Coordination Costs, Organization Structure and Firm Growth

by

Yue Maggie Zhou

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Business Administration)
in The University of Michigan
2008

Doctoral Committee:

Professor Jan Svejnar, Chair
Professor Gautam Ahuja
Professor Scott Page
Assistant Professor Sendil Ethiraj
Assistant Professor Jagadeesh Sivadasan

To My Family

Acknowledgements

In spring 2001, I was considering taking a leave-of-absence from my job in Washington, DC, and joining my husband in Ann Arbor. On my return from a business trip to Gaborone, Botswana, I visited the offices of Francine Lafontaine and Scott Masten and asked them about taking a break from the corporate world and pursuing a PhD in the business economics department. After listening to my half-baked research interests about corporate restructuring, institutions, global competition and firm growth, they both recommended that I talk to Jan Svejnar. Before I left her office, Francine also cautioned me that a PhD study is going to be a long "break."

It turned out to be more than a long "break." It set out a whole new journey for me. The journey started on August 19, 2002, when I flew into my first PhD class from Sophia, Bulgaria, and began to allow linear algebra to crowd out of my mind all the contract terms for the investment projects that I was working on. Six years later, with a dissertation in hand, it is time to thank all the people who generously helped me in passing the most important milestone of this new journey.

I am especially indebted to my committee members. Jan Svejnar has been an inspiration for true scholarship. I am grateful for his extreme flexibility with my research interests, his patience with my adventurous endeavors, and his persistent emphasis on my following rigorous scientific reasoning and robust methodology. He encouraged me to always link strategy phenomena with the most fundamental economic concepts, and supported my pursuit of explanations that are beyond pure economics. Jan is a role model who has successfully blended academic research into effective policy analyses, making a direct impact in the real world. He is a great person who, despite his demanding schedule, never hesitates to offer his wisdom, research experience, and generous help to people regardless of their rank and power.

Gautam Ahuja helped me enormously, not only with my attainment of the PhD but also the job market process. His doctoral seminar is one of the best seminars in the PhD program. After visiting to many top-tier schools, I also start to appreciate the instrumental role that he played in building up the Strategy doctoral program at Michigan. His comprehensive and insightful overview of the strategy field, his passionate and generous support for my pursuit of a cross-discipline subject, his critical yet invaluable comments and suggestions on my dissertation and presentations at every important stage of my PhD study, have made me a much stronger student of management than I would have become on my own.

Sendil Ethiraj has had a dominant influence throughout the dissertation process. I first went to Sendil with a gigantic organization chart of Citigroup, asking for his opinion about writing a dissertation explaining the complex organization structure. I had only the agency theory in mind. It was Sendil who helped me connect the structure with coordination. He attributed so much real-life phenomena to coordination that I jokingly asked whether countries need to coordinate with each other to start a war; now I truly believe the answer is yes. I am grateful to Sendil for his insightful guidance, invaluable advice, numerous rounds of stimulating discussion, and patient reading of consecutive drafts of the dissertation proposal. His exceptional mentorship has been instrumental in my development as a student of management and an academic writer. It is indeed my fortune and pleasure to have worked with him. This dissertation would not have been possible without his close supervision and constant encouragement.

I am thankful to Jagadeesh Sivadasan for offering much help during the dissertation process. He generously shared with me the DCA dataset, which is critical for my empirical analysis, and his research proposals and working papers to provide additional data. He showed me the true color of a pure empiricist and acted as a sounding board for the econometric issues in the dissertation. To hear from him that the dissertation makes a significant empirical contribution despite the data and methodological limitations is very encouraging. He demonstrated a remarkable capacity for managing multiple demanding tasks, including publishing, teaching, advising, and being a temporary PhD coordinator.

I thank Scott Page for agreeing to serve on my committee. He has been a strong and generous supporter despite his busy schedule. He contributed much more than what I had originally expected from him: his expertise on complexity, political science and economics. Despite being a professor outside the business school, he provided a great amount of practical and corporate insights to my study. His superior capability and his passion to reach out to inter-disciplinary research institutions, real corporations, and a diverse group of students have been truly inspiring.

Apart from my committee, I thank the many faculty members at Michigan who have been influential to my academic development. Francine Lafontaine has never hesitated to offer her genuine advice and support. Katherine Terrell has been a PhD coordinator with a warm heart. She also gave me very flexible assignments as a research assistant in my first year, so that I could finish my ongoing work projects on a part-time basis and transition smoothly into the PhD program. Margret Levinstein has been exceptionally

supportive to my application to use the Census data. Scott Masten has always been a great advisor to talk to. Michael Jensen is the first to show me how to write for a management journal, and how to become an interesting researcher and passionate educator at the same time. Hart Posen, Brian Wu, and Minyuan Zhao have read multiple versions of my papers and given very useful feedback. Their generosity with their time and constructive comments make the dissertation process less intimidating. Marina Whitman and Martin Zimmerman provided me their insights into the internal organization of firms by sharing their experiences at GM and Ford. James Westphal, Arvids and Rosemarie Ziedonis have given valuable advices at various points.

In addition, I am grateful to many other professors who have taught me during my PhD study, including the visiting professors and those who have since left Michigan. They help lay a solid foundation for my intellectual pursuit. They include Jay Anand, Juan Carlos Hallak, Gerald Davis, John DiNardo, Fritz Foley, James Hines Jr., Kai-Uwe Kuhn, Illoong Kwon, John Laitner, James Levinsohn, Bill Lovejoy, Mark Mizruchi, Vikram Nanda, Serena Ng, Emre Ozdenoren, Joanne Oxley, Shinichi Sakata, Stephen Salant, Daniel Silverman, Jeffrey Smith, Lones Smith, Linda Tesar and Luigi Zingales, among others.

I am fortunate to be surrounded by a group of dynamic and highly motivated PhD students. Anne, Aradhana, Ben, Bo Kyung, David B., David Z., Eun Hee, Francisco, John, Matt, Mike, Nathan, Na Eun, Noah, PK, Pranav, Renata, Sun Hyun, Vivek, Xiaoyang, Yao, Yuriy and many others provide me with a great amount of energy, inspiration, fun, and excitement. I thank them for their patience to sit through my numerous practice talks,

take notes, and share their thoughts on and beyond research. They make Ann Arbor a great place to study. I will miss their company.

I thank Martine Boron, Chris Gale, Lynn-Marie Kujawa, and Faith Vleck for their invaluable assistance with the administrative matters. Paul Michaud and Zhi Wang made my computing tasks seamlessly easy. I am also grateful for the fellowships received from Gerald and Lillian Dykstra and the family of Thomas William Leabo. The Ross School of Business and the Mitsui Life Financial Research Center provided both fellowships and research grants.

Beyond Michigan, I have received extremely valuable comments on my dissertation from a number of researchers. I gratefully acknowledge the insightful feedback and suggestions provided by John M. de Figueiredo, Michael Jacobides, Daniel Levinthal, Joseph Mahoney, Gabriel Natividad, Phanish Puranam, Charles Williams, and Peter Zemsky. I thank participants at the 14th Annual Consortium on Competitiveness and Cooperation for their helpful comments. I appreciate the thoughtful questions and comments made by seminar participants at Duke, GWU, LBS, Maryland, UCLA, UIUC, UNC, and USC.

Like every other journey in my life, my pursuit of the PhD would not have been possible without the unqualified support and understanding of my family and friends. I begin by thanking my grandpa, for sharing his rich life stories during one of the most dynamic periods in Chinese history, and cultivating in me the thought that business can have a lasting impact on the society beyond wealth-creation. I am deeply indebted to my dear parents for always encouraging me to pursue my full potential, be it in academia or other professional fields. I thank my husband Jianzhi for his continued love and patience.

I would not have started this journey toward a PhD if it were not for him. My boys, Daniel and Andy, bring a whole new world to my life, and give me the strength to continue in my most difficult times. I am grateful to my parents and my in-laws, especially Xiao Qing and Xiao Yu, for taking extremely good care of my children to allow me to concentrate on my dissertation. Last but not least, I thank many of my former colleagues and friends at Arthur Andersen, the World Bank, the International Finance Corporation and the International Monetary Fund, for their friendship, inspiration, and support. Thank you all! Thank you for sharing the journeys with me, laughing with me on the good days and giving me hope on the bad ones. You make my life complete.

TABLE OF CONTENTS

List of Figures

List of Tables

Abstract

Coordination Costs, Organization Structure and Firm Growth

by

Yue Maggie Zhou

Chair: Jan Svejnar

This dissertation views firms as systems of interdependent activities and investigates the role of coordination costs in setting limits to firms' growth strategies and organization structure. It contains three interrelated studies. Study I examines the impact of coordination costs on firms' diversification strategies. A synergistic view of diversification suggests that firms are more likely to diversify into a new business that shares significant resources with their existing businesses: There is more potential for synergies. Study I argues that, to realize the potential synergies, firms need to actively manage the interdependencies caused by resource sharing, which adds to coordination demand from firms' existing businesses, and may cause marginal coordination costs to outweigh marginal synergistic benefits. The impact of coordination costs is particularly significant if the existing businesses are already complex. The argument takes into account the joint effects of synergies and coordination costs, and offers a unique explanation for the limit to related diversification. Study II examines the impact of the activity system on the partitioning and recombination of organization units inside the firm. It investigates how the complexity and decomposability of the activity system affect the firm's choice of a more modular, integrated, or hierarchical structure. It argues that the degree of organization integration is constrained when the activity system is highly complex, whereas for a given level of complexity the degree of organization modularity is constrained by the decomposability of the activity system. Under both constraints, a hierarchical structure plays the important role of coordinating inter-unit interdependencies. Study III extends the inspection of organization structure from firm to unit level and examines the differential delegation of coordination responsibilities within a hierarchical structure. It exploits institutional differences across host countries where multinational corporations operate. It proposes that institutional differences affect the local units' ability to coordinate via the differential availability of information and clarity of property rights; differential delegation is an important vehicle to countervail such coordination constraints. I find support for my hypotheses using data of U.S. equipment manufacturers from 1993 to 2003.

Chapter 1

Introduction

1.1. Theoretical motivation and outline of the dissertation

Why do firms in the same primary industry vary in their scope in related product markets? For example, why does Honda make cars, trucks, motorcycles and even small aircraft (with its recent launch of HondaJet) whereas General Motors and Ford only make cars and trucks? What do "lean-manufacturing systems" and "vertical-disintegration processes" imply for firms' horizontal scope? Finally, with the recent shift toward "flatter organizations" that is reported in both popular press and academic research, what roles do middle managers continue to play?

This dissertation examines these questions with respect to coordination costs. More specifically, it views firms as complex systems of interdependent activities and investigates the role of coordination costs in setting limits to firms' growth strategies and organization structure.

Existing theories of firm growth "explained why there were firms but not how the functions which are performed by firms are divided up among them" (Coase, 1993: 73). We often observe that, even when there are significant transaction costs in the market, firms face limits to growth, suggesting that integration costs rise with firm size and scope. But how such integration costs increase with firm scale and scope is still puzzling (Holmstrom & Tirole, 1989). Without a theory of how integration costs increase with firm scale and scope, an understanding of the limits to firm growth remains essentially incomplete. In this dissertation, I take a first step in outlining such a theory. The starting premise is that the benefits to carrying out an activity within the firm are increasing in the synergies or complementarities with the existing activities within the firm. Without such synergies, there is no added value to integration. Given this premise, it follows that firms must actively coordinate activities to realize the benefits of synergies. Thus, I focus on coordination costs as a central component of integration costs. I argue that limits to firm growth are intimately tied to the coordination costs associated with realizing synergistic benefits.

Furthermore, focusing on coordination costs places a central emphasis on firm difference. To the extent that firms have different activity systems and thus different demand for coordination, we are likely to observe differences in firms' growth strategies and structures even within the same industries. In this context, my theory of how coordination costs vary with firms' activity systems is consistent with a variety of sub-literatures in strategy that suggest persistent differences in firm strategies, structures, and performance (Axtell, 2001; Ijiri & Simon, 1964; Lippman & Rumelt, 1982; Nelson, 1991; Rumelt, 1991).

The dissertation asks the following research questions: (1) How does the cost of coordinating the activity system limit firm scope? In particular, how does the activity system affect firm diversification strategies? (2) How does the need to coordinate the activity system affect the design of organization structure? In particular, how does the activity system affect organization partitioning (modularity) and recombination (hierarchy)? (3) How does the need to coordinate the activity system affect the design of organization structure when the activities span heterogeneous institutions? In particular, how does the activity system affect the delegation of coordination responsibilities within a hierarchical structure? These questions are answered in sequence in three inter-related studies. The studies are presented following the literature review, in Chapters III, IV and V.

Chapter III examines the joint effects of synergistic benefits and coordination costs on the direction of corporate diversification. It complements the dominant synergistic view of diversification by highlighting the costs of coordination. It studies how the complexity of a firm's existing activity system influences its choice of a more vs. less related diversification strategy.

While Chapter III focuses on the impact of the existing activity system on the external boundaries of the firm, Chapter IV examines its impact on the internal boundaries of the firm – the partitioning and recombination of organization units. In addition to complexity, Chapter IV analyzes the decomposability of the activity system based on the inherent interdependencies between activities. It studies how the complexity and decomposability of the activity system affect the tradeoff between specialization and coordination, and consequently the firm's choice of a more modular vs. a more integrated organization structure, and the degree of hierarchy the firm adopts in its organization structure to coordinate interdependencies between organization units.

Whereas Chapter IV predicts the degree of hierarchy in an organization structure, it is agnostic as to how coordination responsibilities over each individual activity could be differentially delegated within the hierarchical structure. Differential delegation is not necessary when the tradeoff between adaptation and coordination is the same across business units – when the units' activities and their local information are equally distant from each other. Differential delegation becomes important when the units carry out activities of varying degree of interdependencies with each other, or operate in different institutional environments that affect the local units' ability to coordinate. Therefore, in Chapter V, I examine the differential delegation of coordination responsibilities within multinational corporations (MNCs), as a function of two variables: first, the degree of interdependence between a local unit's activity and the activities of other units within the MNC, and second, the institutional environment surrounding the local unit.

In the next three subsections, I elaborate on the relationship between diversification strategies and coordination costs, the role of organization structure in reducing coordination costs, and the impact of institutions on organization structure.

1.1.1. Industrial diversification and coordination across business lines

There is a strong consensus in the strategy literature that a driving force behind firm growth is the firm's resources and capabilities that can be deployed to new market opportunities. In particular, scholars have long argued that firms should diversify into more related industries to pursue synergies (Penrose, 1959; Wernerfelt & Montgomery, 1988). This synergistic view prescribes a continuous path for diversification, starting from the most related industries, through progressively less related industries, and stopping where potential synergistic benefits diminish to zero. Yet, one aspect of diversification that has been relatively understudied is the limit to *related* diversification. Is higher degree of relatedness (synergies) always better? Why do firms sometimes pursue less related diversification even before they exhaust opportunities in more related markets? Why do firms differ systematically in the degree of relatedness among their businesses?

