese firms, including manufacturers as well parts suppliers. These consisted of visits to assembly plants, focus groups and interviews with supervisors, various functional engineers and buyers responsible for different type of components. This phase of the research can be best described as an iterative process back and forth between the refining of conceptual model and the development of the questionnaire instrument, in an effort to refine and validate the measures. It was instrumental in (1) identifying the best sampling methods, (2) identifying the most appropriate boundary spanning role to be a key informant, and of course (3) pilot testing the two questionnaires, customized where necessary.
RESEARCH DESIGN

TASK - PARTNER - COMPONENT

Manufacturers

<table>
<thead>
<tr>
<th>US</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>GM</td>
<td>Toyota</td>
</tr>
<tr>
<td>Ford</td>
<td>Nissan</td>
</tr>
<tr>
<td>Chrysler</td>
<td>Mazda</td>
</tr>
<tr>
<td></td>
<td>Daihatsu</td>
</tr>
<tr>
<td></td>
<td>Isuzu</td>
</tr>
<tr>
<td></td>
<td>Yamaha</td>
</tr>
<tr>
<td></td>
<td>Fuji</td>
</tr>
<tr>
<td></td>
<td>Mitsubishi</td>
</tr>
</tbody>
</table>

Suppliers

<table>
<thead>
<tr>
<th>US</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Product Change

Product Complexity
Supplier Relationships

AUTO MANUFACTURER

- Antilock brakes
  - Customized product
  - Complex product
  - Small number of competitors
  - Proprietary technology

- Engineer

- Power Steering
  - High asset specificity
  - Complex product
  - High supplier investments
  - Proprietary technology

- Automatic Transmission

- Batteries
  - Standardized product
  - Mature technology
  - Low asset specificity

Supplier A

Supplier B

Supplier T

Supplier M
for engineering and purchasing. The first draft of each questionnaire was then translated into Japanese by the author, before being pilot tested again in the US and in Japan concurrently.

**Operationalization of the constructs** or the design of the specific measures was derived in two complementary ways: (1) from previous empirical research that has tested measures and scales for constructs similar to those part of the conceptual model (e.g. market characteristics, task characteristics), and (2) from interviews and focus groups conducted with potential respondents and industry experts (from academia and the industry). The objective is to increase the content validity of the indicators (Churchill, 1979). Similarly, the precautions and design choices described above are justified on grounds of increased validity and quality of the empirical findings. These decisions were made in an effort to satisfy the criteria agreed upon by leading methodologists such as Cook and Campbell, Bagozzi and Venkatraman. In the following section, I discuss each of these criteria, explain how I addressed the key threats to validity, and proceed to describe (1) the ex ante trade-offs made in the research design, an (2) the ex post choices of data analysis techniques used to check for validity as well the key results of these statistical tests.

**The operational model**

Table 3 and figure 3 summarize the operationalization and measurement properties of the key constructs.
AN OPERATIONAL OF INTER-ORGANIZATIONAL COORDINATION

in Buyer-Supplier Relationships in the Auto Industry

Environmental

Structural

Partnership

Process

Task

Technological

Performance

Product Complexity
Product Unpredictability
Product Innovation
Product Customization
Market Dynamism
Market Concentration
Market Heterogeneity

Formalization: Control/Coordination
Relative use of written mail
Relative use of group meetings
Multiplicity of channels
Frequency of mutual visits

Absence of Conflict
Conflict Resolution
Commitment
Joint Action

Scope of Use (across functions)
Intensity of Use
Relative use in purchasing
Relative use in engineering
Relative use in production control

Company rating
Satisfaction
Buffer levels (delivery, inventory)
Cronbach alphas ranges from 0.71 to 0.92, indicating a high reliability of the measures used.

Table 3

<table>
<thead>
<tr>
<th>dimensions</th>
<th>variables</th>
<th>number of indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Complexity</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Innovation</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Unpredictability</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Customization</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Dynamism</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Concentration</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Heterogeneity</td>
<td>1</td>
</tr>
<tr>
<td>Partnership</td>
<td>Mutual trust</td>
<td>2</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Continuity</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>History</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Interdependence</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Supplier's invests.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Buyer's invests.</td>
<td>4</td>
</tr>
<tr>
<td>Task</td>
<td>Analyzability</td>
<td>2</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Variety</td>
<td>2</td>
</tr>
</tbody>
</table>

| Structural          |                 |                      |
| Mechanisms          | Multiplicity    | 4                    |
|                     | Visits          | 4                    |
|                     | Coord./control  | 6                    |
|                     | Use of mail     | 6                    |
|                     | Use of groups   | 6                    |
| Process             | Conflict        | 5                    |
| Mechanisms          | Conflict resolution | 1                |
|                     | Commitment      | 3                    |
|                     | Joint action    | 5                    |
| I.T.                | Scope of IT use | 6                    |
| Mechanisms          | Intensity of IT use | 5                |

Threats to validity

Cook and Campbell identified four important threats to the validity of quasi-experiments similar to this study: (1) Statistical conclusion validity; (2) Internal validity; (3) Construct validity; (4) External validity.
Threats to statistical conclusion validity are the threats to drawing valid inferences about whether two variables covary. To avoid low statistical power, which increases the risk of making incorrect conclusions, I made a heavy investment (in particular two separate trips to Japan) to increase the sample size (see table 2), and measure variables using multiple indicators. In addition, violations of the assumptions underlying the statistical procedures used for data analysis significantly reduce the meaningfulness of the interpretation of the results. To reduce this risk I selected to test the measurement model using structural equation models with latent variables, also known as LISREL models. These multivariate techniques present the advantage of not only doing most things traditional statistical procedures can do, but more importantly doing them under less restrictive assumptions.

Internal validity refers to the extent to which conclusions can be drawn about the causal effects of one variable on another. In a single post-test design, the main concern is whether there are alternative explanations for the measured effects different from those explanations proposed by the conceptual model and reflected in the measurement scheme. Thus, to reduce the possibility that exactly the same unmeasured explanation would cause the observed effects in all cases I independently collected data on a large number of relationships in 14 separate companies in 2 countries and controlled for the selection of components (and therefore of respondents). These precautions, however, do not address one alternative explanation possibly at work here, i.e. history. History refers to the threat that the observed effects might be due to an event which took place during the data collection and affected all or some of the relationships. After inspection of the trade press and discussion with industry analysts, I could not identify any event in the auto industry,
new government regulations, new technology nor market disruption that
could have possibly affected the nature of coordination of buyer-supplier
relationships in part or all of the sample. In addition, the data was collected
in the 2 countries as quickly and as concurrently as possible during spring

*Construct validity* refers to the extent to which the constructs included
in the conceptual model are successfully operationalized and measured in the
research. This issue is comprehensively discussed and treated in the "threats
to measurement validity" section below.

*External validity* is the threat of not being able to generalize our
conclusions about constructs to (1) particular targets persons, settings and
times, and (2) generalizing across types of persons, firms, relationships,
settings and times. The immediate population this research would like to
generalize about is the population of buyer-supplier relationships in the US
and Japanese auto industries. For this purpose, particular care has been given
to the sampling and respondent selection so as to ensure that the sample is
representative of the population of all buyer-supplier relationships in both
countries auto industries. For this purpose, time and effort (multiple trips to
Detroit and two trips to Japan) has been spend to ensure participation of all
manufacturers. Further, to ensure representativeness of the sample of
relationships each manufacturer was asked to provide data about specific
classes of components. Finally, as indicated earlier, to avoid self selection of
respondents components were selected first and independently and then the
relevant task agent identified.
On the other hand, it may be questionable to generalize some of findings beyond the auto industry, except for some few constructs and relationships where previous research and knowledge of the context (e.g. more analyzable tasks associated with less group meetings and more structured information exchange).

Threats to Measurement Validity

Threats to the validity of measurement relate to three sets of concerns. First, there are issues about the choice of respondents or more precisely in this case to the validity of key informant analysis (motivational barrier, perceptual and cognitive limitations, and lack of information). As a safeguard against this particular threat to validity I asked for the key informants to be the individual agent directly in touch with and in charge of the supplier and component selected. No supervisory or higher level managers was ask to participate. Further, the questions related to specific tasks that make up the daily jobs of purchasing agent or engineers, and asked only for the respondent's perceptions of the relationship with the supplier. Participation was voluntary, and individual respondents were assured of complete confidentiality (no individual responses or company level responses are identifiable after coding of the data). A separate stamped card was also included to allow respondents to request for the summary report.

Second, there are issues about the measurement scheme and instrument. These are more generally referred to by Bagozzi as: (1) Theoretical meaningfulness of concepts; (2) Observational meaningfulness of concepts; (3)
Internal consistency of operationalizations; (4) Convergent validity; (5) Discriminant validity; (6) Nomological validity.

Traditionally, measurement has been seen as the mere process of assigning numerical values to objects or phenomena according to a specified set of rules. Viewed as such measurement becomes a strictly empirical concern, distinct from the theory of interest. However, there is growing acceptance of an alternate view of measurement as the "intellectual and empirical activity of giving meaning to the theoretical variables in one's theory" (Bagozzi, 1979).

To understand a real-world phenomena social science researchers examine the relationships between a set of research constructs (Blalock, 1969). These constructs, however, are typically not directly observable, but are believed to be latent variables. To test a proposed theory, researchers then measure these theoretical constructs (latent variables) using surrogate operationalizations and observable indicators. In addition, they examine the relationships between the constructs by analyzing the relationships between their observed indicators. This process of theory testing, therefore, involves two major steps: (1) developing and gathering valid indicators of the latent theoretical constructs and (2) testing the relationships between these indicators. This emphasizes the importance of measurement validation to increase the level of confidence in the results. In fact, a researcher who ignores or overlooks measurement validation assumes that the theoretical constructs are measured perfectly and without error (Jöreskog and Sorbom, 1984). Such an assumption is rarely appropriate (Bagozzi and Philipps, 1982).
and can greatly impact the findings of the researchers theory testing (Lee, 1989).

Therefore, this issue of measurement validity has been explicitly considered during the development of the measures (by drawing from a large body of previous empirical work that tested some of the measurement properties of some indicators). Moreover, the properties of the measures and indicators is explicitly tested against the criteria outlined by Bagozzi (1980). This is a simultaneous test of the measurement instrument and the theory behind it -- what Bagozzi refers to as a holistic construal of measurement.

There are six components to construct validity according to Bagozzi. The first two criteria involve semantic issues, and therefore, do not have explicit statistical tests associated with them. Rather they evaluate the internal consistency of the language used to describe a construct and the conceptual relationship between the construct and its operationalization.

The *theoretical meaningfulness of concepts* refers to the nature and internal consistency of the language used to represent the concepts (Bagozzi, 1980). A construct, like environmental uncertainty, is considered meaningful if it reflects the characteristics and quality of the language used to represent the theory. Therefore to capture the scope and richness of each construct I traced each of them to the various bodies of research that offer theoretical definitions and empirical findings. For instance, environmental uncertainty was traced back to the environment-structure literature (and concepts of market stability, concentration, dynamism, heterogeneity -- see Duncan 1972 and Khandwalla, 1977) and the transaction cost economics literature (with
concepts of asset specificity, small number, transaction frequency, uncertainty). This also ensures that the constructs included in the conceptual model and their relationships are consistent with prior research. In addition, when appropriate previously tested indicators and scales were included to the questionnaires (e.g. scales for task analyzability, task variety). Finally, during the pilot test the terminology used to describe to the different constructs was discussed at length with purchasing managers, buyers, and engineers from both countries to ensure there was no confusion about definitions and descriptions in both languages. This information was used during each iteration of the questionnaire development.

The observational meaningfulness of concepts refers to the relationship between the theoretical variables (which are unobservable) and their operationalization (which, of course, are observable). The multiple interviews during early fieldwork in one US and one Japanese firm and during the pilot test revealed whether questions used as indicators for each theoretical construct were clear, unambiguous, and in fact, related to the respondent's view of the theoretical construct. This process resulted in the elimination and/or modification of a number of questions.

Convergent validity refers to the degree to which two or more measures of the same theoretical construct are in agreement. Discriminant validity refers to the degree to which one theoretical construct differs from another. Jöreskog (1971) presents a procedure for simultaneously assessing convergent and discriminant validity using confirmatory factor analysis. These two key validity issues are treated as a separate section where I illustrate the formal and systematic treatment proposed by Bagozzi (1991).
The findings for the remaining variables are summarized in the correlations table #.

The final component of measurement validity is *nomological validity*. This criterion refers to the degree to which predictions from a formal network containing the concept under scrutiny are confirmed (Campbell, 1960). This has been referred to as predictive validity and can be thought of as the relationship of measures of a construct to a single antecedent or consequent, drawn from a wider body of theory (Venkatraman, 1989b). I used our measurement model and replicated previous empirical studies (bivariate relationships) with similar conclusions, thus demonstrating the strong nomological validity of the measurement scheme employed in this study.

*The internal consistency of operationalizations* is concerned with the homogeneity or single factoredness of indicators. It involves two related issues: unidimensionality and reliability. *Unidimensionality* assures that all the indicators, e.g. indicators of asset specificity, indeed measure the one underlying construct of interest. *Reliability* concerns the consistency of measurement or the extent to which repeated applications of the same measure or multiple measures of the same construct (e.g. asset specificity) lead to the same result. Any measurement can be conceived as including two parts: a true score that is free of random error, and a part that is entirely composed of random error. Reliability can then be viewed as the proportion of variance attributable to the underlying construct. The typical summary statistic of reliability is the Cronbach alpha coefficient (Cronbach, 1951), which represents a lower bound of reliability (Lord and Novick, 1968). As table 3 shows the measurement instrument used here is reliable.
However, the Cronbach alpha model makes some restrictive assumptions. First, $\alpha$ applies to a sum of measures presumed to indicate a single (i.e. unidimensional) scale or construct. Yet, if these measures in fact capture two or more different constructs, then the $\alpha$ reliability coefficient may represent the proportion of variance shared by these measures across unsuspected constructs, and thus will yield a misleading measure. Another assumption that $\alpha$ makes is that it applies to measures that have either equal true score variances or both equal trues score variances and equal error variances (Bagozzi, 1991). Finally, $\alpha$ is defined only when there are two or more measures available for a construct.

In the following section, I describe in detail the comprehensive assessment of measurement validity (i.e. reliability, unidimensionality, convergent and divergent validity) for two representative cases: the unidimensional construct of asset specificity and the two factor construct of task characteristics (task analyzability and task variety).

**Single-Factor model: Asset Specificity Construct**

Consistent with the usual definition and conceptualization of asset specificity (Williamson, 1979) I used four indicators ($x_1, x_2, x_3$ and $x_4$) to capture purchasing managers and engineers' perceptions about the level of asset specificity ($\xi$) associated with the particular component for which they selected to answer the questionnaire. I can express the relationships between the measures and the hypothesized construct as follows.
\[ x_1 = \lambda_1 \xi + \delta_1 \]  
\[ x_2 = \lambda_2 \xi + \delta_2 \]  
\[ x_3 = \lambda_3 \xi + \delta_3 \]  
\[ x_4 = \lambda_4 \xi + \delta_4 \]  

where \( x_i \) is measure \( i \), \( \xi \) stands for the hypothesized construct of asset specificity, \( \lambda_i \) is a parameter relating measure \( x_i \) to the construct \( \xi \), and \( \delta_i \) is an error term (also called a residual or error in measurement). It is assumed in equations (2) to (4) that the \( \delta_i \)'s have zero means, are uncorrelated with \( \xi \), and are mutually uncorrelated among themselves. Figure 4 depicts the path diagram summarizing the relationships in this single-factor measurement model of asset specificity. This model is referred to in the literature as the congeneric measurement model (Jöreskog, 1971).