To address these questions, Chapter III argues that to realize the potential synergies firms need to actively manage the interdependencies caused by sharing resources between products, which adds to coordination demand from firms' existing businesses, and may cause marginal coordination costs to outweigh marginal synergistic benefits. The impact of coordination costs is particularly significant if the existing businesses are already complex. Taking into account the joint effects of synergies and coordination costs, firms may forego higher degree of relatedness in favor of lower degree of relatedness in choosing diversification strategies, when the net benefit – the difference between synergistic benefits and coordination costs – from the former is less than the net benefit from the later. Therefore, while diminishing synergistic benefits set a limit to diversification in general, increasing coordination costs set a limit to *related* diversification in particular.

1.1.2. Organization structure

The increasing costs of coordination that accompany firm growth have an important implication for organization structure, which is designed to delimit coordination complexity (Thompson, 1967). According to Williamson (1985: 135), a firm's capacity for coordination is intimately related to the ability of boundedly rational management to selectively intervene in subordinates' activities "wherever coordination yields net gains." Paraphrasing Williamson, if the set of activities to be organized is held constant, and if firms can intervene selectively, a single firm coordinating via hierarchy should not be inferior to a collection of small firms coordinating in markets via the price mechanism.

Thus, limits to firms' coordination capacity and ultimately their growth originate from their inability to selectively intervene.

To see how organization structure can assist in achieving *some* (but not all) selective intervention, it helps to decompose the latter into two parts: the rule for when/where to intervene, and the intervention mechanism itself. The latter addresses the question of how to intervene. It includes design choices such as scheduling, incentive contracts, performance measurement, job assignment, and asset ownership. The selection rule prescribes the scope for intervention, i.e., when and where to intervene.

A firm's organization structure serves the important function of guiding where to intervene and by whom, in various ways. An organization structure provides the infrastructure for information processing, communication, and joint decision making within firms (Galbraith, 1973; Marschak & Radner, 1972; Simon, 1962; Tushman & Nadler, 1978). An organization structure assigns authority and decision rights to supervising units (March, 1994; Simon, 1947). They in turn coordinate the activities of their direct subordinate units. They set priorities when their subordinates have different opinions (Hart & Moore, 2005) and resolve conflicts when their subordinates have different expectations (Simon, 1991). An organization structure groups multiple interdependent tasks into one division and internalizes the tradeoffs between conflicting objectives within the same division (Williamson, 1985). With multiple verifications along the chain of command, an organization structure also makes commitment from any individual manager more credible (Foss, 2003). Finally, an organization structure may deter some influencing activities by making the benefits from such efforts a public good for employees within the same division (Inderst, Müller, & Wärneryd, 2005).

Among all these theoretical lenses, Chapter IV follows the approach of the team theory and modularity literatures, which examine organization structure without the additional complication of divergent incentives among agents. It investigates the tradeoffs between a modular and an integrated organization structure in specializing and coordinating decision making, and the role of a hierarchical structure in balancing these tradeoffs. It characterizes systems of interdependent activities along two dimensions: *Complexity* refers to the degree of interdependencies; *decomposability* describes one particular distribution pattern of interdependencies. It argues that, first, organization modularity has a curvilinear relationship with the complexity of its activities. At low to moderate level of complexity, integration brings more coordination benefits since it allows for more comprehensive decisions, taking into consideration the interaction terms. However, at high level of complexity, due to cognitive constraints of economic agents, firms have to partition the activity system despite the potential interdependencies between organization units. Second, for a given level of complexity it is possible to have more or less decomposability: A more decomposable activity system allows for more modular organization structure. Third, a hierarchical organization structure plays the important role of coordinating the interdependencies between the base units. Therefore, firms are more likely to adopt hierarchical structure when their activity system is highly complex or less decomposable.

1.1.3. Geographic expansion and coordination across institutions

Chapter III and IV investigate the impact of coordination costs on firm scope and structure. Given that institutions affect transaction costs in the market (North, 1990), and that firm boundaries are demarcated by the difference between coordination and transaction costs, it is important to examine how organization structure interacts with institutions to reduce coordination costs relative to transaction costs.

The most salient example of the interaction can be found in the context of MNCs. MNCs' firm boundaries span heterogeneous institutional environments, which gives them competitive advantages in circumventing many obstacles in the market that have hindered the growth of domestic firms in both home and host countries. But if the primary function of MNCs is to exploit arbitrage opportunities across institutional environments, then institutional differences create coordination costs as well.

Chapter V examines how institutional differences and the consequent coordination costs are managed via delegation of coordination responsibilities to local managers. It argues that, lack of complementary information and ambiguous property rights in host countries with weak institutions limit local units' coordination capacity and reduce the amount of delegation that local units will receive from their MNC parent company. In addition, coordination is more important when activities are more interdependent. The extent to which a unit in a host country is engaged in activities that are interdependent with the MNC's activities in other host countries captures interdependencies at the activity level; diversity in institutional environments across all countries in which the MNC operates captures interdependencies at the policy level. Therefore, activity interdependencies and institutional diversity will magnify the impact of institutions on the allocation of coordination responsibilities.

1.2. Research design

There are very few econometric studies of the relationships between activity-system interdependencies, firm scope, and organization structure at the firm level. This is mainly due to the difficulty in operationalizing and measuring the key constructs, and the lack of detailed data on the internal activities and structure of the firm. For this reason, most prior work keeps the concepts at an abstract level and relies on computer simulations or case studies. This dissertation makes a few modest attempts to tackle those challenges.

I operationalize system interdependencies based on the flow of intermediate inputs between business segments of diversified firms. I represent firms' portfolios as networks of interrelated segments. I construct two measures that reflect, respectively, the degree of system interdependencies (COMPLEXITY) and the distribution of system interdependencies (DECOMPOSAILITY). These measures correspond closely to the theoretical definitions of system interdependencies in the modularity literature, based on either task structure matrices (Baldwin & Clark, 2000) or NK models (Kauffman, 1993; Levinthal, 1997; Rivkin, 2000).

For organization structure, I rely on detailed reporting linkages within firms to construct my measures of modularity, hierarchy, and delegation. Though not perfect, the measures allow me to implement consistent analyses across a large sample of firms in a number of industries and over a long period of time, which is rare among existing studies of organization structure.

I test my hypotheses on a sample of U.S. equipment manufacturers from 1993 to 2003. I build a unique dataset of firms' internal activities and organization structures with data from various sources, such as the Directory of Corporate Affiliations, the BEA Input-Output (IO) tables, Compustat Industrial Annual Financial and Compustat Segment datasets, the U.S. Bureau of Census, the World Bank, and the University of Michigan Office of Tax Policy Research. Some of these data have been available for a long time, but have not been fully exploited to the benefit of investigating the internal reality of firms.

Chapter III examines the joint impact of a new business' potential for resource sharing with the existing businesses (a proxy for synergies) and the complexity of the existing businesses (a proxy for coordination costs) on the direction of diversification. I estimate the probability that a firm enters into a potential destination industry as a function of the potential for resource sharing between the existing and the new businesses, and the complexity of the firm's existing businesses. I measure the potential for resource sharing using the similarity of resources between a target industry and the industries the firm already operates in. I measure complexity using the number of segment pairs in the firm's existing portfolio that provide significant inputs to one another. I find that, consistent with the synergistic view, firms are more likely to diversify into a new business when it shares more resources with the firms' existing businesses. However, firms are less likely to diversify into a new business when their existing businesses are more complex, suggesting the constraining effect of coordination costs on firm scope. Last but not least, the complexity of existing businesses mitigates the positive impact of the potential for resource sharing on the direction of diversification. These findings suggest the constraints that coordination costs impose on firms' growth options.

Chapter IV estimates the impact of the complexity and decomposability of a firm's activity system on the degree of modularity and hierarchy of its organization structure. Decomposability is computed with a program designed by Guimerà *et al.* (2005a; 2005b; 2004) based on the algorithm of simulated annealing. Organization modularity is defined as the number of base units at the bottom of the corporate hierarchy – units that do not have subordinate units. Organization hierarchy is defined as the number of supervisory units weighted by their levels in the corporate hierarchy. I find that both organization modularity and organization hierarchy have a U-shaped relationship with complexity. In contrast, decomposability has opposite impacts on organization modularity and hierarchy: While it increases organization modularity, it reduces organization hierarchy. These findings confirm the coordination role of hierarchical structures in managing inter-unit interdependencies.

In Chapter V, I am interested in the amount of coordination responsibilities delegated to an MNC unit in a particular host country. Since this is not directly observable, I track the location of the supervisory unit for each base unit, and estimate the observed probability that the base unit reports to a supervisory unit located in a foreign country. More base units reporting to foreign supervisory units implies that fewer coordination responsibilities are assigned to local supervisory units. Thus, there is more cross-border coordination. Consistent with my hypotheses, my results show that MNCs delegate less supervisory responsibilities to units in host countries with weak institutions than to units in host countries with strong institutions. In addition, MNC base units in host countries with weak institutions are more likely to be supervised by a foreign unit if their activities are more interdependent with the activities of their MNC parents, or if their MNC parents operate in more diverse institutional environments. These findings confirm that differential delegation within hierarchical structure is used by MNCs to achieve coordination among their global units.

1.3. Contributions

The core theoretical contribution of this dissertation is the development of a broad framework that relates intra-firm activities with firm growth and organization structure by emphasizing the firm as a complex system of interdependent activities. In doing so, it contributes to theories of the firm and organization structure.

First, this theoretic framework complements existing theories of the firm by emphasizing that firm boundaries are not determined by technologies of a single plant or the “make-or-buy” decision of a single transaction but result from many choices regarding a variety of inter-related activities. With this fresh perspective, the dissertation joins the recent discussions by several authors around the process of vertical disintegration, modularization, and segregation of supply chains, and suggests that an implication of the process could be broader horizontal scope in related markets. Despite the amount of scholarly attention paid to the challenges of interdependencies for firms, few studies have looked at the impact of interdependencies on firm scope beyond vertical integration. This dissertation fills in this gap by highlighting the impact of interdependencies on the cost of coordinating across business lines or geographic markets and, subsequently, firm scope.

Second, to the organization structure literature, the theoretical framework sheds new light on the recent theoretical debate about modular vs. integrated structures. It rejuvenates Simon’s insight of a match between the hierarchical structure of the activity system and that of the organization: Hierarchical structure enables hierarchical coordination. It shows that tradeoffs between specialization and coordination can be balanced not only through inter-temporal vacillation between modular and integrated structures depending on the specific contingencies, but also through a hierarchical structure that allows for inter-module coordination. In addition, a hierarchical structure allows for differential delegation. Tradeoffs between adaptation and coordination under heterogeneous institutional environment can be balanced through differential delegation within a multinational hierarchical structure.

The dissertation has important implications for strategy scholars and practitioners at the interface of diversification, organization and international business. To diversification strategists, it raises the salience of a balanced cost-benefit analysis of diversification strategies. To organization designers, it sets a boundary condition to "flatter organizations" that are well-received in popular press and academic research, and reestablishes the importance of hierarchical structures. To global strategists, it extends a recent literature that starts to examine MNCs' global strategies in sidestepping institutional obstacles when location and ownership choices are limited. To policy makers, especially those focusing on developing countries, it expands the importance of institutions on FDI beyond the initial capital investment and technological transfer to include ongoing decision making and resource allocation across national borders.

Last but not least, the dissertation makes a few methodological contributions to empirical studies on system interdependencies and organization structure. First, I build a unique dataset of a large sample of firms' internal activities and organization structures with data from various sources. Second, I operationalize system interdependencies in a way that corresponds closely to their theoretical definitions in the modularity/complexity literature. Third, I adopt computational programs recently developed in physics and biology to quantify the decomposability of activity systems with non-randomly distributed interdependencies. To my knowledge, the dissertation is the first to comprehensively quantify the theoretical relationships between system interdependencies, firm scope, and organization structure on a large sample of actual business organizations. It will hopefully encourage more empirical studies that will complement the extensive theoretical modeling efforts in the complexity and organization structure literatures.

Chapter 2

Literature Review

In this chapter I review the literatures on limits to firm growth, diversification as a strategy for firm growth, and organization structure as a mechanism for coordination. In addition, I survey the international business literature that prescribes global strategies for multinational corporations operating across heterogeneous institutional environments. I conclude each subsection with a discussion of potential gaps that motivate my research questions.

2.1. Limits to firm growth

2.1.1. Technology, transaction costs and capabilities

The neoclassical economic explanations of limits to firm growth are based on technological constraints. Traditionally, firms are defined as a single product: Their size is determined by the lowest point on the long-run average cost curve in a perfectly competitive market (Viner, 1932), or the point where marginal cost equates marginal revenue if the competition is imperfect and demand curve is downward sloping. Lucas (1978) enriches these models by adding managerial resources as a separate input to the production function. Baumol, Panzar, and Willig (1982) extend them by incorporating potential economies of scope across multiple products. These models do not distinguish between a plant and a firm and therefore do not treat separately multi-plant firms. It remains an intriguing question why a firm cannot increase its scale or scope by pooling productive or managerial resources from two otherwise independently managed firms.

Coase's seminal work, later developed by Williamson, investigates why production is not all carried out within the market (i.e., why do firms exist) or within one big firm. The Coase/Williamson answer is that there are transaction/contracting costs in the market and integration costs in the firm. The relative magnitude of contracting vs. integration costs determines firm boundary. Because economic agents are only boundedly rational and all states of the world are not foreseeable, it is not always possible to write contracts that cover all contingencies. Such incomplete contracting leads to ex post haggling or opportunistic behavior. For example, when one party to a contract makes a relationship-specific investment, it bears a risk of being held up by the other party—it has to sell its investment to a third party at a discount (due to the relationship specificity of the investment) if the two parties disagree ex post over the split of the trade surplus. Expecting such opportunistic behavior, parties will incur extra costs to draft, verify, and protect contracts for numerous contingencies, or trade less than they would in an ideal world of complete contractibility. When making integration decisions, firms compare the contracting cost for purchasing a good from the market, and the cost of making it within the firm. The higher the relationship-specific investments required to produce the good, the more frequent the transaction; and the greater the uncertainty (including behavioral uncertainty), the more efficient it is to make the good within the firm (Williamson, 1979).

The transaction cost view provides a powerful prediction of firm boundaries based on transaction-specific contracting cost in the market, but its treatment of integration cost within the firm is insufficient. While scholars acknowledge integration has its own costs

(Williamson, 1985), exactly how integration costs increase with firm scale and scope is still a mystery (Coase, 1988; Holmstrom & Tirole, 1989). As a result, what determines whether a set of tasks are to be performed within a single firm or divided and contracted between two separate firms remains an open question (Coase, 1993: 73; Simon, 1991: 26). A firm is not a single production function or a single transaction, but an organization of numerous human actors carrying out various activities. Therefore to better understand integration costs we need to look inside firms at "the other activities that the firms are undertaking" (Coase, 1993: 67).

Both neoclassical and transaction cost economics treat firm productivity and market conditions as exogenously given and focus on comparative efficiencies of markets and organizations in conducting economic activities. In contrast, the strategy literature and the resource-based view of the firm (RBV) in particular stresses the role of firm-specific resources and capabilities in driving variations across firms (Penrose, 1959; Teece, 1982; Wernerfelt, 1984). Since such resources and "organizational capabilities" can be deployed across multiple plants, locations and industries (Chandler, 1990), RBV contributes a theoretical framework of endogenous innovation and growth at the firm level.

According to Penrose (1959: 68), firms have excess resources for three reasons. First, indivisibility of resources forces firms to acquire the "least common multiple" and leave some residual resources idle. Second, the advantage of specialization entices small firms to hire specialized resources that are not used to their full potential due to limited scale of output, a case in point being a chemist being employed as a chemist for only part of the day and engaged in other duties such as inventory checking for the rest of the time. Third, as the entrepreneurial firm accumulates and searches for new knowledge in production, more resources can be spared, and new uses for the excess resources can be learned. However, due to imperfection in factor markets, such capabilities may not be tradable across firms (Barney, 1991). Limited tradability forces firms to constantly look for new opportunities/markets to deploy their resources within firm boundaries. Therefore, the speed at which firms develop and deploy resources limits their growth.

Penrose puts managers at the center stage of growing their firms: Their main tasks are to identify, develop and deploy firms' excess resources and capabilities to maximize returns. Their internal experience, speed of learning, training and planning for future expansion determine firm growth.

2.1.2. Coordination capacity, interdependencies and coordination costs

A small body of literature, mostly theoretical, suggests that the limited capacity of boundedly rational managers to coordinate may cause decreasing returns to scale (Robinson, 1934). According to Williamson (1985: 135), coordination capacity is intimately related to the ability of boundedly rational management to selectively intervene in subordinates' activities "wherever coordination yields net gains." Paraphrasing Williamson, if the set of activities to be organized is held constant, and if firms can intervene selectively, a single firm coordinating via hierarchy should not be inferior to a collection of small firms coordinating in markets via the price mechanism. Thus, limits to firms' coordination capacity and ultimately their growth originate from their inability to selectively intervene.

Interdependencies give rise to the need for coordination or selective intervention: Activities are interdependent when performing one activity affects the marginal returns to other activities (Milgrom & Roberts, 1995). If agents perform independent activities, then limits to division of labor should only be determined by the extent of the market (Stigler, 1951). Only when specialized agents perform interdependent tasks will coordination costs come into play (Becker & Murphy, 1992). Interdependencies among decision variables make them intractable, thereby limiting the size of activity systems that boundedly rational individuals can coordinate (1962).

There are two types of bounded rationality: costly rationality and truly bounded rationality (Radner, 1996). Costly rationality refers to the costliness in making a rational decision when individuals are limited in their cognitive capacity and the task needs to be divided among multiple agents. The team theory literature divides coordination into three components: information processing, communicating, and deciding (Marschak & Radner, 1972; Radner, 1992; Van Zandt, 1999a). Information processing can be further divided into independent computation and aggregation. Independent computation can be done by front units, while aggregation is better performed by supervisory units as they gather information from multiple front units. Cost of information processing is determined by cost of observation, memory, and computation, and are mainly reflected in the time and labor required for these tasks. Cost of decision making, in contrast, includes not only the time and effort involved, but also decision errors due to obsolete information.

Specialization or decentralization in information processing lowers information processing cost since it allows for parallel information processing (both independent computation and aggregation). However, specialization leads to both communication costs and delay in decision making when information needs to be shared for joint decision making. To reduce communication cost and delay in decision making, organizations can decentralize decision making. But the effectiveness of decentralized decision making is limited. When decision variables are highly interdependent, decentralization of decision making implies that individual decisions will be made based on partial information and will not be globally optimal.[1] These tradeoffs in specialization, communication costs, and decision making set limits to organization design and firm growth.

Truly bounded rationality refers to the fact that the solution of certain complex problems is beyond the capacity of any decision maker or teams of decision makers. This notion of coordination difficulty resulting from interdependencies can be traced to the concept of NP-hard or NK models first developed in computer science (Garey & Johnson, 1979) and evolutionary biology (Kauffman, 1993) and later introduced to the management literature (Levinthal, 1997). NK models are often used to characterize the complexity that managers face in decision making, including the search for, imitation of, and adaptation to some optimal solutions.

In the NK model, N is the number of decisions to be made, like the multiple dimensions that managers search along for optimal strategic choices. K is the number of decisions that are interdependent. The relationships are not known a priori. As a firm grows, both N and K increase. For example, as the firm raises its output level, it may need to procure raw materials from more suppliers, satisfy the need of more heterogeneous customers, or supervise more employees. When there is no

[1] A separate literature considers agency problems with decentralized decision making: It collocates information and decision rights but forces top management to give away control. When employees have different objectives than top management, top management's concern for loss of control limits firm size (Williamson, 1967). It is not clear whether agency problems still exist without the presence of interdependencies, or without interdependencies why firms cannot adopt market-based incentives to discipline the agents.

interrelationship among the N decisions, it is feasible that managers divide the problems among themselves and each searches for an optimal solution along a single dimension. Jointly they will find a global optimal for the entire problem set. However, when there is interdependence among the N decisions, i.e, K>0, the search becomes more complicated. Even in the simplest case where all N decisions are binary, the time and costs required to search through all the 2^K combinations of decisions increase non-polynomially in K. The problem falls under a special class called NP problems in computer science (Garey & Johnson, 1979). The numerous complex interactions construct a rugged rather than a smooth selection landscape with many local optima, which slows down adaptation toward a global optimum (Kauffman, 1993; Levinthal, 1997).

Radner compares this truly bounded rationality with costly rationality (1996: 1366):

> Here we come face to face with the hard core of 'bounded rationality'. It is not that, in themselves, the costs of observation, communication, memory storage, and routine computation, necessarily prevent a team of decision makers from conforming to … rationality. Rather, it is that the task of designing decision rules that satisfy savage's consistency requirements is beyond the intellectual capabilities of any organizer or team of organizers.

The challenges of interdependencies for firms have been studied at multiple levels. At the project level, they complicate the innovation and product design process (Ethiraj & Levinthal, 2004b). At the organization level, they obscure the evolutionary path firms take to search or decipher best practices (Levinthal, 1997; Rivkin, 2000), and subject firms to more decision errors (Siggelkow, 2002b). At the operational level, they reduce the value of many operational practices if they are not implemented with their complementary parts. For example, innovative human resource practices (e.g., high-power incentive pay, teams, flexible job assignments, employment security, and training) achieve substantially higher levels of productivity only if they are implemented together

(Ichniowski, Shaw, & Prennushi, 1997). At the industry level, interdependencies lead to industry structures with persistent heterogeneous profits across firms (Lenox, Rockart, & Lewin, 2006). However, despite the amount of attention paid to the challenges of interdependencies for firms, only recently have scholars looked at the impact of interdependencies on firm scope.

These recent studies broaden the notion of transaction costs to include not only transaction hazards among opportunistic agents (Williamson, 1985), but also the “mundane” costs of defining, describing, measuring, adjusting, searching, and compensating for the transfer of material, information, and energy among agents with congruent interests (Baldwin, 2008; Jacobides, 2000; Malone, Yates, & Benjamin, 1987; Schilling & Steensma, 2001). While transaction hazards cause difficulty in making joint effort, the “mundane” transaction costs make joint decision challenging: They are often exacerbated by interdependencies.

Just as firms can mitigate transaction hazards by encouraging joint effort through distinctive governance instruments such as low-power incentives and long-term employment, they can also be more efficient in dealing with the mundane transaction costs. First, firms facilitate communication and information processing through internal information infrastructure and firm-specific language. The information infrastructures enable not only the division of communication and processing tasks but also the integration of information for joint decision making (Arrow, 1974; Galbraith, 1973; Marschak & Radner, 1972; Tushman & Nadler, 1978). Firm-specific language, which includes meanings, codes, and routines, improves communication and interpretation (Arrow, 1974; Crémer, Garicano, & Prat, 2007; Nelson & Winter, 1982). In addition, firms reduce the load of communication, information processing, and calculation through authority, identity, rules, and routines. Authorities are assigned to supervisors; subordinates give up their decision rights for long-term employment with the firm (March, 1994; Simon, 1947). Supervisors set priorities when subordinates have different opinions over the use of joint assets (Hart & Moore, 2005), and resolve conflicts when subordinates have different expectations of joint efforts (Simon, 1991). Identification with a firm and routines of the firm help employees to internalize the "rules of the game," form stable expectation of others' behavior, and behave consistently (Akerlof & Kranton, 2005; Kogut & Zander, 1993, 1996; Nelson & Winter, 1982).

Despite these advantages, internal coordination is not always less costly than external transaction. A few authors observe firms' vertical scope changes dynamically as transaction costs reduce relative to coordination costs. The reduction in transaction costs can be caused by exogenous technological changes that lower communication and information-processing costs (Argyres, 1996; Malone *et al.*, 1987; Schilling & Steensma, 2001), or by firms' conscious design efforts toward product standardization and component modularization that reduce the interdependencies and hence the need for joint decision among component manufacturers (Baldwin & Clark, 2000; Langlois & Robertson, 1995; Sanchez & Mahoney, 1996). Even though these changes reduce both intra-firm coordination costs and inter-firm transaction costs, inter-firm transaction (e.g., outsourcing) may become more efficient than integration since suppliers can specialize in different components to achieve greater economies of scale and learning (Jacobides & Hitt, 2005), and buyers can have more flexibility in selecting suppliers based on their capabilities (Baldwin & Clark, 2000; Hoetker, 2005; Langlois & Robertson, 1992). These studies, however, focus on vertical scope. How changes in interdependencies (as a result of the modularization and outsourcing processes) cause changes in firm's horizontal scope is yet to be examined.

2.1.3. Summary and potential gaps

Neoclassical economics, contractual or transaction costs economics, and resource-based view of the firm each provides powerful yet incomplete explanations for limits to firm growth. Neoclassical economics offers technological constraint as a limit to plant size, but is silent about firm size. Transaction costs economics locates individual transactions within or outside firm boundary but fails to explain the scope of the entire firm. RBV adds the effect of managers but emphasizes their experience and learning rather than coordination capacity. In addition, while the two economic theories focus on coordination and efficient allocation of existing resources between the market and the firm, RBV emphasizes growth and deployment of new resources within firms. It is time to reunite the theories and investigate how coordination challenges limit firms' ability to deploy excess resources for growth. Firm boundaries are not determined by technologies of a single plant or the "make-or-buy" decision of a single transaction but result from many choices regarding a variety of interrelated activities. Outsourcing a single function affects the integration calculation for the procurement of interdependent functions (Novak & Stern, 2007). Although the literature has stressed the challenges of interdependencies at multiple levels, the impact of interdependencies on firm scope has yet to be thoroughly studied.

2.2. Diversification

A context where growth and interdependencies interact is related diversification. Diversification extends firm scope; relatedness implies interdependencies. In this section I survey the literature on diversification, with a focus on efficiency (as opposed to agency) explanations for firms' choice of diversification strategies, and the challenges of coordination.

2.2.1. Diversification, firm growth and coordination capacity

To scholars advocating firm-specific resources and capabilities, diversification is an important engine for growth as firms deploy their excess resources to new market opportunities (Penrose, 1959). It should be a normal state of affairs in firm expansion (Pitelis, 2002). The theoretical argument resonates with reality: Despite the popular claim that firms are returning to their core competency, large firms remain highly diversified throughout recent history. Seventy percent of the largest 500 U.S. public companies operate in more than five industries (measured at the 4-digit SIC level) (Montgomery, 1994). Firms like 3M and GE pursue diversification as a permanent rather than a transitory strategy (Matsusaka, 2001). Among U.S. manufacturing firms, 40% produce more than one product (measured at the 5-digit SIC level) and account for more than 90% of total sales (Bernard, Jensen, & Schott, 2006; Nocke & Yeaple, 2006).

A few studies explicitly model the conjecture that diversification may be an efficient growth strategy endogenous to firm capabilities. Firms may diversify to find an industry that is best matched with their industry-specific capabilities (Matsusaka, 2001), or to gain information about their general capabilities (Bernardo & Chowdhry, 2002). Firms also may diversify if they experience decreasing returns to scale in any industry with respect to their capabilities (Maksimovic & Phillips, 2002), or if negative demand shock in their home industry results in excess capabilities (Gomes & Livdan, 2004; Levinthal & Wu, 2006). Finally, firms may diversify to leverage their capabilities in coordinating multiple product lines (Nocke & Yeaple, 2006).

Among all the theoretical models, that by Nocke and Yeaple (2006) is of particular interest since it explicitly models firms' heterogeneous coordination capacity. In their model, production capabilities are homogenous across product lines and firms, that is, the marginal production cost is the same and constant at the product level. The authors show that even in this case, diversification is an efficient profit maximizing strategy for firms endowed with greater coordination capacity (or "organizational capabilities") at the firm level. In equilibrium, each firm chooses its scope so that the profit of the marginal product line is equal to the negative effect that the marginal product line exerts on the profits of the infra-marginal product lines. Firms with greater coordination capacity will therefore diversify more: The higher marginal costs of the marginal product are offset by the less negative impact the marginal product imposes on infra-marginal products. As a result, firm size and scope are increasing in the firm's coordination capacity. The model sheds light on the important relationship between coordination capacity and firm scope in product market. However, it does not specifically model why coordination costs increase with firm scope. Neither does it address the issue of interdependencies.

2.2.2. Related diversification: Benefits and challenges

Businesses are related to one another "when a common skill, resource, market or purpose applies to each" (Rumelt, 1974: 29). Prior research has supplied ample justifications for related diversification. First, related diversification achieves greater economies of scope (Panzar & Willig, 1981; Teece, 1982). According to Bailey and Friedlander (1982), economies of scope arise from reuse or sharing of inputs, joint utilization of fixed or intangible assets among multiple products, or joint production of networked products. Economies of scope achieved from joint production result in lower unit cost for each product. Resources that can be shared across multiple product lines include intermediate products (Lemelin, 1982), marketing and distribution channel (Montgomery & Hariharan, 1991), R&D and technology (MacDonald, 1985; Silverman, 1999), and human capital (Farjoun, 1994). Second, related diversification facilitates learning and replication of experiences/capabilities: The more closely related the businesses, the easier it is for current management to replicate or train new managers with the knowledge the firm already has learned from its existing businesses (Prahalad & Bettis, 1986; Teece *et al.*, 1994; Winter & Szulanski, 2001). A common knowledge base helps product market sequencing (Helfat & Raubitschek, 2000), technology search and selection or development (Breschi, Lissoni, & Malerba, 2003; Chang, 1996; Kim & Kogut, 1996). Finally, related diversification generates inter-temporal economies of scope as firms exit old businesses and use existing experiences and resources to enter related new businesses (Helfat & Eisenhardt, 2004).