Given the sample of observations I collected on the \( x_i \)'s in equations (1) to (4), I can compute a chi-square measure of goodness-of-fit and some other useful parameters: estimates of the \( \lambda_i \)'s and the variances of the \( \delta_i \) (i.e., \( \theta_{ii} \) in LISREL terminology). These parameter estimates, in turn, can be used to compute two indices. An index of reliability of an individual measure is reliability indices for each indicator is

\[ \rho_i = \frac{(\lambda_i^2)}{\left( \frac{\lambda_i^2 + \theta_{ii}}{2} \right)} \]  

And an index of the reliability of the composite formed by the sum of the four measures is:

\[ \rho_c = \frac{(\sum \lambda_i^2)}{\left( \frac{(\sum \lambda_i)^2 + \Sigma \theta_{ii}}{2} \right)} \]  

Both indices go from 0 to 1, with higher values indicating greater reliability.
The chi-square goodness-of-fit index provides a test of the hypothesis that the four measures used in the questionnaire can be explained by a single underlying factor (called asset specificity) plus random error. Large value of the chi-square index relative to its corresponding degrees of freedom suggest rejection of the hypothesis of unidimensionality. A p-value greater than or equal to .05 for the chi-square index is taken by convention to indicate satisfactory fit of the model to data.

This congeneric measurement model is a very general model useful for testing unidimensionality and estimating reliability with relatively few
assumptions being made. This model can be directly compared to two other somewhat more restrictive models: the tau-equivalent model and the parallel forms model. If I begin with equations (1) to (4) and Figure 1, and in addition specify that \( \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 \), I have the tau-equivalent model. This is a special case of the congeneric model where in addition I assume that each measure \( x_i \) relates to the true-score \( \xi \) in an equal way. If I specify both that \( \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 \) and \( \theta_{11} = \theta_{22} = \theta_{33} = \theta_{44} \), I have the parallel forms model. That is, all measures are assumed to have equal true-score and equal error variances.

This congeneric model implied by equations (1) to (4) was applied to the data collected in US and Japanese auto firms by use of LISREL 7 (Jöreskog and Sorbom, 1990). Table 4 summarizes the results. The findings for the goodness-of-fit indices suggest that the congeneric model cannot be rejected, but the tau-equivalent and parallel forms models are rejected. The \( \lambda_i \) and \( \theta_{ii} \) parameter estimates are all significant (significant t-values). The individual item reliabilities for the first three measures in the congeneric model are high, but the values for the fourth measures are only moderate in magnitude. Nevertheless, the composite reliability is quite high (\( \rho_c = .92 \)). I conclude in this particular example that the four indicators used to measure asset specificity are indeed unidimensional. The congeneric model appears to be the justified model.
### Table 4

**Goodness-of-fit Data**

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>$\chi^2$</th>
<th>d.f.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
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<td>.065</td>
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<tr>
<td>Tau-equivalent</td>
<td>41.21</td>
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<td>.000</td>
</tr>
<tr>
<td>Parallel forms</td>
<td>52.32</td>
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### Parameter Estimates

<table>
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<th>Parameter</th>
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<td>.87</td>
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<td>$\lambda_3$</td>
<td>.88</td>
<td>.85</td>
<td>.87</td>
</tr>
<tr>
<td>$\lambda_4$</td>
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<td>.85</td>
<td>.87</td>
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<tr>
<td>$\theta_{11}$</td>
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<td>.25</td>
<td>.25</td>
</tr>
<tr>
<td>$\theta_{22}$</td>
<td>.21</td>
<td>.22</td>
<td>.25</td>
</tr>
<tr>
<td>$\theta_{33}$</td>
<td>.23</td>
<td>.23</td>
<td>.25</td>
</tr>
<tr>
<td>$\theta_{44}$</td>
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### Reliability Estimates

**Individual Items**

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<td>Tau-equivalent</td>
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<td>.77</td>
<td>.76</td>
<td>.54</td>
<td>.91</td>
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<tr>
<td>Parallel forms</td>
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<td>.75</td>
<td>.75</td>
<td>.75</td>
<td>.92</td>
</tr>
</tbody>
</table>

### Multiple-Factor model: Task Uncertainty Construct

Following is an illustration of the use of structural equation models to assess the reliability of a multidimensional construct: task uncertainty. Thompson (1967) identified two distinct dimensions of task characteristics, task analyzability and task variety. Figure 5 illustrated this model with two
constructs and only two measures per construct. The equations relating measures \( x_1 \) and \( x_2 \) (respectively \( x_3 \) and \( x_4 \)) to construct \( \xi_1 \) (respectively \( \xi_2 \)) are similar to those found for the single-factor case except that I now have two constructs \( \xi_1 \) (task analyzability) and \( \xi_2 \) (task variety) instead of one:

\[
\begin{align*}
  x_1 &= \lambda_1 \xi_1 + \delta_1 \\
  x_2 &= \lambda_2 \xi_1 + \delta_2 \\
  x_3 &= \lambda_3 \xi_2 + \delta_3 \\
  x_4 &= \lambda_4 \xi_2 + \delta_4
\end{align*}
\]

where assumptions are made similar to those needed for equations (1) to (4), and \( \phi_{21} \) represents the correlation between the two focal constructs. I tested this model implied by equations (7) to (10) and estimated the parameters.

To examine the model as shown in Figure 5, I can consider at least four hypotheses:
H₁ : λ₁, λ₂, λ₃, λ₄, θ₁₁, θ₂₂, θ₃₃, θ₄₄, and φ₂₁ free and unconstrained.
H₂ : λ₁, λ₂, λ₃, λ₄, θ₁₁, θ₂₂, θ₃₃, and θ₄₄ free and unconstrained; φ₂₁ = 1
H₃ : λ₁ = λ₂, λ₃ = λ₄, θ₁₁ = θ₂₂, θ₃₃ = θ₄₄, and φ₂₁ = 1
H₄ : λ₁ = λ₂, λ₃ = λ₄, θ₁₁ = θ₂₂, θ₃₃ = θ₄₄, and φ₂₁ free and unconstrained

Hypothesis H₁ is the null hypothesis for the congeneric model and corresponds directly to Figure 5. Hypothesis H₂ is the same as H₁ but adds the restriction that the correlation between the two constructs, ξ₁ and ξ₂, are perfectly correlated (i.e. φ₂₁ =1.00). Hypothesis H₃ is the same H₂ as but introduces the constraints that factor loadings and error variances are equal for measures of the same construct. This is a version of the parallel forms model. Finally, hypothesis H₄ is the same H₃ as but places no constraints on φ₂₁ (i.e. φ₂₁ is a free parameter).

Each of these four hypotheses can be examined with a chi-square goodness-of-fit test to ascertain the reasonableness of each implied model. In addition, Bagozzi (1991) suggests to examine two other sets of hypotheses based on strategic comparisons among hypotheses H₁ to H₄. To see if the two constructs, task analyzability ξ₁ and task variety ξ₂, are distinct or not, one can compare H₁ to H₂ and H₃ to H₄. The first comparison tests the hypothesis that φ₂₁ =1.00 or not, under the assumption that the measures are congeneric; the second comparison tests the hypothesis that φ₂₁ =1.00 or not, under the assumption that the measures are parallel. These two comparisons form the basis for testing discriminant validity, as explained below. On the other hand, to see if the parallel forms hypothesis is tenable or not, I can compare H₁ to H₄ and H₂ to H₃. The former is done under the assumption that the two
constructs are distinct, the latter under the assumption that they are not. Chi-square difference test are used to perform the above tests.

We applied the model implied by equations (7) to (10) to the data for the four items for task characteristics. Table 5 shows the results. The goodness-of-fit results in the table show that the congeneric and parallel forms with $\phi_{21}$ estimated freely cannot be rejected, but the same models with $\phi_{21}$ constrained to unity must be rejected. All parameter estimates are significant as shown it table 5. The individual item reliabilities are at times low, but all composite reliabilities are high in value (see table 5). In sum, the evidence supports the hypothesized two factor structure for task characteristics, and the reliabilities of the measures for the corresponding task analyzability and task variety constructs are shown to be satisfactory.

To more formally test the hypotheses of congeneric and parallel forms I examine the following comparisons of goodness-of-fit indices and use chi-square difference tests to draw our conclusions (Table 5 summarizes the results of these comparisons). Comparing $H_1$ to $H_4$ gives a test of whether the pairs of measures for the two constructs can be considered parallel, given the assumption that $\phi_{21}$ is a free parameter. The comparison yields a chi-square index of for 4 degrees of freedom (the following notation is used. across this document $\chi^2(4)= 1.47$) which indicates that the hypothesis cannot be rejected. Similarly, a comparison of $H_2$ and $H_3$ gives a test of whether the pairs of measures are parallel, given the assumption that $\phi_{21}$ is constrained to be unity. The comparison yields a $\chi^2(4)= 1.34, p= 0.01$, and indicates that the hypothesis of parallel forms cannot be rejected. Together these two
comparisons suggest that the hypothesis of parallel forms cannot be rejected (under both assumptions about $\phi_{21}$), which supports the congeneric model.

**Convergent and Discriminant Validity** Convergent validity refers to the degree to which the two measures for each of the two theoretical constructs identified above, task analyzability and task variety, are in agreement. Table 5 shows that the factor loadings $\lambda_1$ and $\lambda_2$ on the construct $\xi_1$ and factor loadings $\lambda_3$ and $\lambda_4$ on construct $\xi_2$ are all large and statistical significant. This is evidence that each indicator is strongly related to its underlying theoretical construct. Discriminant validity refers to the degree to which one theoretical construct, e.g. task analyzability, differs from another, i.e. task variety and can be evaluated by testing whether the correlation between the pair of constructs is significantly different from unity. The estimate of $\phi_{21}$ is 0.69 with a standard error of .08. An approximately 95% confidence interval for $\phi_{21}$ is $0.53 < \phi_{21} < 0.85$, does not include 1.00 which suggests that the two constructs of task analyzability and task variety are distinct.

A more formal test of the discriminant validity of these two theoretical constructs requires a comparison of hypotheses $H_2$ and $H_3$, which provides a test of whether $\phi_{21} = 1.00$ or not, given the assumption that the pairs of measures are congeneric. This comparison yields a $\chi^2(4) = 1.34$, $p = 0.01$, thus pointing to the rejection of hypothesis that the two constructs $\xi_1$ and $\xi_2$, are perfectly correlated, even after removing random error. Likewise, a comparison a comparison of $H_3$ and $H_4$ test the hypothesis that $\phi_{21} = 1.00$, under the assumption that the pairs of measures are parallel. The results reveal that $\chi^2(4) = 1.47$, $p = 0.01$, which indicates that the hypothesis must be rejected.
In sum, the results suggest that task uncertainty is a multidimensional construct, at least including a task analyzability and a task variety dimensions. In addition, the results shows that the indicators used to measure these two dimensions are highly reliable, and have high convergent and discriminant validity.

Table 5

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>$\chi^2$</th>
<th>d.f.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>H$_1$</td>
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<td>1</td>
<td>.037</td>
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<tr>
<td>H$_2$</td>
<td>162.41</td>
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<td>.000</td>
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<td>H$_4$</td>
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<td>.326</td>
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Parameter Estimates

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<th>Parallel forms Model with $\phi_{21}$ free</th>
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<tr>
<td>$\lambda_1$</td>
<td>.76* (.07)</td>
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<td>.77* (.04)</td>
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<td>$\lambda_3$</td>
<td>.88* (.07)</td>
<td>.81* (.04)</td>
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<tr>
<td>$\lambda_4$</td>
<td>.75* (.07)</td>
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<tr>
<td>$\theta_{11}$</td>
<td>.42* (.09)</td>
<td>.41* (.03)</td>
</tr>
<tr>
<td>$\theta_{22}$</td>
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<td>.41* (.03)</td>
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<td>Parallel forms with $\phi_{21}$</td>
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<td>free</td>
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Goodness-of-fit Measures and Tests of Hypotheses:

<table>
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<th>Hypothesis $H_1$</th>
<th>$\chi^2(1) = 4.34$</th>
<th>$p = .037$</th>
<th>Hypothesis $H_2$</th>
<th>$\chi^2(2) = 162.41$</th>
<th>$p &lt; .001$</th>
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<tbody>
<tr>
<td>Hypothesis $H_3$</td>
<td>$\chi^2(6) = 163.75$</td>
<td>$p &lt; .001$</td>
<td>Hypothesis $H_3$</td>
<td>$\chi^2(1) = 157.94$</td>
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<tr>
<td>$\chi^2(4) = 1.47$</td>
<td>$p = .01$</td>
<td>$\chi^2(4) = 1.34$</td>
<td>$p = .01$</td>
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</tbody>
</table>
Appendix to chapter III
Measurement Issues in Cross-Cultural Studies:
A LISREL Two Group Analysis Across Two Countries

In this section, I apply Bagozzi's (1983) set of formal tests to examine the measurement properties of the US and Japanese versions of the measurement instrument. I proceed in three stages. First, I test whether the two data sets have equal variance-covariance structures. Acceptance of this hypothesis implies I can just pool the two data sets together and treat the two countries as a single population. If this hypothesis is rejected, I then need to test whether the measurement patterns in the US and Japan are invariant (i.e. factors loading onto the construct in a similar way). If the patterns are invariant I then can further test whether the two measurement models are the same across both countries (i.e. similar measurement error).

The first hypothesis to investigate is the one proposing equality of variance-covariance matrices across countries:

\[ H_\Sigma : \Sigma^{US} = \Sigma^{Japan} \]

A failure to reject this hypothesis suggests that the constructs do not differ across countries and therefore may be pooled for further analysis. However, a rejection of the hypothesis suggests the constructs are different across the two groups. To find out in what sense they differ, the sequence of steps suggested by Bagozzi (1983) shown in Table 6 is executed. The appropriate test for each block is the difference between \( \chi^2 \) values for the block in question and the
previous block, with degree of freedom equal to the difference in degrees of freedom between block. For example, given that $H_\Sigma$ has been rejected, one may test $H_\Lambda$ which hypothesizes that the pattern of measurements across countries in invariant. The $\chi^2$ value for this test equal the difference in $\chi^2$ values for $H_\Sigma$ and $H_\Lambda$. A failure to reject this hypothesis might lead to a test that the entire measurement models across countries are equal. That is, $H_{\Lambda^0}$ posits that both the parameters relating measures to constructs and the error variances of measures are equal.