While the literature has been overwhelmingly supportive of related diversification, the boundary condition of the strategy has been overlooked. Only a few authors have examined the difficulties in implementing such a strategy. Among them, Jones and Hill (1988) argue that related diversification implies all three types of task interdependencies – reciprocal, sequential, and pooled, whereas unrelated diversification implies only pooled interdependencies. Because it is more difficult to monitor highly interdependent tasks when employees can act opportunistically, coordination costs are the highest for related diversifiers and lowest for unrelated diversifiers. Hill, Hitt, and Hoskisson (1992) propose that to benefit from economies of scope, firms need to establish cooperative relationships among business units, rather than resort to standard financial controls or market-based disciplines; Nayyar (1992) argues that such relationships are costly and difficult to sustain. Gary (2005) constructs a simulation model to show that growth in a related market can strain the original excess capacity that is to be shared between the primary and related markets; overstretching the resources increases costs exponentially.

These studies provide invaluable insights into the tradeoff between the synergistic benefits from related diversification and the difficulty in maintaining the interrelationships among various business activities. However, the detailed mechanisms through which the difficulty or costs cancel out the benefits are yet to be fully developed and tested. In addition, none of these studies explains within-industry variation in limits to related diversification. Given that explaining differences in firm strategies is an important mandate for strategy research (Lippman & Rumelt, 1982), the omission is unsatisfactory.

2.2.3. Summary and potential gaps

In summary, a large body of the strategy literature, RBV in particular, suggests that related diversification is more beneficial than unrelated diversification: It allows firms to take advantage of their core resources and capabilities without significant loss of applicability, reap intra- and inter-temporal economies of scope, and facilitates learning and replication, all of which promote firm growth. While the literature provides ample theoretical support for related diversification, very little has been studied regarding the "dark" side of the strategy, namely the challenges it poses on management to coordinate interrelated activities.

In addition, while the diversification literature has recently recognized that heterogeneity in firm capabilities may be an important driving force behind firms' diversification strategies, more has to be learned about what differences in firms' capabilities determine their propensity to related diversification. The literature has identified production skills and knowledge gained from experience with existing businesses as a significant factor to determine firms' probability of entering a "similar" industry (Helfat & Lieberman, 2002; Klepper & Simons, 2000). Firms' capabilities to coordinate interdependent activities, an inevitable consequence of related diversification, have been largely ignored. This is an unsatisfactory omission since theoretically firms' capability to coordinate multiple product lines suffices to endogenously drive firm scope under modest conditions such as decreasing return to scale or downward sloping demand curve in each segment. For example, in Nocke and Yeaple's (2006) model, the only disadvantage of firms operating in a single market is the downward sloping demand curve which limits firms' output in each market. Firms pursuing growth have to look for profit opportunities in other markets and balance the tradeoff against increasing coordination costs. Firms with greater coordination capacity will be able to accommodate broader scope for related diversification.

2.3. Organization structure

Organization structures are established to delimit coordination complexity (Thompson, 1967). The most common organization structure is hierarchical with multiple levels of supervisory units. According to Chandler (1977: 7):

> [T]he existence of a managerial hierarchy is a defining characteristic of the modern business enterprise. A multiunit enterprise without such managers remains little more than a federation of autonomous offices. [...] Such federations were often able to bring small reductions in information and transactions costs but they could not lower costs through increased productivity. They could not provide the administrative coordination that became the central function of modern business enterprise.[2]

The hierarchical structure has traditionally been viewed by different organization economists as different mechanisms for coordination.[3] It has been viewed as an information processing network (Radner, 1992), a supervision and control system (Calvo & Wellisz, 1978; Williamson, 1967), an incentive structure and internal labor market (Holmstrom & Milgrom, 1991; Lazear & Rosen, 1981; Waldman, 1984), a nexus of contracts (Jensen & Meckling, 1976), etc.

Following these distinct yet interrelated intellectual roots, a recent strand of literature in organizational economics studies the optimal structure of hierarchies as a means to mitigate various tradeoffs that firms face with coordination. A common feature across these theoretical models is some sort of interdependencies between activities that require joint processing. Units need to not only divide the workload of information processing but also communicate and share information in order to make decisions (Bolton & Dewatripont, 1994; Patacconi, 2005; Radner, 1992, 1993). They collect and share information about costs and benefits of their investment projects so that corporate resources can be allocated among them and the most profitable projects be selected (Friebel & Raith, 2006; Geanakoplos & Milgrom, 1991; Hart & Moore, 2005; Inderst *et al.*, 2005). They own complementary knowledge and help each other solve problems (Beggs, 2001; Garicano, 2000; Rajan & Zingales, 2001). They make decisions and take

---

[2] Cited in Alonso *et al*. (forthcoming).
[3] See Holmstrom and Tirole (1989) for an earlier review of the literature.

actions to adapt to their local demands as well as to accommodate changes in other units' environment (Alonso, Dessein, & Matouschek, forthcoming; Dessein & Santos, 2006). Such divergent objectives, together with different assumptions about decision makers' capabilities and incentives, lead to different structural designs.

In the following subsections I examine some of these models in greater detail. I will review the literature with progressively more complications. Subsection 2.3.1 reviews the team theory literature that views hierarchy as no more than an information infrastructure. Subsection 2.3.2 surveys the modularity literature that sees hierarchy as a structured network of tasks. Subsection 2.3.3 adds the complication that employees in organizations can have conflicting expectations and preferences, and shows how organization structure can mitigate some of these problems to achieve coherent organization goals. Subsection 2.3.4 entertains the possibility that many of these organization goals are contradictory to each other and hence create tradeoffs in organization design. Subsection 2.3.5 covers empirical evidence, and subsection 2.3.6 concludes.

2.3.1. Hierarchy as a information processing system

A hierarchical structure is viewed by team theorists as a way to process information acquired by front-line units from their business environment, to transfer the original or partially processed information to upper-level management for decision making, and to relay management's instructions to front-line employees (Chandler, 1962; Galbraith, 1973; March & Simon, 1958; Marschak & Radner, 1972; Simon, 1947; Thompson, 1967; Williamson, 1967). The main processes analyzed by this literature are division of labor in information acquisition, and communication and aggregation required for joint decision making. "[A] wealth of information creates a poverty of attention" on the part of the receiver (Simon, 1971: 40).[4] Managers are viewed as information processors of limited cognitive capacity; their cognitive constraints limit firm size (Van Zandt, 1999a, 1999b). By specifying information structure and decision rules, different hierarchical structures enable different degrees of specialization in information acquisition, information processing, and decision making. Their efficiency is therefore measured by the costs of information acquisition, processing and communicating, and speed in decision making (Marschak & Radner, 1972).

While it is relatively easier to divide the tasks of information acquisition and processing, it is often difficult to divide decision making. This is because specialized decision making may lead to error when they are based on incomplete information. For example, Geanakoplos & Milgrom (1991) show that, when managers divide up the task of resource allocation by referring only to information they obtain about the costs of workshops under their direct supervision, they ignore the information regarding potential synergistic cost-saving opportunities among themselves. Only their common supervisor with broader information set will attend to these opportunities and lower the joint production cost. Aggregation of information and joint decision making are still required to achieve all potential synergies. The greater synergy, the wider span of control a manager should have, "allowing him or her to reallocate resources across more shops" (Geanakoplos & Milgrom, 1991: 220). Broader span, however, gets us back to the problem of limited managerial decision capacity.

[4] Also according to Simon (1973), "[T]he scarce resource is not information; it is processing capacity to attend to information. Attention is the chief bottle-neck in organizational activity, and the bottleneck becomes narrower and narrower as we move to the tops of organizations, where parallel processing capacity becomes less easy to provide without damaging the coordinating function that is a primary responsibility of these levels" (p. 270).

A hierarchical structure economizes on communication by reducing the channels of communication and eliminating what would otherwise be an unmanageable spaghetti tangle of interconnections as a result of specialization (Arrow, 1974; Langlois, 2002; Zannetos, 1965). At the same time, a structure where many middle managers compute independently and in parallel lowers information processing cost (Radner, 1993). Middle managers share the burden of information processing and bring more information to bear in the decision-making process for the firm as a whole (Geanakoplos & Milgrom, 1991). However, a hierarchical structure also has its weakness. It may lead to delay in decision making as information processing and communication becomes sequential along the vertical chain (Keren & Levhari, 1979). The delay reduces the efficacy of the decisions since they are likely to be made based on old information (Van Zandt, 2003). Given these tradeoffs, firms are often limited in their freedom to adjust organization structure and enhance their coordination capacity.

2.3.2. Hierarchy as a structured task system

Baldwin and Clark (2006) view the firm as a network that transfers material and energy, in addition to information – the focus of team theorists, between tasks. The costs of standardizing, counting and evaluating these transfers are "mundane" transaction costs. Because transfers between highly interdependent tasks are more difficult to standardize, count and evaluate, they should not be converted into transactions between units. Instead, they should be grouped into the same unit or "module" and insulated from the rest of the system. Modularization refers to this process of breaking up the system into loosely coupled subsystems where highly interdependent parts are grouped into subsystems, and between-subsystem interactions are minimized. Therefore, a modular structure, or a network of encapsulated local systems with dense blocks and thin cross points, facilitates complex transfers without making all of them transactions.

The concept of modularity was first applied to product design and innovation (Baldwin & Clark, 2000).[5] Modularized product design in turn enables modularization in organization structure through divisionalization (Sanchez & Mahoney, 1996), outsourcing (Novak & Eppinger, 2001), or vertical disintegration (Jacobides, 2005). A modular structure has its benefit and potential drawbacks. For example, while a modular organization structure facilitates local exploration of knowledge, it reduces overall system-wide exploration and innovation (Marengo & Dosi, 2005; Siggelkow & Rivkin, 2006). A major design goal is therefore to partition organization structure at an appropriate level according to the decomposability of underlying tasks. While a precise match may not always be possible (Nickerson & Zenger, 2002), over- or under-modularizing the organization structure relative to the task structure leads to poor performance, not only for the particular modules but also for the entire system (Ethiraj & Levinthal, 2004b).

However, the role of hierarchy has largely been overlooked by the modularity literature. A "modularity theory of the firm" (Langlois, 2002) acknowledges that a hierarchy arises as a non-modular form to coordinate interactions among the modules. But the design of the hierarchy has been much less studied in the modularity literature than the design of the modules.

In sum, the team theory and the modularity literature complement each other in prescribing specific design rules for organization structure. They assume different types of bounded rationality – costly rationality and truly bounded rationality, as described in

[5] See Sanchez and Mahoney (1996) for a summary of earlier studies.

Section 2.1.2. They also take different approaches toward structure design (Van Zandt, 1999a). On the one hand, the team theoretical approach explicitly models the constraints in information processing, communication, and decision making, imposing relative stable assumptions on the environment. On the other hand, the modular or non-optimal approach often resorts to computers to simulate limits to rationality in the faces of complex environmental or evolutionary forces. In addition, while team theorists have accomplished rather elaborate predictions of organizations' hierarchical structures, modularity theorists have confined their prescriptions on organization structure to basic encapsulated systems. At the same time, while the modularity literature broadens the team theoretic perspective by generalizing the interactions between tasks to be multidimensional, it has overlooked the impact of between-unit interdependencies on organization structure. More progress can be made by examining the intermediate structures that make up a hierarchy, or the lines that connect the boxes.

2.3.3. Hierarchy as a control mechanism

Both the team theory and the modularity literature view organizations as systems of problems or tasks. To team theorists, managers are information processors who solve either static or stochastic control problems in real time (Van Zandt, 2003). To modularity theorists, organizations are encapsulated systems of interdependent tasks (Baldwin & Clark, 2006). But real organizations are populated with employees and decision makers with divergent goals, expectations, and preferences (Cyert & March, 1963). Even without local incentives, agents do not necessarily converge in expectation or preferences due to multiple equilibriums that can be sustained in dynamic exchanges among groups. In this respect, organization structure provides additional coordination mechanisms by assigning authority and decision rights to various supervisors (March, 1994; Simon, 1947). Supervising units coordinate the activities of their direct subordinate units. They set priorities when subordinates have different opinions (Hart & Moore, 2005) and resolve conflicts when they have different expectations (Simon, 1991).

Hart & Moore (2005) explicitly assume that a hierarchical structure, compared to the market, delineates authority in decision making: "[H]ierarchy is a substitute for renegotiation" (p. 698). In their model, each asset has a chain of command. Managers of different ranks may have different opinions as to how the asset should be used but it is the manager of the highest rank that makes the final decision. To the extent that assets could have a joint value that is greater than their individual value, a manager whose task is to coordinate as opposed to specialize should be assigned greater authority and hence a higher rank in the hierarchy, so that she can take control of all the assets required for all the interrelated activities. The larger the gains to coordination are, the more preferable a hierarchical structure is. [6]

2.3.4. Tradeoffs in organization design

Organization design involves complex tradeoffs. Whether between specialization benefits and communication costs, comprehensiveness of information and delay in

[6] In addition to divergent expectations, employees or their units also may differ in their incentives and pursue private benefit at the cost of their firms' profitability. The incentive-based organization economics literature views hierarchy as a governance mechanism where managers' primary tasks are to monitor and supervise the effort of those of lower ranks (Alchian & Demsetz, 1972; Calvo & Wellisz, 1978; Qian, 1994; Rajan & Zingales, 2001; Williamson, 1967). A few recent studies incorporate the idea of multi-tasking into structure models with agency problems. These models allow managers to engage in strategic communication, lobbying or knowledge expropriation (Alonso *et al.*, forthcoming; Friebel & Raith, 2006; Inderst *et al.*, 2005). While interesting and technically sophisticated, these recent agency models depend on additional behavioral assumption of private benefit and strategic communication. Team theorists have argued that the incentive-based theory is incomplete without the team theory. "The incentive-based mechanism design literature … has for the most part ignored communication costs. Most of it makes use of direct revelation mechanisms in which, in one round of simultaneous communication, all agents communicate all their private information" (Van Zandt, 1999a: 142).

decision making, truthful communication and diligent effort, these tradeoffs are difficult to balance. Often optimizing based on one pair of tradeoffs leads to sacrifice in benefits along other dimensions. These tradeoffs provide further explanation for Williamson's problem of impossibility of selective intervention, albeit from an organization structure perspective.