In summary I want to identify which of these three hypothesized models fit the data better:

$$H_\Sigma: \Sigma^{US} = \Sigma^{Japan}$$
$$H_\Lambda: \Sigma^{US} = \Sigma^{Japan}, \text{ and } \Lambda^{US} = \Lambda^{Japan}$$
$$H_{\Lambda^0}: \Sigma^{US} = \Sigma^{Japan}, \text{ and } \Lambda^{US} = \Lambda^{Japan}, \text{ and } \Phi^{US} = \Phi^{Japan}$$

For presentation purposes, I report only three examples of analysis which reflect a different behavior of the measurement scheme used to capture that construct. I also selected a range of constructs from a unidimensional construct for asset specificity, a two factor construct of task uncertainty (task analyzability and task variety), and a three factor construct for partnership uncertainty (mutual interdependence, supplier investments, mutual trust).
Table # : Hypotheses for Testing Measurement Differences Across Countries

Hypothesis of equal variance-covariance structures

$H_{\Sigma}$: accept

Hypothesis of invariant measurement pattern

$H_{\Lambda}$: $\Lambda_{US} = \Lambda_{Japan}$

reject

Hypothesis of equal measurement models

$H_{\Theta_{\Lambda}}$: $\Lambda_{US} = \Lambda_{Japan}$

$\Theta_{US} = \Theta_{Japan}$

reject

Stop and treat pooled countries as single population

accept

The measurement model is the same across the US and Japan

Single-Factor Construct: Asset Specificity

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>$\chi^2$</th>
<th>d.f.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{\Sigma}$</td>
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<td>6</td>
<td>.994</td>
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</table>

We cannot reject $H_{\Sigma}$ and therefore can pooled the two data set. In other words, testing hypotheses involving asset specificity (assuming the other construct also behave similarly) can be done using the total sample as a single population.
### Two-Factor Construct: Task Uncertainty

(task analyzability, task variety)

<table>
<thead>
<tr>
<th>Hypothesis</th>
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<th>p</th>
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<td>$H_{\Lambda\Theta}$</td>
<td>32.47</td>
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<td>.000</td>
</tr>
</tbody>
</table>

### Three-Factor Constructs: Partnership Uncertainty

(Asset Specificity, Trust, Dependence)

<table>
<thead>
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<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_\Sigma$</td>
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Chapter IV
The Empirical Study and Results

The data analysis proceeds in several logical steps gradually building up to the final uncovering of the dominant configurations of uncertainty-coordination fit with the two countries. In the first phase ("two models of supplier coordination"), we examine differences across US and Japanese auto manufacturers at an aggregate level, where the motivation is to identify the existence of two general models of supplier coordination. Specifically, as series of t-tests of mean differences across the two samples conducted for each construct and variable included in the operational model, allows us to specify the "average" supplier relationship in the US and in Japan, and highlight the internal consistency of each model within the idiosyncratic characteristics of its industrial market. I find statistically significant (at the 0.05 level) differences across the two countries in the characteristics of the market for components, the quality of the partnership between the supplier and the manufacturer, the nature of the job of boundary spanning managers, as well as in their coordination strategy and behavior.

It is important to note and remember that these series of analyses and results are useful only in revealing general tendencies in the underlying philosophies or logics for supplier coordination in both countries. It does not inform on the relationship between the six constructs of the model. In addition, it is not sufficient to, for instance, conclude that Japanese relationships are typically long-term and partnership-like. In fact, the additional two sets of data analyses reveal that there exists a wide spectrum of
relationships within the US and within Japan, and that even though there might be a Japanese tendency for long-term partnerships, there are also for certain types of products and suppliers short-term contractual relationships with little investments into nurturing the relationship. Specifically, under low partnership uncertainty contingencies (e.g. low asset specificity, low reciprocal investments, low mutual interdependence), Japanese firms also implement a coordination strategy with lower coordination capacity (e.g. contract-mediated relationship). Also, there are in Japan for certain types of products (i.e. highly standardized and simple one) less performing relationships with large buffers, and at the same time there are in the US for other types of products (i.e. highly customized, new technology components) some strong partnerships exhibiting Just-in-Time delivery and quality levels.

This is demonstrated by two sets of multivariate analyses based on multiple regression between coordination constructs (as dependent variables) and uncertainty constructs (as independent variables), which confirm what has been argued and sometimes tested by some of the theoretical perspectives integrated in the conceptual model. The first set of multiple regressions ("uncertainty and coordination: bivariate relationships) consists of multiple regression between one coordination construct and one uncertainty construct and tests for the individual effect of each type of uncertainty on each type of coordination mechanism (one illustration is reported in this chapter). The second set of analysis ("uncertainty and coordination: multivariate relationships) consists of multiple regression with one coordination construct as the dependent variable but with the three uncertainty constructs as independent variables, and thus provide for a test of the comparative and
collective effect of the three generic sources of uncertainty on each coordination mechanism (one illustration is reported in this chapter).

For instance, I show that, in the US as well as Japan, coordination is highly affected by the characteristics of the product and its market (e.g. complexity, dynamism), which is consistent with the environment-structure fit literature and transaction cost analysis (e.g. asset specificity). The bivariate relationships between coordination and task also are consistent with the [intra-organizational] information processing literature. These analyses not only provide the first empirical test of these relationship at this level of analysis and within the context of buyer-supplier relationships in the international auto industry, but more importantly they provide a positive test for nomological validity. In other words, the measurement model applied to the conceptual model exhibits strong nomological validity, i.e. it is consistent with previous empirical and conceptual work.

Multiple regression analyses, however, reflect the causal and deterministic perspective underlying each of the theoretical perspectives integrated within the conceptual model. I argued in chapter two that a configurational perspective, reflecting the underlying fit axiom of the model, should provide greater insight into how two firms coordinate across their organizational boundaries, and why. In addition, a configurational approach contrasts with the previous multivariate approach as it captures the co-existence and interaction between the three coordination mechanisms.

I selected cluster analysis as the multivariate statistical analysis used to explore this holistic and interaction view of coordination. The analysis
proceeds in two stages. First, I uncover for each country, then for the pooled sample the uncertainty configuration present in the data set. For each uncovered uncertainty configuration I examine its key characteristics, and further test whether these configurations are associated with differences along coordination and performance dimensions (one-way analysis of variance). Second, I uncover the configurations of fit between uncertainty and coordination within each country, and examine their probability of occurrence in each country, their characteristics and performance properties.

Two models of supplier coordination:

t-test differences across US and Japan

In this section we simply present the typical differences which appeared across the two countries. Despite poor theoretical meaningfulness these comparisons at a aggregate and gross level provide some interesting managerial insights into how supplier relationships in the US and Japan typically or "on average" operate within two different market structures, under two distinct managerial logics, and yet exhibit coordination practices highly consistent with their respective market and management logic. We alternatively report the results of the survey for each of the constructs in the conceptual model. We examine first the differences in the context surrounding supplier relationships: (i) the general characteristics of the supply market, (ii) the general characteristics and climate of supplier relations in the US and Japan, and (iii) the general characteristics of boundary roles, such as purchasing managers and [component] engineers. We then
present the results for the differences in the use of the three coordination mechanisms: structural, process and information technology.

<table>
<thead>
<tr>
<th>Characteristics of the Market for Components</th>
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| **Market Instability**  
| US | 2.88 | Japan | 2.57 |
| **Market Concentration**  
| US | 2.96 | Japan | 3.31 |
| **Parts per supplier**  
| US | 9.00 | Japan | 5.41 |
| **Internal Sourcing**  
| US | 21 | Japan | 10 |
| **External Sourcing**  
| US | 20 | Japan | 89 |

The characteristics of the market for components dramatically differ across the US and Japanese auto industries. US component markets exhibit greater market instability and lower market concentration. This seems to indicate that the US supply market still operates under traditional market-like mechanisms, where manufacturers spread their business among multiple suppliers selected from an large pool of potential candidates (see table below by Lamming, 1990). In contrast, there is little change in the number and composition of competitors for a component in the Japanese supply industry (higher market stability). Mostly the same few suppliers have been and are still competing in the same market segments, and deliver a much broader range of parts to the manufacturer. Also, in spite of their larger number of suppliers (and purchasing staff) US manufacturers are still producing internally a greater proportion of a component's total volume.
Interviews with US suppliers reveal that "...the big three still want to keep us in competition with their allied [internal] divisions..."

<table>
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<tr>
<th>Automotive Purchasing in the 1980's</th>
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<tbody>
<tr>
<td>Suppliers</td>
</tr>
<tr>
<td>GM in USA</td>
</tr>
<tr>
<td>Ford in USA</td>
</tr>
<tr>
<td>Toyota in Japan</td>
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<tr>
<td>Nissan in Japan</td>
</tr>
</tbody>
</table>

Source: Lamming (1990); IMVP Research and Estimates

In contrast, Japanese manufacturers design and manufacture less of their componentry, and on average outsource a greater proportion of the total volume for a component. They maintain only a few potential suppliers (i.e. greater market concentration) who typically have the design and manufacturing skills and capabilities to produce a wide range of related components. In fact, as explains Asanuma (1989) Japanese auto makers rarely practice sole sourcing, and usually share the business for a given component among 2 to 3 suppliers perpetually competing and emulating each other in areas of technology development, improvement in process, product, quality and cost.

Japanese manufacturers strategy is to concentrate on their core competencies, keep inside the design and manufacture of the key concepts,
technologies and systems that distinguish them from competitors, but heavily on the other hand rely on an elaborate multi-tier structure of suppliers for other components (Mitsubishi Research Institute, 1987). First tier firms, generally larger ones, assemble and deliver large integrated systems, and together carry much of the burden and responsibility for the coordination of second and third-tier suppliers. This pyramid structure literally permits "a form of vertical coordination within the industry that simultaneously provides the manufacturer benefits that are traditionally associated with high levels of vertical integration, such as control of the production process, profit opportunity, and protection of their technical core, and those associated with low degrees of vertical integration, such as low cost and a high degree of independence" (Flynn and Andrea, 1989 p. 2).

<table>
<thead>
<tr>
<th>Manufacturer Dependence</th>
<th>Supplier Dependence</th>
<th>Manufacturer's Investments</th>
<th>Supplier's Investments</th>
<th>Trust</th>
<th>Long-term view</th>
</tr>
</thead>
<tbody>
<tr>
<td>t = -6.76</td>
<td>p &lt; .001</td>
<td>1-7 scale</td>
<td>not significant</td>
<td>at .05 level</td>
<td>1-7 scale</td>
</tr>
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</table>

**Characteristics of the Relationship with a Supplier**

*The Characteristics of the relationship with a supplier* seem to reflect the differences in the market conditions discussed above. In their highly concentrated component markets Japanese manufacturers have fewer viable
alternative suppliers and thus perceive themselves more dependent on a specific supplier than US firms do. Indeed, faced with larger, more unstable and competitive component markets, US manufacturers can keep their switching costs and dependence on suppliers low. As for suppliers dependence on manufacturers, the data shows no significance across the two countries. In both cases a component supplier, generally a smaller firm, is highly dependent on the revenues brought by the auto company's business.

If we further examine the extent to which manufacturers feel they are making important investments specific to their relationship with a supplier, we find that US managers report a higher score. This may suggest that top management's vision for change is gradually diffusing within US organizations and affecting attitudes and behaviors. Another explanation for lower investments by Japanese manufacturers could be best described in the words of a Japanese manager: "...we have spent the last thirty years developing our relationship with our first-tier suppliers and we now let them do much of the design and development of the component...there is little we need to discover about each other anymore...and we trust they will try hard to keep our business." Japanese suppliers, on the other hand, seem to be the ones in the relationship who are making the critical investments and efforts. US suppliers, in contrast, despite their high dependence on auto companies, seem to avoid tying their assets and investments to any one manufacturer, thus protecting their chances to get business with anyone of the big three or the Japanese transplants.

In addition, the high level of mutual inter-dependence in Japanese manufacturer-supplier relationships seems to foster higher mutual trust and
a stronger predisposition to continue the relationship in the future. We also found that Japanese supplier relations on average have a longer past history (US = 4.42; Japan = 4.90; t = -4.03; p < .001; 1-6 ordinal scale). In fact, follow up interviews with US suppliers revealed that supplier relationships in the US typically date back a long time but tend to be highly inconsistent and intermittent, with little assurance for them to get the contract the next time around.

<table>
<thead>
<tr>
<th>Task Interdependence</th>
<th>Turnover at Supplier's</th>
<th>Structured Tasks</th>
<th>Repetitive Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 2.15</td>
<td>US 2.11</td>
<td>US 3.87</td>
<td>US 3.88</td>
</tr>
<tr>
<td>Japan 2.11</td>
<td>Japan 1.60</td>
<td>Japan 4.41</td>
<td>Japan 3.37</td>
</tr>
</tbody>
</table>

\[ t = 3.45 \quad p < .001 \quad \text{1-5 scale} \]
\[ t = 5.49 \quad p < .001 \quad \text{1-5 scale} \]
\[ t = -6.64 \quad p < .001 \quad \text{1-7 scale} \]
\[ t = -3.21 \quad p < .005 \quad \text{1-7 scale} \]

**Task Characteristics of Boundary Roles**

*The task characteristics of the boundary roles* such as purchasing and engineering also differ across the two countries. Task inter-dependency or the extent to which the purchasing manager or engineer spends his or her time working with a given supplier (e.g. in meetings, over the phone or in visits) is significantly higher in the US sample. A higher level of discontinuity (i.e. turnover rate at the supplier) in the relationship may explain the need for more interactions just to keep track of the relationship. Japanese boundary roles, on the other hand, manage a larger portfolio of suppliers and components, thereby leveraging the synergy embedded in the multiple
sharing of routines in coordination, communication, negotiation and joint production. We also find that boundary roles in Japan involve more structured, modularized and routine tasks that they do in the US. Japanese managers when interviewed attributed this difference to "...the trust that exists between us and the supplier, the high level of information and knowledge exchange over the years...early involvement of the supplier in the design and development of the component..." In contrast, US purchasing managers complained they "spent too much of their time trying to get suppliers up to speed and putting off fires at their factories."

In sum, suppliers relations in the US and Japanese auto industry operate under a very different sets of conditions. Markets for components are structured and regulated under different economic mechanisms, relationships reflect different assumptions about and logics for effective governance, while the tasks that regulate the relationship are configured differently. Let us now turn to the discussion of the differences found across the two countries in their use of structure, process and information technology to increase coordination performance with suppliers.

*Structure for coordination* was measured along several dimensions four of which exhibit interesting and signification differences: the frequency of visits to each other's location, the extent to which managers at the manufacturer work together with multiple functions from the supplier, managers time allocation to different tasks that span the life cycle of the relationship, and finally the comparative use of different media (written mail, phone, fax, face-to-face) for coordination with external suppliers.
US managers report more exchange of visits between them and their supplier, and Japanese managers report working together with a greater number of different functional areas from the supplier. The former finding seems to confirm and illustrate the efforts US manufacturers have been making in the last decade to spend more time with their suppliers, and move away from governing the relationship simply through contracts and pre-established programs and procedures.

To further understand this finding we asked respondents to indicate how much time they spent on different tasks. The results reveal that US managers still spend a great part of their time monitoring the performance of the supplier and resolving urgent problems related to production, quality or delivery issues. Japanese managers, on the other hand, spend comparatively much more time in the early stages of the relationship (e.g. negotiation of the division of labor between the manufacturer, this supplier and other players involved, negotiation of design, cost, quality, inventory and delivery.
requirements) and monitor the supplier to a lesser extent. Japanese managers relate the high performance of their supplier relations to "...the early involvement of the supplier in the design and development stages, and the customary practice of exchanging resident engineers during the design phase...". Transplant managers also commented that "...US firms are starting to make some of the investments [in building the relationship] ...we also had to make early on with our suppliers...we now waste less time testing each others intentions..."

The results about which media is used for the exchange of information with suppliers show no significant difference in the use of the telephone. The use of written mail, though low in both countries, is comparatively higher in US firms. The same data also shows an extremely high level of face-to-face interactions in both countries, with a higher score for the US sample. The important and significant difference, however, appears to be in the much greater use of fax machines in Japanese firms.

Interviews also revealed the extreme importance in Japan of another distinctive structure for coordination. Some Japanese managers attribute a large part of their success to the effective coordination provided by formal supplier associations. These associations, organized along the tiered supply pyramid discussed earlier, promote communication and cooperation between the manufacturer and its suppliers, and between suppliers themselves (e.g. annual meetings, study groups involving all levels from top executives to shop floor managers). The activities of these associations also foster to the diffusion of technical information, product and process innovations.
The use of information technology for coordination with suppliers also offers a contrasting pattern across the two countries. First, Japanese manufacturers are making a greater use of information technology to coordinate with their suppliers than is usually expected. Their pattern and scope of use, however, dramatically differ from US car companies strategy. While Japanese firms are concentrating their investments in a few highly operational areas (i.e. purchasing and production control), US firms not only rely more on technology altogether, but also already apply it to a wider scope of functions (e.g. purchasing, engineering, production control, quality, transportation and payment). Some US information systems managers describe "...EDI (electronic data interchange) as the strategic weapon that should allow them to get data from suppliers faster, with less errors and at a lesser cost..."

US firms established a consortium, the Automotive Industry Action Group (AIAG) to develop industry-wide standards for the electronic exchange of data and documents. The objective is to build an information technology
infrastructure for the standard and common use of EDI with all potential suppliers across multiple functional areas. All manufacturers could then coordinate electronically with any supplier and vice versa, eventually creating an electronic market for components. We find, in particular, that US firms already exchange electronic data mainly over a network, while Japanese auto firms tend to rely on low tech solutions, such as the exchange of magnetic tapes or discs (if not using the fax). Also, when Japanese manufacturers do exchange data over existing Value Added Networks (VAN), they tend to impose their proprietary standards onto the suppliers and provide them with lesser access to their own databases, despite the high level of mutual trust.

More importantly, data shows that despite a more modest use of information technology across organizational boundaries Japanese firms achieve greater data and process integration. In contrast, US suppliers often need to reenter or convert the data they received electronically before using it in their internal information systems. A Japanese manager commented: "...we are not looking for a quick [technological] fix...it is more important for us to first make sure we have compatible assessment methods and technologies, a common language, and that our scheduling and production processes are well integrated...once this is accomplished a tool like the fax can be added to the process if people think we can gain in operational efficiency..." He insisted the main objective is to detect and correct problems as early as in the design process, integrate the production processes between the two companies, and at the same time ensure the perfect execution and coordination of these processes within each company.
**Process for coordination or Partnership in action** represents the activities and processes prevalent in the relationship, which can either foster or inhibit information exchange between manufacturer and supplier. Strikingly, we find a comparatively higher level of conflict or stress in Japanese supplier relations. This suggests a less harmonious reality than what the typical image of Japanese management practices, and confirms that Japanese manufacturers exert their power over suppliers, demanding from them high levels of quality, tight delivery and inventory schedules, shorter lead times and expecting them to lower their costs over time. Data also shows that, at the same time, the resolution of conflict is much more collaborative in Japanese relationships, contrasting with the traditional bargaining and adversarial practices of US firms. In addition, there is more cooperation in Japanese relationships, particularly in areas of joint design and development, together with more commitment (sharing of burdens, risks and benefits) to the relationship by manufacturers.
In sum, the results from the quantitative study reported here seem to suggest a different pattern of response to the contextual factors affecting supplier relationships in both countries. We need, however, to highlight that without further analysis of bivariate and multivariate relationships between the dimensions discussed above and their effect on the performance of the relationship, it is impossible to make valid conclusions about the overall superiority of one coordination strategy over the other.

For instance, the findings from the 447 independent observations of manufacturer-supplier relationships in the US and Japanese auto industry show two radically different models of buyer-supplier relationships, each operating under its proper set of environmental, partnership and task uncertainties with which firms cope in an internally consistent fashion through its distinctive combination of structure, process and information technology. However, do relationships change in the same direction when contextual conditions converge, as when Japanese transplants do business with local US suppliers and US manufacturers deepen their experience with Japanese suppliers?

The fierce competition and virtual globalization of the auto industry contributed to the Big Three's recognition of the importance of their suppliers to their own bottom-line cost and quality performance. This has been followed by a variety of programs to promote a new way of doing business adopting some of the Japanese coordination practices. Yet, the results of our quantitative survey corroborated by interview data seem to suggest that US supplier relations are effectively changing, but at the slow pace and mostly on the surface. These changes, in particular, represent an attempt to blend
together elements of two internally consistent yet inherently different coordination strategies. Their implementation also reflects more a series of reactive business decisions rather than a clear coherent strategy as the one the proposed model would prescribe. No sustained action or measure by US manufacturers has been compelling enough to convey a realistic shift in their commitment to the relationship. Little attention is paid to the necessary changes in process coordination mechanisms and their potential contribution to a closer, more stable and trusting relationship which would altogether augment the effectiveness of the structural and technological coordination mechanisms recently implemented.

Suppliers still face short-term price and quality pressures with little assistance and cooperation from the manufacturer, while at the same time they are expected to make immediate investments to achieve cost reductions, quality and delivery improvements. In fact, they view the increased responsibility (key assumption to the Japanese model) as another way used by the manufacturer to shift its burden onto them (interpretation consistent with the traditional US logic). They understand the short term costs of the changes in structural and technological coordination mechanisms, but they are less persuaded of the long term benefits for them. And it is is no easy matter to convince them without changing their culture, modifying process mechanisms and the climate of the relationship as new structural and [information] technological mechanisms are put in place: after all it took Japanese manufacturers some fifty years of strong commitment and close cooperation to develop smooth and trusting relationships with their now preferred suppliers. And they still see information technology as a tool for and not the driver of change.
Uncertainty and Coordination: Bivariate Relationships

The following set of bivariate analyses represent the direct testing of the bivariate hypotheses underlying the dominant theoretical perspectives when employed separately. Multiple regressions were conducted on the total sample and the two countries samples with each coordination mechanism as the dependent variable, and successively each uncertainty construct as the independent variable. The results from this large number of possible combinations between uncertainty and coordination constructs, however, is consistent with the theoretical predictions. As an illustration, I report here the testing of three such hypotheses:

H1: The greater the partnership uncertainty, the greater the coordination capacity of structural mechanisms,

H2: The greater the task uncertainty, the greater the coordination capacity of process mechanisms,

H3: The greater the task uncertainty, the greater the coordination capacity of information technology mechanisms.

Figure 6 displays the beta values, F ratio and $R^2$ values for the multiple regressions confirming testing H1, H2 and H3. These analyses are not part of a traditional hypothesis-testing study (indeed, were H1, H2 and H3 the original research questions, the research design and measurement instrument would have been different), but rather constitute a test for nomological validity. Specifically, despite low $R^2$, inspection of the sign for beta and the level of significance (t-value) demonstrate consistency with other
empirical work in marketing channels (John and Heide) and organizational theory (Daft and Lengel).

_Uncertainty and Coordination: Multivariate Relationships_

The next set of analyses includes multiple independent variables into the multiple regression. This analysis allows me to compare the relative contribution of each uncertainty constructs to explaining the variations in the dependent coordination variables. This time changes in $R^2$ values and their significances constitute the focus of the interpretation. For illustration, I report the findings for testing the relationship between environmental, partnership and task uncertainty and structural coordination mechanisms.

**H4:** the greater environmental, partnership and task uncertainty, the greater the coordination capacity of the structural mechanisms in use.

Figure 7 displays the results for $R^2$ changes, and their significances, confirming hypothesis H4 and providing strong _nomological_ validity (e.g. Woodward, Lawrence and Lorsch). In addition, the value of $R^2$ change for environmental uncertainty reveals the greater importance of environment or product related uncertainty in explaining coordination strategy. This is an important result which not only supports contingency logic but also suggests that partnership is a second order determinant of coordination.
BIVARIATE RELATIONSHIPS

Environmental → Structural
- $R^2$ change = 22%
- $F$ change = 7.429
- $S$ ig. Change = .000

Partnership → Structural
- $R^2$ change = 5%
- $F$ change = 3.856
- $S$ ig. Change = .024

Task → Structural
- $R^2$ change = 5%
- $F$ change = 2.823
- $S$ ig. Change = .043

Process → Structural

Technological → Structural
Limitations of multiple regression analyses

This set of analyses suffers from its underlying deterministic and reductionist approach to the phenomenon of inter-organizational coordination. It still does not provide any insights into the trade-offs and interactive uses of different coordination mechanisms under various uncertainty contingencies. Though it provides some validation for each of the three theoretical perspectives brought together in the conceptual model, it does not capture the richness of real world dyadic relationships. The immediate normative derivation from these multiple regressions would argue for higher investments in all three coordination mechanisms under higher uncertainty. In reality, such prescriptions are useless given the severe resource scarcity constraints confronting management. Therefore, what is needed is multivariate analyses that can include more than one dependent variable.

It was nevertheless important to conduct these multiple regressions to validate the measurement model (nomological validity) and at the same time to identify the variables to include into the next procedures used to uncover the dominant configurations of uncertainty and the dominant patterns of combining structure, process and technology. More specifically, the variables used in the following set of analyses were selected on the basis of (1) the theoretical grounds underlying the conceptual model and its logic, and (2) the empirical results from the LISREL analyses of the variables measurement properties and from the multiple regressions.
Uncertainty and Coordination: Uncovering Configurations

The previous data analyses informed about the relationship between uncertainty and individual coordination mechanisms, but provide little insight into the patterns in which the three generic coordination mechanisms co-exist and interact among each other. I argued in the theory chapter how a holistic view of coordination and an interaction perspective on the relationship between structure, process and information technology are warranted if we want to capture the complexity of real coordination situations in real industrial settings and go beyond the narrow and incomplete explanation of the theoretical perspectives reviewed: transaction cost economics, organizational theory, political economy.

The uncovering of configurations proceeds in two stages which gradually build up to the identification of nine generic configurations of uncertainty-coordination fit. First, for each country separately as well as the total sample, I uncover the dominant uncertainty configurations. I then test whether these uncertainty configurations defined along 15 variables (7 for environment, 6 for partnership and 2 for task characteristics) exhibit significant differences (oneway analysis of variance with scheffe ranges of 0.05) in coordination and performance. In the second stage of the analysis I uncover the nine dominant configurations of fit between uncertainty and coordination within the data set.

Before interpreting the final results of the analysis, it is important to discuss the techniques used to identify the uncertainty and coordination structures in the sample data set. In particular, it is useful to highlight one of
the methodological contribution of this study in its rigorous and improved use of cluster analysis as a classification technique. Specifically, the analysis conducted here not only implemented the recommendations given by Punj and Stewart (1983) about how to best use cluster analysis, but more significantly represents a first (which warrants a detailed description) in the use of a systematic and objective procedure to determine the "best number" of clusters in a data set. As an example of the use of this procedure we describe how we obtained only nine dominant configurations of uncertainty-coordination fit.

**Cluster Analysis: determining the "best number" of clusters in a data set**

Cluster analysis has become a common tool for social studies researcher. The technique is used for developing empirical groupings of cases or variables which may serve as the basis for further analysis. Despite its frequent use, little is known of the characteristics of available clustering methods and how these methods should be employed. In fact, the use of cluster analysis is frequently seen with skepticism. Punj and Stewart (1983) discuss some of the problems plaguing the empirical use of the technique and build on recent work on clustering algorithms to conclude with some recommendations for an appropriate use of cluster analysis.

A wide variety of clustering methodologies have been developed primarily outside of a single dominant discipline. While factor analysis and other scaling methods can be associated to the discipline of psychology, and regression to econometrics, no single discipline has developed and retained clustering methodology. Rather, numerous disciplines have independently approached the clustering problem (econometrics, psychology, biology, and
engineering). Punj and Stewart (1983) offer an critically important exception to this lack of common language and formal guidelines for the use of cluster analysis.

Cluster analysis when used for classification is typically an inductive technique or a purely empirical method of classification. As such, most techniques developed are concerned with the identification of discrete, naturally occurring categories (taxonomies, configurations, clusters, patterns) within a data set, and makes no prior assumptions about important differences in the population. Resulting clusters should exhibit two key properties, external isolation and internal cohesion (Cormack, 1971). External isolation requires that cases in one cluster be separated from cases in another cluster by fairly empty space. Internal cohesion requires that cases within the same cluster be similar to each other.

Punj and Stewart reviewed these methodologies, and evaluated the most commonly used algorithms. They applied each of these methods to the same data sets and compared their relative performance. The authors propose to distinguish hierarchical methods from nonhierarchical methods. There are primarily four hierarchical methods: single linkage, complete linkage, average linkage, and Ward's minimum variance method. There is, on the other hand, a great variety among the nonhierarchical methods, though they all work on similar principles. These are iterative partitioning methods which begin by dividing the sample into some predetermined number of clusters. Then observations are reassigned to clusters until some decision rule terminates the process. These nonhierarchical methods may differ with respect to (1) the starting partition, (2) the type of reassignment
process, (3) the decision rule used for terminating clustering, and (4) the
frequency with which the cluster centroids are updated during the
reassignment process.

Punj and Stewart conclude from their analysis that three procedures
outperform all other methods: Ward's minimum variance methods, average
linkage, and variants of the iterative partitioning method. Ward's minimum
variance method is therefore the preferred algorithm to uncover the
uncertainty and coordination configurations in our supplier relationships
data set.

Another important conclusion of their review is that the selection of a
similarity/dissimilarity, or distance measure (squared euclidean distance is
preferred), is not critical. More important for determining the outcome of a
clustering solution is the selection of a clustering algorithms (hence, the
choice of Ward's method). The selection of variables is also a frequently
noted concern about the common usage of cluster analysis. Clearly we cannot
know in advance what variables may best differentiate among a set of not-yet
identified clusters. We purposefully avoided the usual approach where
everything known about the observations is used as a basis for clustering and
followed Punj and Stewart's recommendation for a rational or theoretical
basis for selecting the variables.

First, the conceptual model, and its theoretical argumentation provide
the basis for the selection of first set of candidate variables defining the six key
constructs in the model. Secondly, we built upon the previous analysis of
bivariate relationships and other multiple regression results and further
narrow the final set to 15 variables for uncertainty clustering and 14 variables for coordination clustering. This represents an important precaution and a critical strength of the analysis reported here, since one conclusion in several studies is that a variable that is not related to the final clustering solution causes a serious deterioration of the performance of all clustering methods.

Another critical problem plaguing the use of cluster analysis is the lack of a rigorous and objective procedure to identify the number of clusters in the final solution (Everitt, 1979; Sneath and Sokal, 1973). This study also departs from previous empirical uses of cluster analysis as it, for the first time, applies the Calinski and Harabasz variance ratio procedure to identify the "best number" of clusters in the final solution. In hierarchical procedures the researcher is typically required to specify this parameter before running the clustering program, and in nonhierarchical procedures the programs offer the full range of solutions from the one cluster solution to the n clusters solutions. The determination of the final solution is left to the subjective judgement of the researcher.

However, there has recently been a great effort to design reliable and valid procedures for the determination of the number of clusters in a data set (Dubes & Jain, 1979; Milligan, 1981; Perruchet, 1983). Milligan and Cooper (1985) conducted a Monte Carlo evaluation of 30 such procedures applied to artificial data sets containing either 2, 3, 4, or 5 distinct nonoverlapping clusters. They compared the 30 different stopping rules across four hierarchical clustering methods, including the Ward's minimum variance procedure preferred in this study. The results of their simulation revealed
high variability in the procedures ability to determine the correct number of clusters in the data.

One procedure, however, consistently scored very high on the performance and validity criteria: the Calinski and Harabasz (1974) index procedure. It provided excellent recovery of the clusters in the artificial data sets, and performed reliably and consistently across the varying number of clusters. The uncovering of uncertainty and coordination configurations in this study is therefore based on the following decisions:

- data is standardized
- squared euclidean distance is the preferred similarity measure,
- the selection of the variables to include in the clustering algorithms is based on the theoretical considerations underlying the conceptual model and previous analysis of bivariate and multivariate relationships
- the Ward's minimum variance method is the preferred method for cluster formation
- the optimal number of clusters is objectively determined by the Calinski and Harabasz index

Calinski and Harabasz variance ratio criterion

The Calinski and Harabasz index procedure is based on a shortest dendrite method (or minimum spanning tree) for identifying the clusters of points in a multi-dimensional Euclidean space. Their working intuitive definition of a cluster is "that points within a cluster are close together, while
clusters themselves are far apart" (Rao, 1964, p.351). The objective is then to find some minimum variance clusters. The formal index proposed by Calinski and Harabasz is based on two familiar objective functions: the within-group (cluster) sum of squares (WGSS) and the between-groups (cluster) sum of squares (BGSS). The index, referred to as the VRC index, variance ratio criterion, is defined by:

\[
\text{VRC} = \frac{\text{BGSS}}{\text{WGSS}} \quad \frac{k-1}{n-k} \quad n = \text{total sample size} \quad k = \text{number of clusters}
\]

VRC is first computed for a \( k = 2 \) cluster solution, then \( k = 3 \), and so on. For each clustering solution we calculate WGSS, BGSS and VRC. Calinski and Harabasz's conclusion, validated by the Milligan and Cooper Monte Carlo simulation, is to choose that number \( k \) for which the VRC, variance ratio criterion, has an absolute or a first local maximum.