For example, a recent paper (Dessein & Santos, 2006) simultaneously models the conflicting demands of specialization, coordination, and adaptation on organization design. In addition, it differentiates between ex ante and ex post coordination, which is determined by how locally adaptive the organization chooses to be. When activities are interdependent but local adaptation is of less importance, organizations may pursue specialization and eliminate the need for coordination by setting rigid rules ex ante, forgoing adaptive benefits. When local adaptation is important, organizations should broaden the responsibilities of units to facilitate ex post coordination, forgoing the benefit from specialization. Coordination costs are reflected in the sacrifice of potential benefits from specialization and adaptation.

The idea that there are tradeoffs in organization design is not new to organization theorists. Structural contingency theory or the "fit" paradigm stresses that there is not one "best" way of structuring. Only a good fit between an organization's structural design and its environmental demands will lead to effectiveness. External contingencies arise from diversity or uncertainty of the local environment (Burns & Stalker, 1961; Lawrence & Lorsch, 1967), and internal contingencies are mainly caused by technology or interdependence among task components (Thompson, 1967). For example, external and internal contingencies determine organizations' information processing needs (Galbraith, 1973). Since different structures provide different capacity for information processing, organization performance depends on the match between the demand and supply of information processing (Tushman & Nadler, 1978).

In sum, the design of organization structure involves complex tradeoffs. The nature of a firm's technology and its external environment may put different demands on structure. These divergent demands limit the firm's ability to adopt an "optimal" structure.

2.3.5. Empirical studies of organization structure

Most empirical studies of organization structure are found in the literature on contingency theory. They generally focus on three issues: the association between technology or environment and structure, the impact of changes in technology or environment on changes in structure, and the performance consequence of a fit between technology or environment and structure (Donaldson, 2001). The first issue is often studied using cross-sectional personnel reporting data based on small-scale surveys. After controlling for firm size, the role of technology or environment is often found to be limited (Child & Mansfield, 1972). The second issue is often examined based on case studies. Structural innovation is shown to play an important role in accommodating firms' strategic changes (Chandler, 1962; Rumelt, 1982). The third issue has been studied with longitudinal data with highly simplified measures. For example, Hoskisson (1987) compares firm performance before and after the implementation of an M-form structure and finds it only improves performance for unrelated diversifiers but not related diversifiers or vertically integrated firms. Several reviewers have pointed out that this empirical literature has been plagued by lack of consistency in the choice of constructs and their operational definitions and measures, difference in levels of analysis, confusion between formal and informal structures, etc., which lead to weak and inconclusive results (Child, 1973; Donaldson, 2001; Pennings, 1992; Scott & Davis, 2006).

There have been some recent efforts to systematically quantify organization structure for firms across industries. Argyres (1996) counts the number of product divisions and major manufacturing subsidiaries, and defines the degree of divisionalization as: $\frac{Number\_of\_divisions + 1.5 * Number\_of\_subsidiaries}{Total\_revenue}$. Rothwell (1996) counts the number of levels in the longest line of control from the plant manager to the first line (lowest level) supervisor (LONG), and the number of people reporting to the plant manager (SPAN). He then constructs a measure of hierarchy as: $H = \sin\theta = LONG/(LONG^2 + SPAN^2)^{0.5}$. Argyres and Silverman (2004) check the presence of central R&D laboratories as opposed to divisional R&D units to measure centralization. Rajan and Wulf (2006) count the number of levels between division heads and the CEO to proxy for the "flatness" of organization structure. These studies provide some guidance for my measures of organization structure.[7]

2.3.6. Summary and potential gaps

In summary, organization structure has been studied in numerous strands of literature in organization theory and organization economics. They include, among others, team theory, modularity theory, agency theory and contingency theory. The consensus is that there is not an optimal organization structure. Instead, there are many tradeoffs in

[7] Using large-sample, confidential surveys, a separate group of studies examine the centralization and decentralization of authority, regardless of the physical shape of the organization structure. The typical survey questions include whether the firm is organized into profit centers (Acemoglu et al., 2007), the degree of using work-teams and allocating decision rights or responsibility to workers (Bresnahan, Brynjolfsson, & Hitt, 2001; Foss & Laursen, 2005). These measures are about allocation of authority rather than partitioning and integration of organization units for the purpose of coordination.

structural design, such as those between specialization and coordination; those among information processing, communication, and decision making; and those between delegation and control.

There are some gaps in this literature. Mainly, the literatures tend to be developed independently of each other. For example, the team theory and the modularity literature both treat problem solving and decision making as key functions of organization structure, but they each has a different focus. Team theory pays limited attention to the complex interrelations between decisions, and the modularity literature has not adequately addressed the role of hierarchy in handling inter-module interdependencies. In addition, the enduring research interests and extensive modeling efforts about organization structure are in stark contrast with scarce empirical evidence, due to difficulty in construct operationalization and lack of detailed data for large samples of firms.

2.4. Institutions and multinational hierarchy

The literature reviewed in Section 2.3 suggests that organization structure affects coordination costs inside the firm. Given that institutions affect transaction costs in the market (North, 1990), and that firm boundaries are demarcated by the difference between coordination and transaction costs, understanding limits to firm growth requires an examination of how organization structure interacts with institutions to reduce coordination costs relative to transaction costs.

The most salient example of the interaction can be found in the context of multinational corporations (MNCs). MNCs are believed to have superior capabilities that allow them to overcome the fixed costs of setting up plants overseas and exploit the additional market demand or lower costs in host countries (Buckley & Casson, 1981;

Helpman, Melitz, & Yeaple, 2004). As a result, their firm boundaries span heterogeneous institutional environments. In addition to superior capabilities accumulated in their home market, multinational presence gives MNCs further advantages in circumventing many obstacles in the market that have hindered the growth of domestic firms in both home and host countries.

In this section, I first survey the literature about the aspects of institutional underdevelopment that affect firm growth. I then review MNC strategies that deal with institutional drawbacks, namely location choice, governance mode, and organization structure.

2.4.1. Institutions and firm growth

Coase (1960) makes the essential link between institutions, transaction costs, and neoclassical economic theories: With positive transaction costs, institutional arrangements such as property rights assignment alter resource allocation. North (1990) defines institutions as "humanly devised constraints that structure human interaction" (p. 3). Some of these constraints are formal, such as rules, laws and constitutions. Others are informal and include norms of behavior, conventions, and self-imposed codes of conduct. Institutions shape the incentive structure of economic societies by setting the rules of the game. In response, organizations design strategies to win the game according to the rules.

North connects institutions to economic growth: Institutions influence the costs of both exchange and production. They affect the costs of measuring and enforcing the terms of exchange, and the uncertainty discount pertaining to such costs. For example, information disclosure provisions and property rights structures reduce measurement costs; judicial systems lower enforcement costs. Together they shape the transaction costs at which firms can secure their inputs and sell their outputs. In addition, institutions influence firms' (and their financiers') perception of their business risks, affect firms' investment decisions and cost of capital, and consequently change firms' production costs.

The empirical evidence suggests several mechanisms through which institutions affect firm growth. For example, law and order give firms confidence in granting trade credit to their customers and promote sales (Johnson, McMillan, & Woodruff, 2002a); they also encourage banks to provide long-term financing for investments (Demirguc-Kunt & Maksimovic, 1998). Efficient judicial systems support firm expansion: Firms in R&D-intensive industries are larger in countries with better patent protection (Kumar, Rajan, & Zingales, 2001). More developed local financial markets supply cheaper external capital to supplement firms' internal cash flows (Guiso, Sapienza, & Zingales, 2004; Rajan & Zingales, 1998). In contrast, less secure property rights discourage private investment and hinder firm expansion (Johnson, McMillan, & Woodruff, 2002b). Crime and political instability curb firm growth (Ayyagari, Demirguc-Kunt, & Maksimovic, 2006).

Despite their significantly negative impact on the growth of domestic firms, weak institutions do not impose an equally binding constraint on MNCs. In fact, MNCs are established to arbitrage between differential institutional constraints, effectively putting "sovereignty at bay" (Kobrin, 2001; Vernon, 1971). Trade barriers make MNCs more competitive than domestic importers or exporters (Caves, 1996). Firms with greater foreign operations benefit more from differences in tax regimes by shifting assets and redistributing profits among host countries (Desai, Foley, & Hines, 2004a, 2006a). Capital account restrictions imposed by policymakers or underdeveloped local financial markets only prompt MNCs to arbitrage through the internal capital market, giving them additional competitive advantage relative to domestic firms (Baker, Foley, & Wurgler, 2005; Desai, Foley, & Forbes, 2005; Desai, Foley, & Hines, 2004b, 2006b). Weak regimes for intellectual property rights (IPR) protection dampen incentives of local inventors but not those of MNCs: They manage to source from weak IPR countries innovations that are of greater value to their internal use than to their potential competitors (Zhao, 2006).

The literature suggests that MNCs can use two global strategies in circumventing institutional constraints to their growth: location choice and governance mode; each has its limitations. Location choice refers to the selection of host countries depending on the quality of their institutions. Every location has its advantages and disadvantages. For example, MNCs can locate their affiliates at places where local talent and technologies are abundant (Almeida, 1996; Chung & Alcácer, 2002), or where it is less likely that the firm's knowledge will leak to a competitor (Yoffie, 1993), but it is difficult to achieve both objectives at the same location. In addition, some locations are unavoidable due to the attractiveness of local factor endowment, labor costs or market demand. Very few MNCs can afford to avoid countries such as Brazil, Russia, India, or China (BRIC countries), despite their weak institutions. Finally and most fundamentally, if MNCs only go to locations where institutions are strong and markets are efficient, then they do not have a competitive advantage over domestic firms trading across borders.

Governance mode refers to the choice of ownership based on the quality of institutions. It also has several limitations. First, depending on the parties' (including the government's) bargaining power, the MNC and its local partners may settle on a transfer price that effectively redistributes profits regardless of their equity or contractual entitlement (Svejnar & Smith, 1984). Second, the optimality of various governance modes in dealing with weak institutions is often undetermined. For example, a joint-venture gives local partners the incentive to help the MNC effectively navigate the corrupt government bureaucracy, but can also put the MNC at the risk of being expropriated by the local partners for their own benefits (Henisz, 2000; Wei & Javorcik, 2002). Finally, from the agency literature, we know that even 100% ownership does not guarantee control, since ownership and control are different elements of corporate governance (Berle & Means, 1932; Fama & Jensen, 1983). Ownership only gives owners the right to residual profits. In contrast, control provides a broad range of intangible benefits. For example, managerial control over the production and procurement processes provides managers with experience and know-how, which improve their outside options for alternative employment or entrepreneurship, and competition the MNC (Feenstra & Hanson, 2005). The weaker the institutions, the more ownership rights will diverge from control benefits (Bertrand, Mehta, & Mullainathan, 2002).

2.4.2. Institutions and organization structure

Limited by location and governance choices, MNCs have organization structure as a natural element of design. In fact, organizational forms such as family firms, business groups, and Japanese bank-centered "Keiretsu" have all been credited for improving operational efficiency when there are "institutional voids" (Anderson & Reeb, 2003; Hoshi, Kashyap, & Scharfstein, 1991; Khanna & Palepu, 2000).

Viewing MNCs as global networks of production and distribution, an emerging strand of literature examines MNCs' internal organization of global activities as an explicit strategy. For example, Hanson, Mataloni, and Slaughter (2001) investigate MNC strategies in assigning production and distribution tasks either separately or collectively among affiliates. In addition to production and distribution, Alcacer (2006) includes R&D activities into his analyses. He examines firms' organization strategies to balance the tradeoff between agglomeration benefits and competitive pressure in making location choices. He suggests that MNCs colocate a centralized R&D unit with other firms to benefit from knowledge spillover, but disperse the production and marketing activities to less congested places to avoid competition. Zhao (2006) focuses on R&D activities and proposes that even R&D activities can be strategically disaggregated. She shows that MNCs can divide up R&D tasks and assign affiliates in weak IPR countries to work on innovations that are only valuable after being combined with innovations developed by affiliates in other countries, effectively reducing the independent value of the innovations developed in weak IPR countries and lowering expropriation risks.

While innovative and insightful, these studies do not directly test the underlying organization structures that make task reassignments possible. The strategy of operating a global value chain involves reallocating resources and combining efforts among affiliates across borders, which requires significant coordination effort. Given that organization structure affects coordination costs, understanding the organization structure of MNCs will help us understand the vital forces behind their growth.

2.4.3. Summary and potential gaps

Weak institutions limit firm growth because they increase both transaction and production costs. These costs reduce the efficiency of resource allocation. The comparative advantage of MNCs lies in their ability to arbitrage proprietary assets across institutional barriers and reallocate resources to where they are most needed. Location choices and governance modes, two of the most studied strategies for MNCs, are necessary but not sufficient conditions for achieving the goal of arbitrage. Organization structure, by directing information and decision rights, may help lower coordination costs for cross-border activities and achieve growth.

2.5. Summary of the literature review

Firm boundaries are not defined by a single production technology or transaction, but by managers' capacity to coordinate sets of interdependent activities. Absent limits to managers' coordination capacity, firms should face less binding constraints in pursuing growth strategies such as related diversification, an otherwise "beneficial" strategy due to synergies.

Organization structure directs the flow of information and channel of communication; divides the task of information processing and decision making; prescribes expectations, priorities, and roles of authority; and aligns incentives. It therefore may have an important bearing on firms' coordination capacity and consequently their growth.

The role of structure in directing information and providing authority for resource allocation is crucial when firms operate in heterogeneous institutional environments. MNCs, through their multinational hierarchical structure, may be able to arbitrage across institutional constraints and grow beyond the scope of domestic firms.

In the next three chapters I present three empirical studies. Chapter III examines the impact of coordination costs on firms' choice of diversification strategies. Chapter IV investigates how firms design their organization structure to enhance coordination capacity and alleviate coordination costs. It examines the role of a hierarchical structure in balancing the tradeoffs of a modular vs. an integral structure. Chapter V extends the inspection of hierarchical organization structure from firm to unit level and studies the delegation of coordination responsibilities within a hierarchical structure. It exploits institutional differences across host countries where MNCs operate. It shows that, delegation is an important vehicle to countervail coordination costs imposed by weak institutions.