WGSS is the within-group sum of squares (here squared euclidean distances). The distance \( d_{ij} \) between two data points \( P_i \) and \( P_j \) is defined by the function:

\[
d^2_{ij} = (x_i - x_j)' (x_i - x_j), \quad i,j = 1,2, ..., n
\]

If \( d^2_g \) denotes the general mean of all \( n_g (n_g - 1) / 2 \) squared distances between data points within the \( g \)-th group (\( g = 1, 2, ..., k \)). Then WGSS is given by:

\[
\text{WGSS} = \Sigma_i \text{WGSS}_i \quad i = 1,2,g, ..., k
\]

or \[
\text{WGSS} = 1/2 \left( (n_1 - 1) d^2_1 + (n_2 - 1) d^2_2 + ... + (n_k - 1) d^2_k \right) \quad (#)
\]
BGSS can be derived from the value of TSS the total sum of squares. We know that $TSS = WGSS + BGSS$, but also TSS is the general mean of all $n (n - 1) / 2$ squared distances $d^2_{ij}$.

**Uncovering seven uncertainty configuration in the US sample:**

The cluster analysis was conducted first along 9 context variables: 4 variables for product characteristics, 3 for market characteristics, and 2 for task characteristics. Each of the derived clusters was then treated as a separate data set and a cluster analysis was conducted along 6 partnership variables (3 variables for economic interdependence, 3 variables for the climate of the relationship).

As no available statistical package currently provides a program to run the Calinski and Harabasz procedure, the author wrote SPSS subroutines using MATRIX language to compute intermediary computations (see tables below), and manually calculated the index.

**Context clusters: N=140**

The total sum of all pairwise squared distances between the 140 data points in the US sample is $TSS = 1251$. There are $140 \times (140 - 1) / 2$ such distances. A $k=2$ clusters solution gives two context clusters with $n_1 = 57$ and $n_2 = 82$. The sum of squared distances between the cases in cluster 1 is 405, and the sum of squared distances between those in cluster 2 is 701. Consequently, $WGSS$ is given by (#):

$$WGSS = 405 + 701 = 1106$$ and $$BGSS = 1251 - 1106 = 145.$$
and VRC is then derived by (#); \( VRC = \frac{145}{2 - 1} / \frac{1106}{140 - 2} = 18.11 \)

A k=3 cluster solution gives three configurations with:
\( n_1 = 41, n_2 = 16 \) and \( n_3 = 83 \) with respective within-cluster sum of squared distances
\[ \text{WGSS}_1 = \frac{1}{2} (41 - 1) d^2_1 = 229, \]
\[ \text{WGSS}_2 = \frac{1}{2} (16 - 1) d^2_2 = 95; \] and
\[ \text{WGSS}_3 = \frac{1}{2} (83 - 1) d^2_3 = 701. \]

Therefore \( \text{WGSS} = 229 + 95 + 701 = 1025 \) and \( \text{BGSS} = 1251 - 1025 = 226 \), and finally \( VRC \) has a value of: \( VRC = \frac{226}{3 - 1} / \frac{1025}{140 - 3} = 15.09 \)

Following Calinski and Harabasz variance ratio rule to select \( k \) for which \( VRC \) has a general or local maximum as the "best number" of cluster in the data set, we conclude that \( k = 2 \) is the best number of clusters for relationship context in the US sample (cluster A and cluster B).

**Partnership clusters:**
For each of these two clusters A and B we repeat the procedure. Cluster A, including 57 cases, gives a best solution with 4-cluster, while cluster B, with its 83 cases, gives a 3-cluster final solution. The intermediate parameters used to compute the successive VRC indexes are given in the following tables:

**Cluster A: \( n = 57; TSS = 337 \)**

<table>
<thead>
<tr>
<th>( K=2 )</th>
<th>( n_j )</th>
<th>cluster 1</th>
<th>cluster 2</th>
<th>WGSS</th>
<th>BGSS</th>
<th>VRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n_j )</td>
<td>5</td>
<td>52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{WGSS}_j )</td>
<td>28</td>
<td>260</td>
<td>288</td>
<td>49</td>
<td>9.44</td>
<td></td>
</tr>
<tr>
<td>K=3</td>
<td>cluster 1</td>
<td>cluster 2</td>
<td>cluster 3</td>
<td>WGSS</td>
<td>BGSS</td>
<td>VRC</td>
</tr>
<tr>
<td>-----</td>
<td>------------</td>
<td>------------</td>
<td>-----------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
</tr>
<tr>
<td>(n_i)</td>
<td>5</td>
<td>33</td>
<td>19</td>
<td></td>
<td></td>
<td>10.34</td>
</tr>
<tr>
<td>(WGSS_i)</td>
<td>28</td>
<td>147</td>
<td>69</td>
<td>244</td>
<td>93</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K=4</th>
<th>cluster 1</th>
<th>cluster 2</th>
<th>cluster 3</th>
<th>cluster 4</th>
<th>WGSS</th>
<th>BGSS</th>
<th>VRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n_i)</td>
<td>5</td>
<td>21</td>
<td>19</td>
<td>12</td>
<td></td>
<td></td>
<td>11.48</td>
</tr>
<tr>
<td>(WGSS_i)</td>
<td>28</td>
<td>63</td>
<td>69</td>
<td>44</td>
<td>204</td>
<td>133</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>K=5</th>
<th>cluster 1</th>
<th>cluster 2</th>
<th>cluster 3</th>
<th>cluster 4</th>
<th>cluster 5</th>
<th>WGSS</th>
<th>BGSS</th>
<th>VRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n_i)</td>
<td>5</td>
<td>21</td>
<td>14</td>
<td>12</td>
<td>5</td>
<td></td>
<td></td>
<td>11.24</td>
</tr>
<tr>
<td>(WGSS_i)</td>
<td>28</td>
<td>63</td>
<td>30</td>
<td>44</td>
<td>16</td>
<td>181</td>
<td>156</td>
<td></td>
</tr>
</tbody>
</table>

VRC values first increase with the number of clusters, exhibits a first (local) maximum for \(k=4\), then decrease for \(k=5\) and more. Four cluster is then the best number of clusters in the data set represented by cluster A.

The summary data for VRC computations for cluster B shows that the best solution is for \(k=3\).

**Cluster B: \(n = 83\); TSS = 491**

<table>
<thead>
<tr>
<th>number of clusters (k)</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BGSS</td>
<td>87</td>
<td>156</td>
<td>197</td>
</tr>
<tr>
<td>WGSS</td>
<td>404</td>
<td>335</td>
<td>294</td>
</tr>
<tr>
<td>VRC</td>
<td>17.43</td>
<td>18.71</td>
<td>17.71</td>
</tr>
</tbody>
</table>

In the following sections we discuss the characteristics of the various clusters obtained in the US, Japan and total sample for uncertainty and coordination. The use of the Calinski and Harabasz technique allows us to argue that the clusters identified constitute the patterns which best reflect the structure of each data set. In other words, the determination of a seven uncertainty cluster solution for the US sample and only a four cluster solution for the Japanese sample was done in a systematic and objective way.
Uncertainty Configurations

The results for the first set of analysis reveal 7 dominants uncertainty patterns in the US sample, but only 4 in the Japanese and the pooled samples. The mean values for each of 29 standardized variables are used to uncover the configurations, the coordination and performance variables, as well as for a few other variables providing greater detail and insight into each configuration. The analysis for each country separately provides the highest precision and truly reflects the practice and behavior proper to that country. Qualitative comparisons of the patterns across the two countries may identify whether similar configurations exist in both countries and whether some configuration is specific to one national setting. In contrast, the analysis of the total pooled sample "washes away" the specificities of each country and highlights instead the communalities.

The results demonstrate that in both countries there are only a limited number of dominant patterns of uncertainty. Further in both countries these distinct uncertainty patterns exhibit significant differences in coordination and performance. This finding supports a contingency view of inter-organizational coordination. However, we need to further explore the total pattern along the six constructs and identify the configurations of fit between uncertainty and coordination.

Configurations of Uncertainty-Coordination Fit
Figure 8 depicts the original and key findings of this dissertation, i.e. the uncovering of the nine dominant configurations of uncertainty-coordination fit. Each configuration is described in terms of the individual contributions of the environment, the partner and the task to the general level of uncertainty facing the focal firm in its relationship with a given partner, and the coordination mix or combination of structure, process and information technology. The first important general finding is that only nine patterns of fit emerged as valid (see previous methodology section on cluster analysis with Calinski and Harabasz VRC index) and significantly differently across the 29 variables of the operational model (see F ratio, p value and Scheffe ranges data in the appendix). For presentation purposes and to reduce the complexity associated with looking at all 29 variables to represent each configuration, I assign each configuration an aggregate score coded as High, Moderate, or Low (based on the individual score and their significance) along the six constructs. The total number of possible combinations of the six constructs along three levels (H/M/L) is $3^6 = 729$. In other words, there are theoretically 729 different possible configurations of fit (of which only a few could be eliminated on theoretical grounds, e.g. the basic axiom underlying the information processing view of organizations), but the data shows there are only 9 dominant ones in the total sample.

Another critical finding is that four configurations out of the nine patterns of matching coordination to uncertainty (i.e. configurations labelled electronic integration, partnership control, remote control and structural relationship) are common to US and Japanese firms. This strongly attest to the existence and importance (these represent 42% of the total sample of 447 relationships) of institutional practices characteristic of the industry and
transcending the country idiosyncrasies. This result needs to be strongly emphasized in particular in an industry where much of the comparative research (seldom based on large cross sectional databases, but rather on anecdotal or small sample observations) tends to focus solely on the differences across Western (probably the lower performing end of the spectrum) and Japanese (probably the higher performing end of the spectrum) supplier relationships. Also, performance comparisons across configurations reveal that there are also low performing relationships in Japan and highly performing ones in the US. I am in fact in a position to report on which configurations outperform others in each and both countries.

A further inspection of the appendix and the nine patterns of fit shows the high complexity and heterogeneity in the make-up of the two key constructs of uncertainty and coordination. On the basis of a oneway analysis of variance across the 29 variables we classified the configurations into two general domains of lower uncertainty (i.e. a low score for at least two of the three uncertainty constructs) and higher uncertainty (i.e. at least two high scores) conditions, uncovering only three completely homogeneous configurations (i.e. structural relationship appear in a context with systematically high environmental, partnership and task uncertainty, while control through partnership and electronic integration develop in a context low on all three sources of uncertainty) The other six configurations exhibit a composite and mixed fabric for uncertainty.

Discussion of the other key findings follow the detailed description of each of the nine configurations of fit between uncertainty and coordination. Each one of them is first defined in the generic and abstract terms of the
conceptual model. We then add richness and details to the general definition, describing the configurations within the specific auto industry context. Other variables, than the initial 29 used to uncover the configurations, are examined to find out differences along performance measures and other appropriate variables (such as content of supplier proprietary technology, significance of the interface between this component and the rest of the vehicle, level of manufacturer ownership of the supplier, etc...).

High, moderate and low scores are assigned on the basis of the data from the oneway analysis of variance using the severe test of multiple comparisons with 0.05 Scheffe ranges. The US and Japanese samples are treated separately. A hierarchy of three criteria is used to distinguish across configurations. If the first criteria is insufficient to capture the essence of the pattern of fit we move to the second criteria and so on. The first discrimination operates along those variables (tagged with a double star**) for which not only differences across clusters are significant (see F ratio and p-value < 0.05) but also multiple comparisons across clusters are further significant with 0.05 Scheffe ranges. The second set of variables (tagged with a single star*) consist of those that display only significant differences across configurations (these do not pass the Scheffe test). The third criteria (i.e. a pattern of differences, not necessarily significant, across some of the 29 variables or even additional variables for the same construct) was not necessary but nevertheless added some "anecdotal" richness to the definition of each configuration.
Nine Configurations of Uncertainty-Coordination Fit

High Uncertainty

Common
- Structural Relationship
  - High (H) High (H)
  - High (H) Low (L)
  - High (H) Low (L)

- Electronic Integration
  - High (H) High (H)
  - Low (L) Medium (M)
  - High (H) High (H)

Low Uncertainty

- Remote Control
  - Low (L) Low (L)
  - Low (L) Medium (M)
  - Low (L) High (H)

- Partnership Control
  - Low (L) Low (L)
  - Low (L) Low (L)
  - Low (L) High (H)

Unique to US

- Arms length Relationship
  - High (H) Medium (M)
  - Low (L) Medium (M)
  - High (H) Low (L)

Unique to Japan

- Electronic Coordination
  - Medium (M) High (H)
  - Low (L) High (H)
  - Targeted (T)

- Mutual Adjustment
  - High (H) Medium (M)
  - Medium (M) Low (L)

- Quasi-Integration
  - High (H) High (H)
  - Low (L) Low (L)

- Electronic Control
  - Low (L) Low (L)
  - Low (L) High (H)
Four Configurations Common to both Countries

Control through partnership, remote control, electronic integration and structural relationship are the four dominant configurations which exist in both countries (figure 8 in chapter 5 reports their respective proportion in each country and for the total sample).

\[
\begin{array}{cc}
L & L \\
L & H \\
L & L \\
\end{array}
\]

Partnership Control:

Control through partnership comes about in the extreme contextual setting notified by L-L-L, where the market environment, the chosen partner and the task at hand all three give rise to limited uncertainty. The mix of coordination mechanisms, notified by L-H-L, reflects a focus on control activities combined with a strong commitment to nurturing an initially trusting relationship. Invariably this configuration displays higher performance in both country providing strong support for the axiom underlying the conceptual model. Lower uncertainty gives rise to low coordination requirements easily matched by low structural and I.T. mechanisms the coordination effectiveness of which is sustained by way of highly collaborative processes. It is important to notice at this point that the data collected does not allow to verify whether this configuration represents an over-design. In other words, it may be argued that lower investment in process may still yield reasonable performance levels at a lower total coordination cost.
We can elaborate a more detailed and precise definition of control through partnership in the buyer-supplier context as we examine one by one the mean score for each of the 29 variables defining the nine configurations. Product complexity** data (which satisfied the first criteria -- i.e. highly significant $F = 4.90$ and $p$-value $= .0001$ and passed the 0.05 Scheffe ranges test) shows that the components involved are standard** products with a very low level of customization. Technically very simple** they are typically based on a mature technology** and require low engineering efforts and expertise**. In addition, no major innovations** (i.e. functionality improvements, product or manufacturing innovations, price/performance improvements) are likely to occur in the next five years in this type of components. Key informants involved in such "control through partnership" relationships also indicate that volume requirements for the components involved are typical predictable* and testify that the volume forecasts established by their firm are reliable* (product unpredictability satisfied the second criteria -- i.e. highly significant $F = 3.03$ and $p$-value $= .008$).

These same boundary agents estimate that the work they do with the supplier in question is well structured*. There tend to follow a clearly known way to execute their tasks, as specified in the contract or the job description manual. Also for standard products negotiation of the contract, regulation of delivery, inventory and monitoring of quality can be executed following established and proven practices and procedures. Their task is also highly repetitive*, when the same tasks are done in the same way much of the time.

We also conclude from the results for those variables defining partnership uncertainty that this common configuration emerges when the
manufacturer perceives little risk and uncertainty about the supplier. None of the member of the dyad has made any investments specifically for this relationship (low supplier's** and buyer's investments**). Also, not only can the auto company (and the component supplier as well) easily switch to an alternative source of supply if necessary (low mutual inter-dependency**), but in addition they describe their relationship as a highly trusting one (high mutual trust**) and strongly expect the business relationship with this supplier to last a long time (high continuity**). The history of relationship, though, does not need to be long (other configurations displayed significantly higher or lower scores for length of the relationship*).

In this contextual setting where the products are standard, well understood and controlled on both sides, unlikely to undergo major unexpected technical transformations, where boundary spanning tasks are highly structured and repetitive, the coordination capacity of the structural and I.T. mechanisms in place is consistently low. Purchasing managers and engineers reported very few visits made in the last year by an engineer from the supplier to their engineering departments, assembly plant or even purchasing offices. Similarly, they agreed that their purchasing, manufacturing and quality people do not frequently visit the supplier about this component (low mutual visits**, low buyer visits**, low supplier visits**). More to the purchasing managers and engineers time is allocated to control activities* such as negotiating price, monitoring the supplier's performance and resolving very urgent problems.

The use of information technology is non-existent. The scope of I.T. reveals no use across the board (no systematic implementation of a common
infrastructure across multiple functional areas such as purchasing, engineering, production control, transportation, etc...). Responses also indicate that the formal documents used in the multiple transactions involved (e.g. negotiation documents, requests for quote, purchase order, ship schedules, etc...) are still exchanged in paper form via regular mail.

The distinctive characteristic of control through partnership, however, stems from the significantly high investments made by the auto manufacturer in what the conceptual model designates as process mechanisms. There is minimal disagreement between the two firms about component price and design, quality and inventory levels and delivery schedules (low conflict**). Moreover, major past disagreements have usually been resolved in a collaborative manner, based on problem-solving and negotiation rather than confrontation. Finally, the manufacturer report a strong commitment** to the relationship where they equally share the burden, risks, and benefits of the relationship with the supplier. The choice to label this configuration "control through partnership" is motivated by on the synergy created by low partnership uncertainty (strong mutual trust and a belief that the relationship is a long-term one) and investment in process coordination mechanisms (limited conflict, collaborative conflict resolution, high sharing of burdens and benefits).

Performance** measures for the supplier relationships that make up this configuration strongly testify to the virtues of a control relationship embedded within a close and nurtured partnership. The relationship is, for instance, perceived as productive, worthwhile and the boundary agents are satisfied with the level and quality of the information exchange, given their
needs (high satisfaction**). The manufacturer's internal supplier rating also manifest appropriate delivery, quality, or price levels (high performance** composite). Buffer levels**, measured as inventory levels at the manufacturer and the supplier, delivery frequency, and quality levels . are also maintained at an extremely low level.

\[ H \quad H \]

\[ H \quad L \]

Structural relationship:

At the opposite end of the uncertainty spectrum, we uncovered a configuration for relationships operating under high uncertainty conditions. On the one hand, it is difficult to understand and predict the behavior of competitors, the future trends in technology, products and process innovations, and to establish a clear set of goals, procedures and assessment measures around which boundary agents can organize their tasks. On the other hand, the partners available in the marketplace typically present a high risk, primarily because the focal firm depends on their products and at the same time little mutual trust has been built in the dyad.

Despite the poor quality of the climate of the relationship, the focal firm overlooks or decides not to invest in better processes, such as engaging in more joint planning, involving the partner in design processes, offering training and education to its personnel and developing conflict resolution processes based on problem-solving rather than confrontation. The core of
the coordination that needs to be accomplished within the dyad (and these needs are extremely high) is primarily implemented in the form of structural mechanisms, and limited use of information technology capabilities. Structural relationships tend to be low performing ones, as structural coordination capabilities alone are insufficient to cope with the overwhelming set of sources of uncertainties. In a environment where product and market uncertainties run high, a focal firm needs to choose a partner which presents lower risks or invest in developing and maintaining through cooperative processes a close partnership with a select group of partners.

US and Japanese data show that the components transacted through structural relationships are generally specialized products* with a high level of customization to one model from one auto company. They tend to be complex products to manufacture, for which the technology is currently well known, but the expectations in the industry is for major innovations in functionality, product or manufacturing process within the next five years. In other words the nature of the products gives rise to long term uncertainty about the necessary core competencies required to remained a strong competitor in this particular marketplace. In addition, product unpredictability data suggest that even short-term design changes (i.e. during the current design process) are difficult to predict.

It comes as no surprise that boundary spanners rated their tasks as highly ill-structured*, with no objective procedure to follow when problems arise. In fact, much of their time is spent thinking about what to do and how to accomplish it. Moreover, the high frequency of unexpected or novel
events (low task variety) makes it difficult for purchasing managers and engineers to pre-plan and analyze their task in terms of ex-ante established set of alternative courses of action, costs, benefits and outcomes.

This turbulent environment also gives little opportunity for the manufacturer to choose a low risk and uncertainty partner. First, the two partner are from an economic point of view tied to each other (high mutual inter-dependency). The supplier's business is economically important to the manufacturer, and vice versa. In addition, if the buyer or the supplier decided to terminate the current contract it would be extremely difficult and costly to switch to another business partner for the particular component. Reciprocal investments are also substantial. The manufacturer made investments in tooling dedicated its relationship with this supplier and some of its products have been tailored to using this component bought from this supplier. It also has taken a lot of time and effort to learn the supplier's business practices. As for the supplier, they have developed very unique skills and capabilities to design, manufacture and deliver this product to this manufacturer. The layout, facilities and tooling required for the production of this component are typically unique to this supplier. Its technological knowledge, design and manufacturing skills and capabilities are other assets whose specificity to this relationship is reported as high*.

Doing business with a partner you highly depend on becomes even more risky and uncertain when the climate of the relationship is extremely poor. Indeed, structural relationship typically have a short history**, and there is a strong likelihood that it will be re-negotiated or even terminated at the end of the production of the current model (low continuity**). The
extent to which the two firms trust each other is also extremely weak**, which further contributes to the manufacturer fear and uncertainty about opportunistic behavior by the supplier (e.g. asking for the re-negotiation of design constraints, price structure, inventory and quality levels, or delivery frequency).

The only coordination mechanisms extensively in use are structural mechanisms (moderate in the US and high in Japan). The extensive use of rich media such as group or team meetings** testifies to the extent and importance of information exchange between the two firms. However, inspection of boundary agents time allocation reveals that much of their coordination activity involves dealing with very urgent operational problems. There is virtually no use of electronic data interchange between the two firms (extremely low scope of I.T. use** and intensity of I.T. use**). Finally, the processes within which the transactions are accomplished are very unlikely to foster the exchange of information between the manufacturer and the supplier. The key informants at the manufacturer reported extreme levels of disagreement with the supplier about component price, its design specifications, the quality levels the supplier has to achieve, as well as the level of stock to be carried by the supplier and the frequency of delivery to the assembly plant (high conflict*). These disagreements are usually resolved in an adversarial climate through confrontation, and with a negative effect on the relationship. There also is little joint effort and cooperation* between the two firms. The manufacturer's side even agreed that it has a tendency to not share the benefits from the relationship and download the burden and risks onto the supplier (low commitment*).
Just as our model of fit predicts, structural relationship are plagued with low performance. The manufacturer's ratings of the supplier mirror complaints about the supplier development time, its delivery and quality performance, while the key informants subjective assessment of the relationship shows dissatisfaction with the exchange of information and the overall virtue of this relationship. The results about the level of slack or buffers** granted to the supplier also indicate low productivity. Excessive stock has to be maintained, delivery increments are too far apart and the average level of components that the manufacturer has to scrap or return to the supplier is below standard expectations. Also, supplier engineers require a great deal of detail and supervision during the development phase.

Remote Control:

Both countries also have in common another low performing configuration of fit between uncertainty and coordination, where minimal coordination capacity, i.e. a L-L-L structure-process-I.T. combination, does not constitute an appropriate match for a relationship plagued by partnership uncertainty, despite the fact that the focal firm can find other partners partners to do business with, and that the nature of interface coordination allows for "remote control" of transactions by means of a "complete" contract, standard practices and procedures.
Components are typically simple standard products* which require little engineering efforts and expertise, which makes it possible for a large number of mom and pop factory shops to compete in this market (low product complexity*). These are small (small size** as measured in number of employees) independent firms (as measured by its ownership structure**). They generally enjoy a short lived relationship** with the manufacturer, which implies a high turnover among similar suppliers. Examination of additional variables about the characteristics of the supplier, also point to a extremely narrow portfolio** of products submitted to the manufacturer, and a low content* of supplier proprietary technology in the design and manufacture of these car components. Any of these small independent firms can manufacture and deliver these standard parts, but in addition each one of them can sell its total annual production to any one of the major car companies.

Negotiation of the contract, the price for the component, as well as the coordination of ordering, scheduling and delivery processes can be done through the terms of the standard contract governing the relationship, and a set of rules and procedures used for a wide range a such products (i.e. high task analyzability** and low task variety**). Other task characteristics, such as task interdependence*, also mirror an extremely low level of task uncertainty.

It is, though, an unexpected finding to uncover some significant level of partnership uncertainty, despite the stable nature of the product and its market. In fact, we found two separate mechanisms that seem to contribute to the manufacturer's concern about the supplier it is currently doing business with. The first type of remote control relationship (found invariably
in the US and Japan) operates in a negative climate with strong distrust** of one another, under the assumption (by the manufacturer) that the relationship will be terminated at the end of the current contract**. This at first glance should not present a high risk or uncertainty for the manufacturer given the extremely low level of specific investments* and long-term economic dependency on this supplier**. However, further examination of data about the sourcing policy for such components reveals that in spite of its size and power, the manufacturer can potentially be held "hostage" by the supplier for at least the duration of the current contract and confronts serious short-term dependency upon this supplier. Indeed, we traced a clear single sourcing policy for these standard products, where the ratio of annual volume for this component comes primarily from this supplier only*, with no reliance on internal divisions** or other supplier.

The second type of remote control relationship, that we found only in the US sample, offers a brighter picture of the supplier and the dynamics of its relationship with the customer, though partnership uncertainty is still substantial. These relationships perpetuate a long tradition of doing business together (high history** score), and still operate under mutually shared belief that the relationship is a long-term partnership (high continuity**). Nevertheless, insomuch as the two firms have along the years invest a lot of time and effort learning about each others products, manufacturing and management processes, a long history represents for the manufacturer a set of investments highly specific to this relationship, though the supplier and its products can be easily replaced at low costs and adverse consequences to its production process.
The distinctive properties of the "remote control" configuration, however, are not limited to its unusual L-M-L uncertainty pattern, but also include a L-L-L combination of coordination mechanisms, individually and collectively accounting for the poor coordination capacity of the dyad. The purchasing managers and engineers who responded to the questionnaires reported spending little of their time on coordinative tasks*, such as coordinating with this supplier for continuous improvements, exchanging ideas and future plans, or keeping in touch with this supplier. Control tasks*, such as negotiating contracts, monitoring supplier performance, or resolving very urgent operational problems* with the supplier constitute the core of their job. The media most importantly used for information exchange is highly formal and impersonal (written mail*), while richer media such as face-to-face encounter such as group or team meetings or visits* to each others plants are seldom used. Much of the coordination is accomplished along the terms of the contract, with the support of standard procedures and pre-printed paper documents, such as requests for quote, response for requests for quote, purchase order, purchase order, purchase order acknowledgement, etc... Also electronic versions of these structured documents, for which the industry have developed a set of standards under ANSI X.25, have not be implemented.

The processes within which the relationship is embedded also contribute very little to a coordination strategy focused solely on controlling operational transactions from a distance without direct physical manufacturer involvement. Conflict** is extremely high, and in the respondents opinion (i.e. manufacturer side) disagreements are usually resolved in an highly adversarial and confrontational way. The assembler also displays no desire to
share burdens and benefits with the less powerful supplier (low
commitment*), or help the supplier improve through joint efforts and
training/education (low joint action). This lack of investment by the
manufacturer into constructive and cooperative processes indicates it lack of
interest in transforming the relationship (i.e. the first type of market-like
relationship as well as the second one of tradition-mediated relationship) into
a sustained partnership. We noted that for control through partnership the
supplier commitment* and joint action do not provide the type of processes
and activities which could compensate for the stressed relationship, and
indicate no interest for the buyer to invest in the relationship to transform it
into a partnership. In other words, process coordination mechanisms reflect
no desire to try to match and eventually decrease the initial high level of
partnership uncertainty.

We described control through partnership as a "virtuous cycle" where
specific actions and processes (such as reduction of conflict, use of problem-
solving to resolve disagreements, high sharing of burdens and benefits, joint
efforts and cooperation in long range planning, design, process and product
engineering, technical assistance and training/education) are implemented
within the dyad, reinforcing the feeling of mutual trust and the belief that the
two partners are engaged in a long-term mutually beneficial relationship.
Similarly, we argue that remote control represent a "vicious cycle" where
conflict, lack of cooperation and commitment to the relationship feeds into
distrust and a view of the relationship as a bundle of short-term standard
transactions.
US and Japanese firms which resort to this configuration may enjoy low coordination investments and costs, but clearly collect little benefits from it. Indeed, both the first and second type of remote control relationships display poor performance. The constraints and costs of larger buffers, such as poor quality of the supplier's output, or lack of just in time delivery to the assembly line, all move upstream and become a major burden the manufacturer has to bear. The same manufacturers also giving low marks to these suppliers in terms of their price competitiveness, their contribution to lowering costs, or their technical/engineering contribution.

This finding thus provides strong support for our conceptual model and its underlying argument for a fit conception of the relationship between uncertainty and coordination, and the integration of multiple theoretical perspectives. Only explicit consideration of all the multiple sources of the uncertainty faced by a relationship, especially partnership uncertainty, provide an explanation for the poor performance of these relationships. Indeed, the coordination capacity of a L-L-L combination of structure, process and information technology, does not suffice to make up for the poor climate of the relationship. As a result, exit from such a relationship is a frequent recourse considered by US as well as Japanese auto manufacturers.
Electronic integration emerges as an alternative configuration in the high uncertainty domain, and exhibits a heterogeneous H-L-H composite of sources of uncertainty, contrasting with the homogeneous H-H-H uncertainty context for structural relationships. Electronic integration is the configuration of fit reserved for high risk and uncertainty products or market segments, and for those partners whose future behavior presents low risk. In fact, the data collected in the US and Japanese auto industry indicates that under these contingencies focal firms select to internalize or take a majority control over the activity. The associated level of coordination capacity is extremely high along all three mechanisms of structure, process and information technology.

The products entrusted to electronically integrated suppliers are typically the ones close to the core competencies of the manufacture. Their level of complexity** transpires from the design process, through the development of tooling and manufacturing process to the harmonization of production and delivery schedules. These integrated subsystems require high levels of technology** and engineering capabilities manufacturers usually keep close to themselves (high "supplier" content of proprietary technology), and typically undergo frequent major innovations*. In fact, competition in new car models is often wagered in the technology and design of these core components (key informants indicated that the interface between these components and the rest of the car is highly critical).

The fast pace of change in the technology and product design renders the task of purchasing managers and engineers alike difficult to structure and program. Forecasting and pre-planning is not only a high uncertainty task,
but the results and recommendations can quickly become obsolete and irrelevant (very high task variety**). As boundary agents they function in a world of high ambiguity, confusion and lack of understanding of what constitutes the best direction for the future (very low task analyzability**). Likewise the important level of task interdependence* (measured as the proportion of time allocated to dealing with this supplier and this component, and the proportion of that time spent on the phone, in visits and group or team meetings) further speaks to the magnitude of task uncertainty.