Chapter 3

Synergies, Coordination Costs and the Direction of Diversification

> [The Nature of the Firm] explained why there were firms but not how the functions which are performed by firms are divided up among them.
>
> – Coase (1993: 73)

> [Integration costs of a particular activity] may be determined by the other activities that the firms are undertaking.
>
> – Coase (1993: 67)

3.1. Introduction

As a critical engine for firm growth, diversification is of central concern to strategy scholars (Chandler, 1962; Montgomery, 1994; Penrose, 1959; Rumelt, 1974; Teece, 1982). The focus of the diversification literature over the last three decades has been the comparative synergistic benefits of more vis-à-vis less related diversification: Firms diversifying into less related industries will find it more difficult to transfer managerial knowledge, capabilities, routines, and repertoires (Nelson & Winter, 1982; Penrose, 1959; Prahalad & Bettis, 1986), or to apply physical, human, and technological resources (Farjoun, 1994; Montgomery & Wernerfelt, 1988; Silverman, 1999) to the new business. This synergistic view prescribes a continuous path for diversification, starting from the most related industries, through progressively less related industries, and stopping where potential synergistic benefits diminish to zero. Yet, one aspect of diversification that has been relatively understudied is the limit to *related* diversification. Is higher degree of relatedness (synergies) always better? Why do firms sometimes pursue less related diversification even before they exhaust opportunities in more related markets? Why do firms differ systematically in the degree of relatedness among their businesses?

To address these questions, this paper argues that, to realize the potential synergies, firms need to actively manage the interdependencies created by sharing resources between products, which adds to coordination demand from firms' existing businesses, and may cause marginal coordination costs to outweigh marginal synergistic benefits. The impact of coordination costs is particularly significant if the existing businesses are already complex. Taking into account the joint effects of synergies and coordination costs, firms may forego higher degree of relatedness in favor of lower degree of relatedness in choosing diversification strategies, when the net benefit – the difference between synergistic benefits and coordination costs – from the former is less than the net benefit from the later. Therefore, while diminishing synergistic benefits set a limit to diversification in general, increasing coordination costs set a limit to *related* diversification.

Despite its importance to the completeness of the theory of diversification, the coordination cost of related diversification has been highlighted by only a handful of scholars (Hill, Hitt, & Hoskisson, 1992; Jones & Hill, 1988; Nayyar, 1992). While these studies insightfully point out that related diversification implies greater coordination costs than unrelated diversification, they do not specify or operationalize a mechanism that may cause both synergies and coordination costs, let alone the contingencies under which coordination costs may surpass synergies.

Meanwhile, the impact of coordination costs on firm scope has received renewed interests from scholars (Baldwin & Clark, 2000; Fine & Whitney, 1999; Hoetker, 2006;

Jacobides, 2005; Jacobides & Hitt, 2005; Langlois & Robertson, 1992; Schilling & Steensma, 2001). This literature, however, has largely been focused on vertical integration rather than horizontal diversification. There have been some recent calls for the representation of the firm as a system of interdependent tasks, rather than horizontal or vertical scopes (Baldwin, 2008; Ethiraj & Levinthal, 2004b; Sanchez & Mahoney, 1996). Yet, due to difficulty in operationalizing interdependencies systematically across a large sample of firms in different industries, most of the prior work on system interdependencies keeps the concept at an abstract level and relies on computer simulations (Burton & Obel, 1980; Ethiraj, Levinthal, & Roy, 2008; Lenox *et al.*, 2006; Lenox, Rockart, & Lewin, 2007; Levinthal, 1997; Rivkin, 2000; Rivkin & Siggelkow, 2007), or case studies (Siggelkow, 2001, 2002a).

The current study first pinpoints the sharing of resources between different businesses as one driver for both synergies and coordination costs. When different businesses require similar resources, sharing the resources creates synergies. However, sharing resources also requires coordination (e.g., scheduling, adjustment, joint design), which is costly. Therefore, the potential to share resources between the existing and the new businesses has both a positive and a negative effect on the direction of diversification.

The study then specifies a contingency under which marginal coordination costs of related diversification surpass marginal synergistic benefits: the complexity of the firm's existing businesses. Complexity refers to the number of activities that are interdependent with each other. It has been argued to impose significant coordination demand on managers and consequently affect firm profits, firm scope, and industry dynamics (Ethiraj & Levinthal, 2004a, 2004b; Lenox *et al.*, 2006, 2007; Levinthal, 1997; Rivkin, 2000; Rivkin & Siggelkow, 2007). Since the firm's overall coordination capacity is limited (Simon, 1947), greater demand for coordination from a more complex business portfolio leads to a higher rate at which the coordination cost increases with the degree of resource sharing between the existing and the new businesses. Therefore, different levels of complexity of different firms' existing businesses generate different demands for coordination, thereby imposing different constraints on the degree of related diversification firms pursue. By connecting related diversification with the existing businesses of the firm, the paper implies that firms' scope choices may be substitutive. Efforts to reduce coordination along some dimensions (e.g., disintegration through modularization and outsourcing) may free up coordination capacity for other activities, such as related diversification.

I examine the impact of the potential for resource sharing with a new business and the complexity of existing businesses on the direction of diversification using a unique dataset of U.S. equipment manufacturers from 1993 to 2003. I measure the potential for resource sharing using the similarity of resources between a target industry and the industries the firm already operates in. I measure complexity based on the flow of work inputs between the industries the firm already operates in. I find that, consistent with the synergistic view, firms are more likely to diversify into a new business when it shares more resources with the firms' existing businesses. However, firms are less likely to diversify into a new business when their existing businesses are more complex, suggesting the constraining effect of coordination costs on firm scope. Last but not least, the complexity of existing businesses mitigates the positive impact of the potential for resource sharing on the direction of diversification. These findings suggest the constraints that coordination costs impose on firms' growth options.

The rest of the paper is organized as follows. In Section 2, I elaborate on the joint effects of synergies and coordination costs, and develop the theory and hypotheses. Section 3 describes the study setting and the research design. Section 4 presents the results. Section 5 discusses the limitations and concludes.

3.2. Theoretical background and hypothesis development

3.2.1. Benefits of related diversification

Potential synergies or scope economies for related diversification arise from sharing common inputs and joint production (Bailey & Friedlaender, 1982; Panzar & Willig, 1981; Teece, 1980). For example, indivisible physical inputs, such as a machine that can be used for manufacturing multiple products, are an importance source of scope economy (Teece, 1982). The notion of "common inputs" has been expanded to include managerial know-how (Prahalad & Bettis, 1986), marketing and distribution channels (Montgomery & Hariharan, 1991), technology, knowledge and human capital (Chang, 1996; Farjoun, 1994; MacDonald, 1985; Robins & Wiersema, 1995; Silverman, 1999). Given that firm resources are in limited supply (Penrose, 1959), there is an opportunity cost to diversify (Levinthal & Wu, 2006). A diversifying firm will rank potential target industries according to the degree to which its resources are applicable to each industry; greater applicability increases the probability of entry (Silverman, 1999). The synergistic view therefore suggests the following baseline hypothesis.

Hypothesis 1: Ceteris paribus, firms are more likely to diversify into a new business when it shares more resources with the firms' existing businesses.

3.2.2. Coordination costs and diversification

Firms' incentive to diversify depends on not only the potential synergies, but also the coordination costs (Markides, 1995). Coordination is to manage interdependencies between activities (Malone & Crowston, 2001). At the transaction level, it is often believed that an integrated firm is more efficient than two separate firms at coordinating interdependent activities. However, at the firm level, because the firm's overall coordination capacity is limited (Simon, 1947), coordination costs rise as the firm's coordination demand approaches the limit of its coordination capacity. Therefore, to understand the coordination costs of diversification, a firm-level strategy, we need to investigate other activities within the firm that also demand coordination. A firm is better represented by a system of tasks that are interdependent with each other to varying degrees (Bladwin, 2008): It is a "miniature economy" that carries out a subset of the tasks embedded in the larger economic system (Holmstrom, 1999). Such system view conjectures that firm boundaries should be determined by the distribution of the interdependencies in the task system: They should be located at the thin cross points – points where there is low degree of interdependence between tasks, since it will be more costly to coordinate between two firms when their tasks are highly interdependent (Baldwin, 2008; Ethiraj & Levinthal, 2004b).

Whether a crossing point is too thin to be integrated or too thick to be left out depends on the demand for coordination from the tasks that are already integrated. The more complex the integrated tasks – the denser the interrelations among them – are, the greater the existing coordination demand. Complexity raises the demand for communication among agents about factors that affect each others' decisions, and the actual decisions when multiple equilibriums exist (Arrow, 1974; Becker & Murphy, 1992). Complexity also raises the demand for information processing to track the multiple interactions among decision variables (Simon, 1957, 1962). Finally, because of the increased workload of communication and information processing, complexity raises the probability of decision errors (Levinthal, 1997; Rivkin, 2000; Sutherland, 1980). Given the opportunity cost of coordination capacity to managing any interdependent tasks, the greater the existing coordination demand is, the less likely the firm will integrate a new task, or diversify into a new business.

I therefore propose the following hypothesis.

Hypothesis 2: Ceteris paribus, firms are less likely to diversify into a new business when their existing businesses are more complex.

3.2.3. Coordination costs of related diversification

While coordination costs pose a challenge to diversification in general, firms pursue a higher degree of relatedness – potential synergies – as their diversification strategy may incur greater coordination costs. This is because synergies do not come for free. To achieve synergies, firms need to create and actively manage the interrelationships between tasks, which is costly (Hill, Hitt, & Hoskisson, 1992; John & Harrison, 1999; Jones & Hill, 1988; Nayyar, 1992). For example, to achieve economies of scope, managers have to undertake the difficult task of balancing the need for differentiation vs. standardization when they produce different products on the same platform (Krishnan & Gupta, 2001; Robertson & Ulrich, 1998).

Figure 1 illustrates a cost-benefit analysis of different diversification strategies. For simplicity, assume there are only two groups of industries that the firm is considering diversifying into. The first group of industries has greater potential for synergies (and hence are more related) with the firm's existing businesses, whereas the second group of industries is less related. Industries within each group are equally related with the firms' existing businesses. SB^{MR} and SB^{LR} represent potential synergistic benefits that can be achieved from diversifying into the two groups, respectively; CC^{MR} and CC^{LR} represent the respective coordination costs that are required to realize the potential synergies. Let's first assume that the coordination costs to diversify into the two groups are the same (Figures 1a and 1b). If the firm sees opportunities only in the first group, it will diversify up to the point where the net benefit is the greatest, or where the marginal benefit equals to the marginal cost (D^{MR*}, Figure 1a). Likewise, if the firm sees opportunities only in the second group, it will diversify up to the point where the marginal benefit equals to the marginal cost (D^{LR*}, Figure 1b). If the firm sees opportunities in both groups, then it will compare the slopes of SB^{MR} and SB^{LR}, and pick an industry that provides the highest marginal benefit as it builds up its portfolio. If SB^{MR} is steeper than SB^{LR} (copied from Figure 1a for comparison) all the way up to D^{MR*}, the firm will diversify only into the first group. If, in contrast, SB^{MR} becomes less steep than SB^{LR} as the firm expands out, the firm will diversify into both groups, depending on the relative marginal benefit of adding industries from either group.

Now let's allow the coordination cost curve to rise faster for diversifying into the first group than for the second group. This change in assumption has two immediate consequences for the degree of related diversification. First, as the coordination cost curve rotates inward for the first group, marginal coordination cost increases, and the optimal level of diversification into the first (more related) group decreases. In addition, as the net benefit from the first group decreases, it becomes less attractive; the firm is even more likely to diversify into the second (less related) group. The proportion of industries that the firm operates in the two groups depends on the relative steepness of CC^{MR} vs. CC^{LR}.[8]

The relative steepness of CC^{MR} vs. CC^{LR} depends on the complexity of the firm's existing businesses. The more complex the existing businesses are, the greater the existing demand for coordination, the more the coordination costs will increase with the degree of relatedness between the existing and the new businesses, and the less likely the firm will pursue a related diversification strategy.

Hypothesis 3: Ceteris paribus, the effect of H1 will be mitigated by the complexity of the firms' existing businesses.

3.3. Research design and methodology

3.3.1. Empirical context

I tested my hypotheses on a sample of U.S. equipment manufacturers from 1993 to 2003. Together these firms produce fabricated metal products, industrial machinery and

---

[8] A similar but less detailed figure is presented in Jones and Hills (1988). There are, however, significant differences between the two figures. First, Jones and Hill compare related diversification and (totally) unrelated diversification that only benefits from internal capital markets; while I compare more vs. less related diversification. Second, Jones and Hill assume that "for unrelated diversification higher levels of diversification are necessary for capital market gains to be realized." Hence, they claim "related diversification to be associated with the highest level of profit" (pg. 169 and Figure 3b). My analysis does not rely on such assumption. Finally, while Jones and Hills insightfully point out that bureaucratic cost will increase geometrically with the level of related diversification, they do not specify whether the cost increases at different rates for the same type of diversification within different firms. As a result, while bureaucratic costs are different for related and unrelated diversification, bureaucratic costs for each type (related or unrelated) are the same across firms. The diversification choice again boils down to the benefit side; total benefits drive net benefits when costs are fixed: "In essence the choice is governed by the extent to which *commonalities* between divisions allow for the exploitation of rent-yielding resources through sharing. The closer commonalities, the greater the ability to exploit rent-yielding resources, the greater the *total economic benefits* associated with related diversification, the greater the *relative profitability* of this strategy when compared with unrelated diversification"(pg. 170, italic added). In contrast, I am more explicit about how complexity rotates the coordination cost curve and changes the relative net benefits of more vs. less related diversification strategies for different firms.

equipment, electrical and electronic equipment, transportation equipment, and instruments and related products (SIC 34-38). According to data provided by the Bureau of Economic Analysis (BEA), equipment manufacturers produce about $1.6 trillion of output in terms of shipment value, or 30% of the output produced by all manufacturing sectors. When adjusted for inflation, their shipment value grew by 85% from 1993 to 2002, whereas the average growth rate for the entire manufacturing sector was only 32%.

I chose this empirical setting primarily because equipment manufacturing entails multiple stages and requires large quantities of intermediate inputs, which provides large variation in firm scope and complexity across firms in the same primary industry. In addition to cross-sectional variations, firms in the equipment manufacturing sectors have also experienced significant scope changes over the last two decades. Many have been evolving toward "vertical disintegration," whereby a previously integrated production process is divided up between two sets of specialized firms in the same industry (Baldwin & Clark, 2005; Fine & Whitney, 1999; Macher, Mowery, & Hodges, 1998). These cross-sectional and longitudinal variations provide strong explanatory power to my empirical models.

3.3.2. Data and sample

I built a unique dataset of firms' internal activities and their interrelationships with data from various sources. These data have been available for a long time, but have not been fully exploited to the benefit of investigating the internal reality of firms.