The two dyad members are closely tied to each other. Their economic fates are tightly connected (mutual interdependency**). The extent of the manufacturer's specific investments** and assets tied to this relationship illustrates the potential risk and damage to the car company, where the supplier to become opportunistic and suddenly exit the relationship, or worst move to a competitor or simply start leveraging such threats. Not surprisingly, the level of manufacturer ownership of these suppliers indicates that US suppliers governed through electronic integration are internal or allied divisions completely owned by the manufacturer, while their Japanese counterparts are either internal divisions or firms where the auto company's equity ratio typically exceeds 51%. Additional measures of supplier size**, the number of distinct products** supplied by this supplier, and the ratio of internal sourcing** (to compare with the low ratio of external sourcing**) support this conclusion. We thus to electronic integration in the US as electronic hierarchy and in Japan as"electronic keiretsu". These relationships as the product of a long history** of doing business together, a rich climate of mutual trust** and close long-term partnership (high continuity**).
The coordination strategy distinctive of electronic integration consists of the concurrent extensive use of structure, process and I.T. This is in fact the only configuration uncovered that reflects no implicit trade-off or substitution among the three generic coordination mechanisms. Engineers from the supplier side, in particular, pay frequent visits** to the assembler's engineering labs, purchasing headquarters and assembly plants. The practice of guest engineers** residing on the manufacturer's premises or being an integral member of the team involved in the design of a major system. The extensive reliance of impersonal media such as written mail* suggests a exchange of large amounts of data and information, while the amount of time key informants reported spending in visits, group and teams meetings reflect the use of rich media best to deal with ambiguity and lack of mutual understanding. Likewise, boundary agents task allocation reflects a prevalent coordination focus.

The use of I.T. application across the two firms boundaries represents some of the best practice in E.D.I. (electronic data interchange). Assemblers exchange data with the supplier in a form directly readable by a computer. This can be done by exchanging tapes or discs (primarily in Japan), or by sending data from one computer to another via modem or telecommunication links (we of course exclude the use of fax machines): EDI is practiced across multiple functional areas: from purchasing, engineering, quality and production control to transportation or payment through electronic fund transfer (high scope of I.T. use**). In addition, purchasing managers and engineers reported a frequent and consistent use of EDI (high intensity of I.T. use**).
While Japanese purchasing managers emphasize the electronic exchange of purchase orders related documents (i.e. purchase orders, purchase order acknowledgements, purchase order changes, purchase order change acknowledgments) and shipment notice related documentation (i.e. shipment schedule, advance shipment schedule, receiving advice), their US counterpart concentrate their use around negotiation related documents and quotation documentation (e.g. request for quotes, response for requests for quote).

In the engineering arena, this configuration includes those relationships where some the most advanced implementation of exchange of CAD/CAM data with suppliers. Most implementation are first limited to the exchange of paper drawings and two dimensional CAD data. The more advanced relationships also exchange three-dimensional wireframes, three dimensional surface data and even three-dimensional solid data. Also, once they received the electronic data the supplier needs to do very little conversion before using it. The high level of process integration implies that there is little or no need at all to manually re-enter the data into the suppliers internal information systems, and in some instances data is automatically and directly used by the supplier systems.

Process coordination is typically high. This is not to suggest that there exist little disagreement between the manufacturer and the supplier. In fact, data indicates that component pricing, cost structure (and contribution to lowering cost over time), product design, quality levels to achieve, as well as levels of inventory and delivery policies all constitute causes for frequent disagreements and tensions (high conflict**). However, the processes by
which these disagreements are resolved are invariably highly collaborative**, constructive** and based upon problem-solving and negotiation rather than on confrontation. The manufacturer also involves the supplier at early stages of the component design and engages in joint action and cooperation in long range planning, advanced research, product, process and tooling development as well as in technical assistance and training/education. These are the kinds of processes and actions that induce greater information exchange between the individuals involved in a structure-based (i.e. during a visit, a meeting or simply through memos or letters) or I.T.-mediated coordination effort.

Performance measures testify to the high performance of electronic integration. Key informants indicate they are highly satisfied** with the relationship itself and the level of information exchange with the supplier. The independent supplier ratings** conducted by the manufacturer also show short development times, strong technology/engineering capabilities, high quality of equipment, labor management and strong financial standings. Delivery of the component is typically done on a Just in Time basis, with minimal inventory levels at the manufacturer. The average proportion of components scrapped or returned to the supplier is extremely low, attesting to high quality standards.

Two configurations unique to US firms

Two configurations appeared only in the US sample. Electronic coordination presents not only a unique uncertainty pattern, but also a unique coordination strategy, while arms length relationship can be seen as
an alternative coordination strategy dealing with the same H-L-H uncertainty
contingency as the common electronic integration configuration discussed
above.

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Electronic Coordination:

The distinctive characteristics of this configuration is the seemingly
rich coordination mix, somewhat of an over-design, given the low
uncertainty contingency. Indeed, firms engaged in electronic coordination
type of relationships appear to not only implement rich structural
mechanisms and highly targeted I.T. applications, but also make important
investments into nurturing the relationship with the particular supplier, in
spite of a low level of partnership and task uncertainty, and a moderate
environmental uncertainty.

The level of product complexity* (.05) of those components transacted
through electronic coordination is typically moderate. This is to say that
compared to other configurations it is not significantly the highest (i.e. .63)
nor the lowest (-1.09). In fact, we observe the same phenomenon for other
environmental variables, such as product change*, product customization*.

The degree of product complexity, product innovation and product
unpredictability is, however, within bounds which allow for some structure
and routinization for boundary tasks. Task analyzability** displays a significantly high score, suggesting that despite the relative complexity and customization of these products, the operational coordination of the relationship can be analyzed and broken down into manageable and well-understood steps and procedures. In other words, it is possible to analyze and define the set of intrinsic cause-effect relationships underlying boundary spanning tasks. Purchasing managers and engineers can then delineate and control the boundaries for each activities, introducing standardization and routineness* in their job (low task variety*).

Sourcing decisions lead to the selection of supplier with whom manufacturers perceive having a high level of mutual interdependency**. They believe their business is important to the supplier's economic viability and vice versa (high mutual inter-dependency**). Also, none of them, given the high level of asset specificity** (or supplier's investments) can easily switch** to another business partner. The perception of sharing a mutual fate, however, is also associated with a highly positive climate contributing to lesser anxiety about any possible shirking or other opportunistic behavior by the supplier. Trust* and readiness to share sensitive information is strong. Respondents also agreed the relationship is more likely to last a long time than to be terminated at the end of the production of the current model (moderate continuity*).

The logic underlying the conceptual model would however predict and prescribe a mix of coordination mechanisms with collective lower coordination capabilities. In contrast, US data reflects important investments in all three generic mechanisms for inter-organizational coordination.
Purchasing managers and engineers reported a high frequency* of visits from the supplier to their engineering department, their purchasing office and assembly plants. Similarly, they accounted for frequent visits* from their purchasing, manufacturing and quality function to the supplier sites. Multiplicity of channels in the relationship reveals that, for instance, purchasing managers and engineers work together with multiple functions from the supplier, such as sales, product engineers, manufacturing or quality. Information exchange through interpersonal media (low use of mail*) is significantly lower in this configuration than in other. Boundary agents' time allocation does not reflect a control focus*, in spite of the low uncertainty context.

The way I.T. is used in these relationships represents a unique pattern. Information technology is not applied to a wide range of functional areas, as is the case in the electronic integration configuration, but rather concentrated to a few functions (e.g. purchasing and product control). However, the intensity of use in these targeted functional areas is high (intensity of I.T. use). Within the purchasing area, for instance, a large number of the documents traditionally exchanged between the manufacturer and the supplier on paper form (requests for quote, purchase orders, material releases, shipment schedules), are now send over an EDI linkages.

This combination of rich structural mechanisms and highly targeted use of I.T. operates within a set of collaborative and supportive processes. Conflict**, as measured by the extent of disagreements between the two firms in such varied areas as component price, component design, quality levels, delivery schedules and inventory policies, is extremely low. When such
disagreements arise they are dealt with in a highly collaborative* and problem-solving* atmosphere. The manufacturer is also willing to commit* itself to the relationship and share the risks, burdens and benefits of the relationships with the supplier. This configuration also displays the highest level of joint action. This close cooperation extends beyond joint design of the component, its production processes or the tooling machines required, and includes long range planning, technical assistance and training/education.

These arguably over-designed relationship exhibit the highest level of performance** across the configurations making up the US sample of supplier relationships. The manufacturers' supplier rating teams assessed very highly the relationship in terms of the time required to develop the new component, the timeliness of delivery of products to the assembly plant, the quality of the products supplied. The respondents to the questionnaires also express the highest satisfaction** with these relationships. In particular, they praised the quantity, quality, timeliness, usefulness and reliability of the information exchanged between the two firms.

Arms length relationship:

This configuration presents a H-L-H set of uncertainty conditions similar to the one characterizing electronic integration, but a distinct coordination strategy. There is no significantly high investment in either
coordination mechanisms, when compared to the other configurations. Investments are primarily made in structural mechanisms and processes to cultivate the good climate of the relationship. I.T. is not considered as an alternative coordination mechanism.

The differences across configurations along variables for environmental uncertainty were highly significant (F=4.90) and multiple comparisons with 0.05 Scheffe ranges pointed to electronic integration and arms length relationships as the highest in product complexity, product innovation, and product customization. But no difference between the two configuration was significant at a 0.05 level of Scheffe ranges. Thus, similarly to electronic integration, arms length relationships involve highly complex** products with a high level of customization** to the manufacturer's car model. The technology involved in new**, requires great engineering efforts and expertise** and quickly changing (high product innovation**). Short-term unpredictability* (i.e. specification changes, volumes requirement estimations) and uncertainty is also rated high. Agents involved in the management and coordination of such products perceived their tasks as highly ambiguous, un-structured**. Faced with frequent new events or unanticipated problems they enjoyed great variety** and little routine

Though both electronic integration and arms length relationships exhibit low partnership uncertainty, the factors underlying this result are slightly different. Here, what contributes to lower uncertainty about the supplier, is the combination of low mutual inter-dependency** (in contrast with an extremely high level for electronic integration), low manufacturer's investments* into the relationship (in contrast with an extremely high level
for electronic integration), an extremely high level of trust. The other major
difference between the two configurations resides in the shorter history** of
arms-length relationship (this difference between the two configuration is
highly significant at 0.05 Scheffe ranges).

The low frequency of visits**, the moderate use of rich media such as
face-to-face meetings do not use suffice to rate this configurations as high in
structural mechanisms (when compared to other US configurations which
display significantly higher scores). Written mail*, a highly formal and
impersonal media, is used extensively, suggesting the large extent of
information exchange with the supplier. Moreover, the time allocated to
coordinative tasks** (as opposed to control tasks), i.e. coordinating with
suppliers for continuous improvement, exchanging ideas and future plans
with the supplier or keeping in touch, is extremely high.

The use of information technology is low (low scope and intensity),
though not necessarily completely non existent as compared to other non-I.T.
mediated relationships such as structural relationship or control through
partnership. This suggest some emerging investments in EDI applications.

The processes surrounding the relationship reflect a supportive
context, with some tension (moderate conflict level*) though it is resolve in a
somewhat collaborative manner. The manufacturer side also viewed itself
committed to its relationship with the supplier, willing to share the risks,
burdens and benefits involved. These processes contribute to nurturing the
relationship with a business partner about which the level of uncertainty is
typically low to start with.
In the same way that structural and processes mechanisms do not exhibit the highest scores across US configurations, the performance level of arms length relationships is positive, yet not the highest. Objective ratings** by the manufacturer's supplier evaluation team judged favorably the supplier on dimensions of development time, component pricing, quality and delivery performance. Similarly, the purchasing managers and engineers who responded considered the relationship constructive, worthwhile and expressed satisfaction with the quantity and quality of information exchange with them and the supplier. Objective measures of the buffers* (inventory levels at both the manufacturer and the supplier, defect levels of the delivered products, and frequency of shipments to the assembly plant).

Three configurations unique to Japanese firms

As we uncovered two unique patterns in the US sample, we also found three configurations in the Japanese sample with no appropriate equivalent among American relationships. The US sample presented a unique uncertainty pattern in the low uncertainty domain, and an alternative coordination response to the H-L-H uncertainty pattern of electronic integration. Japanese quasi-integration appears as the Japanese alternative to electronic integration, common to both countries, and to the typically US arms length relationship. Electronic control is also the Japanese response to the L-L-L uncertainty contingency which in both countries is managed by remote control.
Electronic Control:

This configuration stands out primarily by its high investment in information technology applications across the two firms boundaries in the context of a close and strong partnership. Its L-L-L uncertainty contingency is typical of the remote control configuration found in both countries.

The components involved are very standard and low technology products (lower product complexity than in the case of remote control), unlikely to experience major technical innovations in the next five years. To manage the interface with the supplier boundary roles typically rely on a set of rules and standard procedures around which they structure their daily activities, as shown by high task analyzability*. Few new and unexpected problems in areas as varied as design (for engineers) as well as production control (for purchasing managers) seem to disturb the ensuing built-in routine (low task variety).

The relationship with the supplier does not give rise to high partnership uncertainty. Mutual trust* is high, and the belief that the relationship will last a long time* is strong. The relationship is unlikely to be terminated after the current contract. The manufacturer did not tailor its products, facilities or tooling to accommodate the supplier's components. It has not either made substantial investments into developing and nurturing a close relationship with the supplier. However, it is aware the high level of specificity* of the suppliers skills and assets (thus investments) to this
relationship (e.g. facilities and tooling, manufacturing skills and capabilities). The end result is a strong perception of mutual interdependence* on each other's business and the belief that it would be difficult for either firm to look for another partner.

The most striking finding about the use of structural mechanisms in this configuration is the important emphasis on control activities. Engineers and purchasing managers responding to the questionnaires typically reported spending a large portion of their time monitoring the supplier's performance or putting off fires. In other words, the high frequency of visits*, and the use of rich face-to-face or group meetings** media do not as of themselves create coordination capacity as they are the tools for controlling the behavior of the supplier (in contrast electronic integration displayed similarly high frequency of visits and group meetings that contribute to high coordination capacity since they are the preferred media used for coordinative tasks such as exchange of ideas and future plans with the supplier, coordination with the supplier for continuous improvements or keeping in touch).

The use of information technology is important not only in its wide scope** of use across multiple functions, but also in the intensity of its use by the department to which the key informants are affiliated to. Indeed, among the technologies currently available for purchasing and engineering, and more specifically among those processes for which data can technically be exchanged in electronic form these relationships exhibit the greater frequency of use (intensity of use**). I.T. applications are also used to coordinate in production control, transportation, quality or payment.
The context surrounding I.T.-mediated control is characterized by a highly supportive set of processes and actions. Conflict**, or disagreements about fundamental terms and conditions of the transaction remains extremely low. In addition, whenever such tension emerges it is dealt with by in a collaborative, and constructive problem-solving mode**. The extent of joint action* is important with cooperation in the long-range planning phases, design as well as operational phases of the life cycle of the relationship. The manufacturer also provides technical assistance, training and education to support the relationship. These processes are also consistent with the reported strong commitment** by the manufacturer to the relationship, in the form of sharing burden, benefits and risks with the supplier.