First, I started with the Directory of Corporate Affiliations (DCA) offered by LexisNexis. DCA provides corporate reporting information on parent companies and their "units" (e.g., groups, departments, divisions, subsidiaries, etc.), down to the seventh level of corporate linkage. In addition, the dataset describes up to 30 segments (four-digit SIC level) for each unit. A similar dataset, albeit for Canadian firms, was used by Lemelin (1982) in his study of related diversification.[9] Several factors contribute to the reliability of the DCA data. According to LexisNexis, the dataset is compiled from information reported by the companies, as well as from annual reports and business publications in the LexisNexis database. In addition, each company is contacted directly for information verification (LexisNexis, 2004). An example of the segments operated by all automakers is provided in Table 1.

While the DCA dataset provides unique and more comprehensive information about firms' business segments, it has several limitations. For example, it does not provide sufficient information for the units. An important piece of information that is missing is unit size or the level of firm activity in each segment. In robustness checks, I adjusted complexity by weighting each interdependent segment pair with the number of units operating in the pair; results were similar. Another limitation of the DCA dataset is that firms do not report their units consistently over time, resulting in some units disappearing from the dataset for a few years before they reappear in the dataset. If not corrected, this will lead to overestimation of entry. For units that reappeared during the sample period, I interpolated the data for the missing years, assuming their scope had remained unchanged

[9]Prior research on diversification primarily relies on the Compustat segment dataset. However, as pointed out by various authors, the dataset has its limitation when used to measure diversification (Davis & Duhaime, 1992; Denis, Denis, & Sarin, 1997; Villalonga, 2004). Mainly the dataset tends to under-report firms' level of diversification due to its10% materiality rule (Lichtenberg, 1991). In addition, it does not capture vertical integration (Financial Accounting Standards Board, 1976; Villalonga, 2004). These shortcomings are particularly problematic for my study of intra-organizational activities. A major advantage of the DCA dataset is that it provides unique and more comprehensive information about firms' business segments. For example, Villalonga (2004) finds, based on confidential plant-level datasets provided by the U.S. Bureau of the Census, that the most diversified firm operates in 133 segments; but the number of segments reported by the same firm in the Compustat dataset is ten. More consistent with the Census datasets than the Compustat dataset, the DCA dataset shows the most diversified firm has 166 segments.

during those years. This approach would not capture units that reappeared after my sample period. However, given that only 1% of the units in the dataset have gaps in their appearance in the dataset over the entire sample period, and the average number of missing years for these units is only three years, I do not expect the impact of missing years to be significant for the entire sample.

I started with the DCA dataset for publicly traded firms from 1993 to 2003, which covers firms with revenues of more than $10 million and more than 300 employees (LexisNexis, 2004). The dataset contains 9,850 parent companies and 120,113 units. 2,075 parent companies list their primary industries as in the equipment manufacturing sectors.

Second, to construct interrelationships among the business segments, I used the BEA Input-Output (IO) tables. The tables contain the value of pair-wise commodity flows among roughly 500 private-sector, intermediate industries. The tables are updated every five years. Since the IO industry code system was changed by BEA in 1997, to ensure comparability I used the tables for 1992.[10]

Finally, in order to obtain financial data for the parent companies, I augmented my dataset with Compustat Industrial Annual Financial and Compustat Segment datasets. I matched the datasets by parent company names first through a software program[11] and then through manual checks. Ambiguous matches were further verified via company Web sites. I matched 1,246 (60%) diversified companies in the equipment manufacturing sectors. I dropped 164 firms for which there were missing values in the Compustat financial data. There are 459 four-digit SIC manufacturing industries (SIC2011-SIC3999).

[10] Several authors have observed that the coefficients have been fairly stable over the years.
[11] I thank Minyuan Zhao for her help with the matching.

I was able to extract industry growth, concentration and financial data from the U.S. Bureau of Census and Compustat for 429 of them. Each of these 429 industries that a firm does not operate in the previous year is a potential target for entry. I used lag value for all my independent and control variables. My final sample contained 1,082 firms, 5,311 firm-years, and 1,973,939 firm-year-destination-industry observations.

3.3.3. Variable definitions and operationalization

Dependent variables

DIVERSIFICATION (D_{ijkt}) was coded as a dummy variable based on the DCA dataset. D_{ijkt} =1 if firm i diversified from its primary industry j into industry k in year t. Similar to prior studies (MacDonald, 1985; Silverman, 1999), I treated any industry k in which firm i did not operate in the previous year (t-1) as a potential destination industry in the current year (t). Any industry that the firm operated in the previous year was excluded from the set of potential destination industries. Among the potential destination industries, those that firm i did operate in year t were entries, and coded as 1.[12]

Independent variables

INPUT-SIMILARITY ($IS_{ik,\ 1992}$) measures the degree to which firm i's primary industry share productive inputs with a potential destination industry k. From the BEA IO tables, Fan and Lang (2000) calculate the correlation coefficients across industry input structures between the amounts of intermediate inputs from every other industry in the IO

[12] However, while both MacDonald (1985) and Silverman (1999) code entries as those potential destination industries that the firm does not participate at the beginning of the sample period but participates at the end of the sample period, I code entries according to the firm's portfolio in each year during my sample period. This is in order to measure entry timing more accurately and to take advantage of the panel nature of my data. To ensure consistency with prior findings, I used MacDonald's and Silverman's approach in robustness checks; my main results hold.

tables that the two industries directly require per dollar of their respective output. I used their coefficients. The measure is based on the assumption that the manufacturing firms' resources are embedded in the productive processes. Therefore, the more similar the productive inputs required by the firms' existing and the new businesses are, the greater the potential for resource sharing and joint production.

Such measure has been used in prior studies of diversification (Alfaro & Charlton, 2007; Fan & Lang, 2000; Lemelin, 1982; Matsusaka, 1993; Schoar, 2002; Villalonga, 2004). The approach is consistent with the attempt by strategy researchers to "develop indirect indicators of … underlying similarities among SIC industries based on secondary data about industrial activity," when "direct measurement may be difficult or impossible" (Robins & Wiersema, 1995: 282). It does not depend on the hierarchical scheme of the SIC system to define relatedness, but uses resource, input, and task similarity between industries to proxy relatedness and synergy potential (John & Harrison, 1999). Other similar measures of inter-industry input similarity, such as similarity in human capital (Chang, 1996; Farjoun, 1994) and technology (Robins & Wiersema, 1995) have also been used in prior studies to proxy inter-segment relationships within firms, or to predict the direction of diversification.[13]

COMPLEXITY(K_{it-1}) was defined as the number of segment pairs in firm i's portfolio in year t-1 that supplied *significant* productive inputs to each other.

[13] The major shortcoming of the measure is that it captures input similarity at the industry rather than the firm level. Segments within a firm can choose to share inputs between two segments more or less than the average flow of inputs between the two industries. This results in a measurement error which may cause an attenuation bias toward zero and make my results more conservative. Despite this shortcoming, the measure has a major advantage of being exogenous to any individual firm's decision and is therefore less likely to be correlated with unobserved firm heterogeneity.

There are very few econometric studies of complexity – degree of interdependencies – in task systems at the firm level. This is because the construct is difficult to operationalize and measure. For this reason, most of the prior work on system interdependencies keeps the concept at an abstract level and relies on computer simulations (Burton & Obel, 1980; Ethiraj *et al.*, 2008; Lenox *et al.*, 2006, 2007; Levinthal, 1997; Rivkin, 2000; Rivkin & Siggelkow, 2007) or case studies (Siggelkow, 2001, 2002a).

I made a modest attempt to tackle this challenge. A firm often produces not only the final goods but also various intermediate inputs and their ancillary outputs along the value chain. I operationalized complexity as the number of productive tasks that are interdependent through the flow of work inputs (Wageman & Baker, 1997). Theoretically, productive complexity has been argued to impose significant coordination demand on managers and consequently affect firm profits and industry dynamics (Lenox *et al.*, 2006; Lenox, Rockart, & Lewin, 2007).

My measure is similar to a "density" measure if the firm's business portfolio were to be viewed as a system of tasks supplying inputs to one another. It corresponds to the theoretical definition of complexity in the modularity literature, based on either task structure matrices (Baldwin & Clark, 2000) or NK models (Kauffman, 1993; Levinthal, 1997; Rivkin, 2000). It captures the prevalence of interactions among tasks. Similarly, Burton and Obel (1980) use a computer-simulated IO table to measure technological complexity and its impact on performance under an M-form structure.

I defined the flow of productive inputs between two industries as *significant* if they on average contribute more than 1% of the inputs to one another, based on the BEA IO

Tables. The few prior studies that measure interrelationships between two industries based on the IO tables choose either 5% (Matsusaka, 1993; Schoar, 2002; Villalonga, 2004), or 1% (Lemelin, 1982) as the threshold. I used 1% in my main analyses and 5% in robustness checks; results were similar.

Control variables

Following Silverman (1999), I controlled for other factors that may affect a firm's diversification decision, such as firm characteristics, destination industry characteristics, and firm-industry relatedness characteristics. Firm-level variables included size (employees), age, R&D intensity, accumulative level of diversification (number of segments) and its square term,[14] geographic dispersion, among others. Destination-industry variables include growth, concentration, and R&D intensity.[15] In addition, I included the intensity of capital expenditure to control for the size of capital sunk cost that has been pointed out in the industrial organization literature as a major obstacle for entry (e.g., Sutton, 1991).[16]Firm-industry relatedness variables capture the fungibility of firm-specific resources to the target industry (Silverman, 1999). They included the absolute difference between the firm's R&D intensity and the destination industry's R&D intensity, and the absolute difference between the firm's capital intensity and the destination industry's capital intensity.

---

[14] By controlling for the number of segments (N) and N squared, I indirectly controlled for the total number of segment pairs: N(N-1)/2.

[15] Industry growth and concentration data were obtained from the U.S. Bureau of Census; R&D data was obtained from Compustat segment datasets; Advertising intensity was not included due to large amount of missing values in the Compustat datasets.

[16] In addition to capital intensity, in robustness checks, I also controlled for asset liquidity - defined as the share of used capital in aggregate industry capital expenditure - in the primary and destination industries to more accurately measure sunk costs (Balasubramanian & Sivadasan, forthcoming; Schlingemanna, Stulz, & Walkling, 2002). As expected, asset liquidity turned out to be positively associated with diversifying entry. However, since the SIC codes were changed in 1997, I was able to test the impact of asset liquidity only for a sub-sample-period: 1993-1995. My main results hold with the addition of asset liquidity.

In addition, I included growth and concentration in the firm's primary industry to control for opportunity costs of diversification. In robustness checks, I included a leverage ratio (Mansi & Reeb, 2002), an Equity-Dependence Index (Baker, Stein, & Wurgler, 2003; Kaplan & Zingales, 1997; Lamont, Polk, & Saa-Requejo, 2001), and a corporate governance index (Gompers, Joy, & Metrick, 2003), to control for alternative motivations for unrelated diversification, based on portfolio, internal-capital-markets, and agency theories; results were similar.

3.3.4. Model specification

Following prior studies (Montgomery & Hariharan, 1991; Silverman, 1999), I used a logit model to predict the probability that a firm diversifies into a particular industry. I extended the prior models by including the measure of complexity. According to the model, the expected probability of entry is:

$$E[D_{ijkt} = 1] = \beta_0 + \beta_1 IS_{jk,1992} + \beta_2 K_{i,t-1} + \beta_3 IS_{jk,1992} * K_{i,t-1} + I_{j,t-1} + I_{k,t-1} + \Lambda_{i,t-1} \qquad (1)$$

where,

D_{ijkt}=1 if firm i diversifies from primary industry j into industry k in year t;

$IS_{jk,1992}$ is input similarity between industries j and k based on 1992 IO tables;

$K_{i,t-1}$ is complexity calculated based on firm i's portfolio in year t-1;

$I_{j,t-1}$ and $I_{k,t-1}$ are characteristics of industries j and k, respectively, in year t-1;

$\Lambda_{i,t-1}$ is a vector of characteristics of firm i in year t-1.

I predict $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 < 0$.

Since there are large quantities of non-entries, the standard logit model may underestimate the probability of entries, and the coefficients may be biased (King & Zeng, 2001a, 2001b). As a robustness check, I ran a rare-event logit model (RE Logit) to correct for the potential biases (Tomz, King, & Zeng, 1999). The rare-event logit model has been applied in prior studies of market entry that involve large quantity of non-entries (Jensen, 2003; Wu, 2007).

3.4. Results

3.4.1. Descriptive statistics

On average, there are 1,973,939 potential entries during my sample period; 204,906 in 1994 and 230,531 in 2003. Entry occurred in about 1,178 (0.06%) of the potential destination industries. Sample firms' diversifying entry ranged from zero SIC to 22 SICs entered.

Table 2 provides descriptive statistics of the sample. The average firm has a sales revenue of about $235 (exp(5.46)) million; 86% of which comes from the firm's primary segment. On average the firm has 1.43 (exp(0.36)) million employees. Capital investment and R&D expenditure account for 5% and 8% of sales, respectively. An average firm operates in more than seven segments; the most diversified firm (Emerson Electric) operates in 105 segments. The average growth in the firms' primary industry is 13%. The primary industries are fairly competitive, evidenced by the low concentration ratio. On average, firms have 40 (47%) segments pairs that supply more than 1% of productive inputs to one another.

At the industry level, the average correlation coefficient in input similarity between the primary and destination industries is 0.28. The average growth rate in the destination industry is 1%, whereas the average Herfindahl Index is 726. Capital investment and R&D expenditure account for 8% and 7% of sales, respectively, in the destination industries. The absolute difference in capital (R&D) intensity between the firm and the destination industry is 12% (21%). There is great variation across industries, suggesting that an entry model controlling for individual industry characteristics is appropriate.

Table 3 summarizes the average level of diversification, complexity and probability of diversifying entry, by sector and year, respectively. First, there is large variation across sectors. Firms in the transportation equipment sector are most diversified, and firms in the electrical and electronic equipment sector have the most complex productive system. To control for sectoral differences, I add sector dummies. Second, with rare exceptions and consistent with the disintegration literature, there is a general trend toward simplification of productive systems, evidenced by reducing level of complexity over the years. There is no general trend in diversification and diversifying entry over the years. To control for macro conditions that may affect firms' general diversification pattern, I add year dummies.

Table 4 summarizes the pair-wise correlation coefficients between the key variables in this study.

3.4.2. Direction of diversification

Table 5 estimates the probability that the firm diversifies into a potential destination industry. All regressions are estimated following Equation (1). Since STATA's RELogit model does not report goodness-of-fit statistics, I start with the standard logit models to show the improvement in the goodness-of-fit statistics with the addition of each independent variable. I then compare the coefficients with those based on a RELogit model in the last two columns. Results are similar across these models.

Control variables

Column (1) includes all the control variables. First, the impact of firm characteristics is in line with expectation. Firm size, measured based on employment, is positively associated with entry: Larger firms are more likely to diversify, suggesting that they may have more resources to share across segments. Firms' stock of diversification, in terms of number of segments it operates in the previous year, is positively correlated with entry, again suggesting that they may have more resources to share across segments. In contrast, geographic expansion is negatively associated with product diversification; this may be due to constraints in coordination capacity but is left for future study. The impact of firm age is insignificant.