Performance measures reflect a design of the relationship strong in its coordination capacity given the low level of uncertainty requirements. In fact, the manufacturer's independent rating** of the supplier points to electronic control relationship as the most performing ones in the Japanese sample. The informants satisfaction with the relationship and the nature of information exchange with the supplier is also rated the highest for this configuration. This suggests that under low uncertainty conditions an extensive use of information technology combined with supportive processes can be very efficient. Also this findings suggests that electronic control is a viable, though more costly, alternative to control through partnership.
Quasi-Integration:

This configuration offers an alternative coordination strategy associated with the H-L-H uncertainty context already uncovered in the electronic integration configuration. A major difference between the two configurations of fit stem from the extent to which they leverage information technology capabilities in the relationship. In quasi-integration, the level of I.T. use (scope and intensity) is non-existent, while as we have described above, electronic integration own its name to wide range of functions using information technology to coordinate across boundaries. Another key distinction resides in the level of vertical integration, where electronic integration represents an I.T.-mediated hierarchy. Quasi-integration reflects a strong and active partnership in a high uncertainty context.

As for electronic integration, quasi-integration happens for those products critical to the manufacturer. These are typically high in product complexity (complex to design and manufacturer, requiring great engineering efforts and expertise, based on new technologies). Moreover, the underlying product and manufacturing technologies are not stable, but likely to undergo major innovations in the near future. For instance, a better design may emerge improving the components functionality or price/performance ratio. Some new material or new process technology or tooling machine may be developed, thus reducing the cost of producing the component. In other words, the industry is expected these improvements and therefore little pre-
planning and even forecasting of competition can be done, thus the high environmental uncertainty. Even, short term unpredictability further adds to the instability of the relationship environment as design specification changes and volume requirements are difficult to predict.

As a consequence, the job of those agents responsible for coordinating key transactions such as purchasing and design (e.g. negotiating price, component design specifications, delivery, inventory, and quality levels) is rated as highly ill-structured and non-routine. New problems frequently arise at multiple stages, not only at the planning or design phases, but difficulties may come back to haunt engineers after production has started.

However, in spite of the high risk environment, Japanese manufacturer have developed and nurtured a set of partnership relationship with some suppliers. The mutual trust they achieve in the relationship, thus constitutes the safeguard against any opportunistic behavior from this supplier. As we have discussed in the "two models of supplier coordination" section the manufacturer establishes such a relationship with two to three highly capable and trustworthy suppliers which it get to compete and collaborate, therefore maintaining its control over and pressure onto suppliers. This "visible hand" competition as Itami (1989) refers to it, emulates the suppliers to develop new technologies and improve their manufacturing process so as to stay in the select club and maintain some "constructive" pressure. The results from the analysis, for instance indicate significant mutual trust* and perception of continuity* (though not as high as for electronic integration). The supplier typically has highly invested in this relationship. Its tooling and facilities, its design and manufacturing skills and
capabilities are also specific to the manufacturer (high supplier's investments*). The manufacturer side also has heavily invested into the relationship, though not as high as in the case of electronic integration or coordination by cooperation (described in the next section).

The coordination practice in quasi-integration reflects a strong structural linkage with a high frequency of reciprocal visits*. The exchange of guest engineers, i.e. engineers from the supplier or the manufacturer, involved in the design process living on the partners premises. These frequent visits to engineering, purchasing or assembly plants do not necessarily occur only when there is a problem, these instead represent regular efforts to coordinate production and delivery between the supplier's production factory and the manufacturer's assembly plant. This is also confirmed by the results for boundary agents time allocation. Coordination*, as opposed to control, is their primary focus, as reflect the greater time spent on activities such as coordinating with supplier for continuous improvement, exchanging ideas and future plans, keeping in touch, or jointly developing and testing this component with this supplier. Group or teams meetings* also appear as the preferred way of exchanging information with the supplier.

On the other hand, the scope** and intensity** of information technology are significantly low, indicating no desire to substitute this rich set of structural mechanisms and leverage I.T. capabilities.

As for process mechanisms, they represent a key component of the coordination strategy of quasi-integration. This is not to say that there are no
disagreements between the two partners, in fact, respondents reported a high level of conflict** around issues central to the operational efficiency of the multiple transactions involved, e.g. component price and design, quality tolerances, inventory policies and delivery quantities and frequencies. However, it is clear that these frictions are resolved in a highly collaborative** manner, which indicates a constructive and intense level of information exchange between the two firms. A distinctive characteristic of quasi-integration (in particular, when we compare it to the following configuration of coordination through cooperation) is the high level of commitment** (sharing of risks, burdens, and benefits with the supplier), but not necessarily a high level of effective cooperation and joint action* (this particularity of quasi-integration is further discussed in the next section for coordination through cooperation).

As for performance, quasi-integration appears as a moderately performing* configuration, in other words other configurations, such as electronic control or control through partnership for low uncertainty and electronic integration for high uncertainty cases exhibit higher performance.

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Mutual Adjustment:

This is a unique configuration which displays the only H-M-H uncertainty pattern uncovered and a -M-H-L coordination mix. It operates in a contingency environment which falls in between the high uncertainty
context surrounding structural relationships and the one surrounding partnership rich electronic integration and arms relationship (found only in the US). The difference across these uncertainty pattern stems from the sole construct of partnership uncertainty. This uncertainty, as illustrated in some of the previous configurations, tends to abate in two typical cases: (1) when the focal firm's specific investments into this relationship are not important, thus decreasing its dependence upon and the influence of the other dyad member, or (2) when the focal firm can trust the partner not to take advantage of its privileged position and status (arising from high mutual dependency or high manufacturer's investments). As for coordination, processes appear as a key to the effective functioning of the structure (no information technology), and the success of these relationships.

In a mutual adjustment type of relationship, Japanese firms typically invest in structural and process mechanisms in spite the high level of uncertainty arising from the environment, the task and the partner. The components handled through this configuration are products for which the manufacturers are highly dependent on the supplier, even though the trusting climate has not been developed or nurtured for different reasons. Interviews with Japanese purchasing agents suggest two general cases: (1) a new technology developed by multiple suppliers and the manufacturer has not yet committed itself to any particular supplier, or (2) a supplier is gaining power and influence by controlling the design and manufacturing of a key technology and the manufacturer decides to safeguard itself from potential opportunistic behavior by this supplier and outsources to other supplier or re-establishes an internal sourcing capability. The important implication is a
perception of risk and uncertainty rated much higher than for quasi-integration.

Task uncertainty, as we have noticed by now, usually follows environmental uncertainty. High complexity and innovation components generally lead to greater levels of uncertainty about the market, the future structure and rules of competition, but at the same time they represent products for which it is difficult to forecast, pre-plan or standardize what has to been done on a daily basis in areas such as design, manufacturing or delivery transactions.

What distinguishes mutual adjustment from quasi-integration, is their significant differences along the construct of structural mechanisms and two dimensions of process mechanisms (i.e. commitment and joint action). In both configurations the use of information technology is extremely low (low scope of I.T. use and low intensity** of I.T. use). All measures of structural mechanisms rate as significantly moderate. In particular, the manufacturer and the supplier pay each other less visits* than in quasi-integration relationships. The emphasis on either control or coordination is not apparent, which implies that boundary spanners do not significantly allocate a greater amount of time to control tasks (such as negotiating the contract, monitoring the supplier) or coordination tasks (such as coordinating with supplier for continuous improvement, or exchanging ideas and future plans with the supplier).

As for processes, quasi-integration and mutual adjustment emerge as two configurations with high aggregate process capacity when compared to
other configurations uncovered in the Japanese sample. However, future inspection of the make-up of this process construct across the two configurations reveals similarities and differences. In both cases the tension (high conflict**) in the relationship is high with major disagreement about the key conditions to the relationship (component price, design specifications, delivery, inventory and quality). This occurs, also in both configuration, in a collaborative** and problem-solving context. The distinction between the two, however, stems from a lower extent of (current) commitment** to the relationship (i.e. sharing of risks, burden and benefits of the relationship with the supplier) on the part of the manufacturer in mutual adjustment, despite their substantial investment in joint action for various areas along the life cycle of the relationship (planning, design, manufacturing, technical assistance).

Performance measures reflect an inherent mismatch underlying mutual adjustment. Indeed, the coordination capacity of a M-H-L structure, process, I.T. pattern does not seem to suffice to cope with the high uncertainty contingency of a H-M-L uncertainty pattern.
Chapter V

Pulling it together:
Contributions, Implications, and Extensions

Theoretical Contribution

The theoretical contribution stems from the development and empirical validation of a conceptual model for inter-organizational coordination which bring together three dominant research perspectives usually considered separately, i.e. transaction cost economics, organization theory and political economy. The model argues for an interaction view of the relationship between structure, process and information technology, under the strong contingency effect of sources of uncertainty. This integrative model provides a rich conceptual tool to better understand and describe the determinants and components of inter-organizational coordination. In particular, it predicts the existence of a wide range of hybrid arrangements between the two extreme pure forms of market and hierarchy proposed by transaction cost economics. Indeed, the model developed in this dissertation includes not only the economic, structural, and technical elements of a relationship but also its behavioral and socio-political elements. At the same time as the model allows to organize the complex set of factors that could influence the nature of coordination, it achieves parsimony (i.e. consists of 3 generic sources of uncertainty and 3 generic coordination mechanisms), internal consistency and domain coverage (through the fit logic and the integration of appropriate theoretical perspectives).
Empirical Contributions

The conceptual model in addition can serve as a framework to empirically examine several research issues in specific industrial contexts. Specifically, I apply the model to the context of buyer-supplier relationships in the US/Japanese auto industries and show that the six constructs of uncertainty and coordination mechanisms can be operationalized using observable and measurable indicators (Bagozzi, 1980). Chapter 3 demonstrates further that the observable indicators used to operationalized and measure the constructs satisfy the required measurement properties (Bagozzi, 1980).

The results derived from a variety of statistical analyses conducted on a highly reliable and valid data set collected from US and Japanese manufacturers (447 data points) provide insights about:

(i) differences in supplier relations coordination across the US and Japan, testifying to the existence of two general models of supplier coordination,

(ii) but also differences within each country supply system. In particular,

1. we uncover distinct configurations of uncertainty in the US and Japan,
2. we uncover distinct patterns of coordination across these uncertainty configurations,
3. we observe performance variations across these uncertainty configurations.
4. we uncover nine configurations of fit between uncertainty and coordination. These configurations also display performance variations.
The empirical findings, summarized in figure 8, also demonstrate that a configurational approach to uncovering patterns of coordination is more insightful than sets of bivariate and multivariate reductionist analyses (the two sets of multiple regressions). First, it shows that under different uncertainty contingencies — i.e. for different types of products — (there are altogether six distinct uncertainty patterns) relationships with suppliers exhibit variations in coordination.

More precisely the findings support the conception of fit as configuration (or gestalt) for the relationship between uncertainty and coordination. As illustrated in the appendix, higher performance is displayed by relationships which reflect a fit between coordination and uncertainty. In other words, I did not find high coordination systematically leading to high performance. For instance, partnership control does not reflect high coordination capacity, but it seems sufficient to cope with the low uncertainty for highly standardized and simple products. On the other hand, the coordination capacity of structural relationships is inadequate to balance the high uncertainty for complex and customized products.

The findings also are consistent with the equifinality perspective. For instance, the same H-L-H pattern of uncertainty is balanced in both countries by a H-M-H coordination mix (electronic integration) or by a M-M-L coordination mix in the US (arms-length relationship) or by a H-H-L coordination mix in Japan (quasi-integration).

The nine configurations also provide an empirical taxonomy for dyadic relationship that span the range provided by transaction cost
economics. Between electronic integration (hierarchy) and remote control (pure market) I uncovered 7 hybrids and offer a conceptual framework and a descriptive instrument to represent and define these intermediate arrangements. Some lie in the low end on the uncertainty spectrum, as variations of the pure market relationship, e.g. control partnership and electronic control. Others differ from a hierarchy in their governance structure (ownership) but offer either a strong process and partnership integration (e.g. mutual adjustment and quasi-integration), or a strong structural integration only (i.e. structural relationship).

As for the role of information technology, it appears that there are only three of the nine dominant configurations that exhibit I.T.-mediated coordination. All have in common a strong partnership characterized by low partnership uncertainty and strong investments into process mechanisms. This result is consistent with the general conclusion from the management in the 1990's project (Scott Morton) suggesting information technology implementation is successful when processes have been changed as well. In the case of inter-organizational coordination, the equivalent conclusion argues for the association of implementation of electronic exchange of information with a strong partnership.

**Methodological Contributions**

The two original methodological contributions consist of:

1. a LISREL two group analysis across the two countries which reveals a set of critical measurement issues for cross-cultural studies, (described in chapter 3)
(2) the first application of the Calinski and Harabasz (1974) Variance Ratio Criterion index to a empirical data set for the identification of the best number of clusters (described in chapter 4).

Implications

Findings about the proportion of each country sample and of the total sample the nine configurations represent by each configuration show that 42% of the total sample consists of the four common configurations, which also display a similar distribution across the two countries. This result strongly demonstrates the importance of the institutional effects germane to the auto industry, beyond the culture or national differences. It also shows that arms-length relationships (37% of the US sample) constitute the most dominant configuration in the US, while mutual adjustment and quasi-integration are the most dominant ones in Japan.

Figure 9 graphically positions the nine configurations along two independent dimensions: relative degree of information exploitation (correlated with partnership), and relative degree of technological exploitation. This figure demonstrates the variety in supplier relations in both countries, and warns against the danger of drawing inappropriate conclusions from comparing randomly selected supplier relations. For instance, comparing a Japanese quasi-integrated relationship with a US electronic coordinated relationship would unjustly lead to conclude the superiority of the Japanese model, when our findings about fit demonstrate that electronic coordination is also a performing configuration given the lower uncertainty contingency it faces.
These same empirical findings show that three of the common configurations lie in the low-low corner, indicating that manufacturers in the two countries tend to differ in the economically and technically critical area of complex, highly customized and fast changing products. Japanese firms emphasize the development and maintenance of the long-term partnership relationship (i.e. mutual adjustment and quasi-integration), without necessarily investing into information technology. Technology is implemented with those close partners (i.e. electronic integration or first tier keiretsu suppliers) for which processes are highly integrated already or for those where the processes are so simple that they can be automated (i.e. electronic control). In contrast, US firms tend to implement information technology with vertically integrated divisions (i.e. electronic integration) or with suppliers where the processes have not necessarily been integrated (electronic coordination). This may reflect a desire to substitute information technology for the more costly investments into developing and nurturing a long-term relationship based on trust, mutual benefits and joint action.

Limitations and Extensions

One important limitation of this empirical study lies in exploration of only one side of the dyadic relationship. The perceptions collected from purchasing managers and engineers from the auto manufacturers should be confronted to those perceptions from the supplier.

In addition, the data set did not provide an exact matching of the components across the two countries, which prevents conclusions about differences across specific products instead of the conclusions reached formulated along theoretical dimensions of the characteristics of different
components. I can only conclude about difference between simple and complex products, standard and customized products, when it might be useful to compare across tires, disc brakes, anti-lock brakes, etc...

The uncovering of nine configurations of uncertainty-coordination fit may well be limited to the auto industry. Other configurations may emerge in other industrial (e.g. electronics, pharmaceutical, insurance), national (e.g. European firms) or relationships (e.g. strategic alliances, joint ventures). Similarly, some configurations appearing in the US/Japanese auto industry may not exist in other contexts.

These limitations call for further empirical research in other industries and countries. Study of the transplants should provide further insights and uncover configurations of cross-national relationships (a Japanese manufacturer with a US or European supplier).

Also the low proportion of electronic configurations calls for an examination of the dynamics of the relationship. In particular, revisiting the same sample in two to three years may reflect a different proportion for each configuration.

Finally, future research should include the other side of the dyad. A sample of matched manufacturer-supplier pairs would provide a strong research design to examine the determinants and components of inter-organizational coordination as they are perceived by each side of the relationship.
References


Gardner, J. and M.C. Cooper (1988). *Elements of Strategic Partnership,*