Second, at the industry level, as expected, growth in the destination industry is positively correlated with entry, whereas growth in the primary industry is negatively correlated with diversifying entry (although the impact is not always significant). At the same time, market concentration in the target industry is negatively correlated with entry, whereas the impact of concentration in the primary industry is ambiguous. These results suggest, consistent with prior studies (e.g., Silverman, 1999), that the characteristics of the primary industry alone are not as significant as expected, but the characteristics of the destination industry are important.

Finally, at the firm-industry level, capital intensity of the firm is negatively associated with diversifying entry, whereas the impact of capital intensity in the destination industry is insignificant, so is the difference in capital intensity between the firm and the destination industry. Consistent with prior studies, R&D intensity in the destination industry seems to attract diversifying entry, and the difference in R&D intensity between the firm and the destination industry deters entry (Silverman, 1999). Surprisingly, R&D intensity at the firm level is negatively associated with entry.

Hypothesis testing

Column (2) in Table 5 introduces input similarity. The results show that, consistent with H1, the degree to which the primary and destination industries share productive inputs is positively correlated with the probability of entry. Introducing input similarity also significantly improves the fit of the logit model, as evidenced by the log-likelihood ratio test ($\chi^2(1)$ =1,294.92, p<0.0001).

Column (3) introduces complexity. As suggested by H2, complexity is negatively associated with diversifying entry in general. The log-likelihood ratio again significantly improves ($\chi^2(1)$ =16.44, p<0.0001). Column (4) introduces the interaction term between input similarity and complexity. Consistent with H3, complexity mitigates the positive impact of input similarity on entry; and input similarity intensifies the negative impact of complexity. The log-likelihood ratio improves further ($\chi^2(1)$ =24.05, p<0.0001). The coefficient of input similarity remains positive and significant. To control for macro conditions at given time that may affect all firms' diversification pattern, Column (5) includes the year dummies; results were similar, albeit with less statistical significance.

Columns (6) and (7) use the rare-event logit model to address potential bias that may result from using the standard logit model. Compared to Columns (4) and (5), the coefficients of the independent variables based on the rare-event logit model are similar.

To quantify the impact on the estimated probability of entry for an increase in each of the two main independent variables from its mean to one standard deviation above the mean, I calculate a risk ratio after running the rare-event logit model (King & Zeng, 2001a) in Column (6). The risk ratio is computed as the ratio between the probability of entry conditioning on the independent variable being set at one standard error above the mean, and the probability of entry conditioning on the independent variable being set at the mean, keeping all other variables at their mean values. The results show that increasing input similarity from its mean value to one standard deviation above the mean more than triples the probability of entry. Increasing complexity from its mean value to one standard deviation above the mean reduces the probability of entry by 9%.

Since the marginal effect of interaction terms in logit models cannot be straightly read from the coefficients (Allison, 1999; Hoetker, 2007; Huang & Shields, 2000; Norton, Wang, & Ai, 2004), I plot in Figure 2 the estimated probability of entry against selective values of input similarity and complexity. It shows that across all deciles, input similarity is positively associated with entry. Complexity shifts the probability curve down and outward, as my hypotheses suggest.

Robustness checks

Table 6 presents results from robustness checks. One limitation of Equation (1) is that it only takes into account the potential synergies between the firm's primary industry and the destination industry. However, diversification may be an evolutionary process (Teece *et al.*, 1994). Firms may enter into a new business that is related to any of its existing businesses, rather than just the primary business. Column (1) therefore tests the following alternative specification, where I replace the primary industry j with the set of N industries that firm i already operates in year t-1: $J=[j_1, j_2, \ldots, j_N]$, and input similarity of the destination industry k to the primary industry j with the maximum input similarity of k to any of the industries that the firm operates in year t-1: $IS\_\max_{Jk,1992} = \max\{IS_{j_1k,1992}, IS_{j_2k,1992}, ...IS_{j_Nk,1992}\}$.

$$E[D_{iJkt} = 1] = \beta_0 + \beta_1 * IS\_\max_{jk,1992} + \beta_2 K_{i,t-1} + \beta_3 * K_{i,t-1} * IS\_\max_{jk,1992} + \bar{I}_{J,t-1} + I_{k,t-1} + \Lambda_{i,t-1} \quad (2)$$

Column (2) replaces the number of interdependent segment pairs with the share of interdependent segment pairs to standardize the measure of complexity. Column (3) adjusts this complexity measure by weighing it with the number of organizational units operating in each segment pair. This is because the DCA dataset does not provide the size of the firms' operation in each segment. If a firm only produces a small amount of output in a segment, the coordination demand may not be as significant as if the firm produces a large amount of output in that segment. These alternative measures of complexity lead to similar results, except for H2. In Columns (1) and (3), the impact of complexity is insignificant; H2 is not supported. H1 and H3 are supported in all the columns.

Overall, the results in Tables 5 and 6 and Figure 2 show that, consistent with my hypotheses, input similarity increases the probability of diversification, whereas complexity mitigates the positive effect of input similarity, and input similarity intensifies the negative impact of complexity. All three hypotheses are supported. The results are robust across most of the alternative specifications.

3.5. Discussion and conclusion

This study examines the joint effects of potential synergies and coordination costs on the direction of corporate diversification. It argues that, while synergy is a necessary condition for related diversification, it is not sufficient. The choice between target industries that are more related with the firm's existing businesses and those that are less related depends on the comparison of not only synergistic benefits but also coordination costs. Coordination costs accompany efforts to realize potential synergies, and may surpass potential synergies, making diversification into highly related industries less attractive. The analysis of coordination costs is particularly important when the firm's existing businesses are already complex, leaving less extra capacity to coordinate the potential interrelationship between the existing and the new businesses.

My empirical results support these arguments. I find that, consistent with the synergistic view, firms are more likely to diversify into a new business when it shares more resources with the firms' existing businesses. However, firms are less likely to diversify into a new businesses when their existing businesses are more complex, suggesting the constraining effect of coordination costs on firm scope. Last but not least, the complexity of existing businesses mitigates the positive impact of the potential for resource sharing on the direction of diversification. These findings suggest the constraints that coordination costs impose on firms' growth options.

The study has several limitations. First, it treats the complexity of productive tasks that a firm operates in house as exogenous or predetermined. It does not further investigate why some firms choose to integrate complex productive tasks, whereas others outsource them. The literature provides several explanations for why some firms are more integrated than others. Firms may integrate to leverage its core competencies into adjacent value chain tasks (Leiblein & Miller, 2003). For example, as a pioneer of the automotive industry, Ford developed capabilities in making machine tools better than any suppliers, and decided to manufacture the tools in house (Argyres & Zenger, 2007; Langlois & Robertson, 1995; Williams et al., 1993). Firms may also integrate to facilitate coordination along certain dimensions (Chandler Jr., 1977; Monteverde & Teece, 1982; Scherer, 1980; Williamson, 1975). Finally, firms also may integrate to accommodate differential positioning strategy for its products (Argyres & Bigelow, 2007). The current study does not argue against these justifications for integration. Rather, it points out that there is an opportunity cost of coordination that may lead to less subsequent related diversification. How firms endogenously decide complexity and the degree of related diversification is left for future study.

In addition, the study examines one type of synergies and coordination costs – those arising from sharing productive inputs across businesses. Whether the propositions can be generalized to other types of synergies, such as synergies in knowledge base (Robins & Wiersema, 1995; Silverman, 1999), is still an open question. Take knowledge as an example. On the one hand, knowledge, once it is developed, is more like a public good and less constraining in its application to new businesses (Teece, 1980; Wu, 2007). On the other hand, to ensure the proper development and diffusion of knowledge, significant coordination effort has to be exerted. A key element in knowledge development is researchers' ability to search beyond and recombine their individual knowledge bases (Henderson & Cockburn, 1994; Kogut & Zander, 1992; Rosenkopf & Nerkar, 2001). Broad search, however, requires that collaborative interrelationships between research units, as well as between knowledge-creating and knowledge-using units, be established and actively managed (Argyres, 1996; Argyres & Silverman, 2004; Gupta & Govindarajan, 2000). In addition, the more complex are the interdependencies among different elements of knowledge, the more costly the coordinated research and development effort (Ethiraj & Levinthal, 2004b; Rivkin & Siggelkow, 2003; Siggelkow

& Rivkin, 2006). For example, large pharmaceutical companies like GlaxoSmithKline have thousands of scientists working on drugs across multiple therapeutic classes. The budget allocation, task design, review, approval and decision processes throughout the cycles of drug development all take a significant amount of coordination effort (Huckman & Strick, 2005). Therefore, it is plausible that coordination costs also set a limit to diversification aimed at sharing technologies. However, an empirical test of the proposition in the context of technology involves major data work; it is therefore left for future study.

Despite the caveats, the study makes two important contributions to the literature on firm scope. First, it extends the cost-benefit analysis of diversification strategies and offers a unique explanation for the limit to *related* diversification: Diseconomies of scope in the form of coordination costs reduce the net benefit from related diversification. Such explanation sheds light on several empirical anomalies about firms' diversification strategies, primarily the lack of consistent evidence that related diversifiers outperform unrelated diversifiers (see reviews in Grant, Jammine, & Thomas, 1988: Table 1; Stimpert & Duhaime, 1997: 565), and the prevalence of unrelated diversification strategy among diversified firms (e.g., Berger & Ofek, 1995: 43 and Table 6; Schoar, 2002: Table I). To address the performance irregularity, significant methodological improvements have been made to sharpen the measure of firm-specific resources (Farjoun, 1994; Robins & Wiersema, 1995; Silverman, 1999). These methodological improvements, however, do not fully address the underlying theoretical puzzle. That is, if a performance difference exists between the more vs. less related diversification strategies, what prevents firms from pursuing the more beneficial strategy? The current study highlights the importance of a performance prediction based on analysis of both benefits and costs.

In addition, the study extends the modularity literature on firm scope by uniting studies of horizontal diversification with those of vertical integration, and providing a more comprehensive theory of firm boundary arising from the structure of task networks. The impact of task interdependencies has received considerable interest in recent studies of firm scope (Baldwin & Clark, 2000; Fine & Whitney, 1999; Hoetker, 2006; Jacobides, 2005; Jacobides & Hitt, 2005; Langlois & Robertson, 1992; Schilling & Steensma, 2001), but the focus has been on vertical (dis)integration. In this connection, the current study reinforces recent efforts to redirect our attention to the representation of the firm as a system of interdependent tasks (Baldwin, 2008; Ethiraj & Levinthal, 2004b; Sanchez & Mahoney, 1996). In doing so, it suggests that firms' scope choices are interdependent: They can be substitutive due to constraints in firms' coordination capacity. When making vertical integration decisions, firms also need to consider the implication of these decisions on their horizontal diversification strategy.

Chapter 4

Integration, Modularity and Hierarchy

> The major components of a complex organization are determined by the design of that organization. Invariably these major components are further segmented, or departmentalized, and connections are established within and between departments. It is this internal differentiation and patterning of relationships that we will refer to as structure.
>
> – Thompson (1967: 57)

> The primary theorists of modularity at a systems level … don't provide clear guidance for how to characterize intermediate points along the range from modular to integral.
>
> – MacDuffie (2006: 11)

4.1. Introduction

The choice between a modular and an integrated organization structure is of central concern to organization theorists. On the one hand, modularity facilitates specialization and adaptation. On the other hand, integration promotes coordination and ensures fit among interdependent activities. How to balance the advantages and disadvantages of the two structures has been an important line of enquiry over more than half a century (Burns & Stalker, 1961; Galbraith, 1973; Simon, 1962; Thompson, 1967), and has recently attracted renewed attention (Baldwin & Clark, 2000; Marengo & Dosi, 2005; Puranam, Singh, & Zollo, 2006; Sanchez & Mahoney, 1996).

The difficulty to choose between the two structures arises from the underlying inherent interrelations or interdependencies among the tasks to be managed. Such interdependencies are ubiquitous within organizations (Thompson, 1967), which not only provides potential gains from integrated coordination efforts but also places cognitive burdens on the coordinators (Simon, 1962). If the distribution of the inherent interrelations is such that the task systems are fully decomposable, that is, they can be divided into subsystems with dense intra-module interdependencies but rare inter-module interdependencies, then a corresponding modular organization structure can distribute the cognitive burden among organization units and enhances the overall coordination capacity of the organization. Unfortunately, most task systems are nearly rather than fully decomposable (Simon, 1962). With significant inter-module interdependencies in the underlying task system, a modular organization structure will miss opportunities that may enhance the overall performance of the organization (Ethiraj & Levinthal, 2004b; Fleming & Sorenson, 2001a; Henderson & Clark, 1990; Siggelkow & Rivkin, 2006).

To address these tradeoffs, prior studies turn to the contingencies under which one organization structure is more favorable than the other. For example, modular organization designs are favored when the task systems are too complex to allow integrated coordination efforts (Parnas, 1972), when flexibility and speedy innovations are more important than overall performance (Ulrich & Eppinger, 2000), or when corporate strategies such as outsourcing and diversification mandate changes in firm scope (Galunic & Eisenhardt, 2001; Helfat & Eisenhardt, 2004; Schilling & Steensma, 2001).

This paper examines a different direction of design effort that has been understudied in the recent literature: hierarchy. A defining feature of a hierarchical organization structure is the intermediate units situated between the CEO and the base units at the bottom of the organization. A hierarchical organization structure is important because it is a non-modular form to coordinate interactions between the modules (Langlois, 2002). It is most effective in dealing with nearly decomposable task systems. On the one hand, Simon (1962) states that the near decomposability of task systems "is a major facilitating factor enabling us to understand, to describe, and even to see such systems and their parts" (p. 477, italics added).[17] On the other hand, Simon (2002) proposes that a hierarchy structure "is an exceedingly powerful architecture for effective *organization* …. [I]t appears with regularity also in human social organizations – e.g., business firms and government agencies – with their many-layered *hierarchies* of divisions, departments and sections" (p. 598, italics added).

Despite the importance implied by Simon's statements, how should the underlying structure of the task system and the hierarchical structure of the organization be matched remains an open question. While the recent literature has largely focused on the correct partitioning of interdependent tasks into modules, less has been said about how a hierarchical organization structure should be further built to connect the modules and manage the residual interdependencies between modules. The few studies that recognize the importance of a hierarchical structure have simplified their analyses to a two-level structure with two units and a CEO at the top (Rivkin & Siggelkow, 2003; Siggelkow & Rivkin, 2005, 2006). The focus of these studies is delegation of decision rights or information processing responsibilities within a given hierarchical structure of one CEO and two managers, rather the design of the structure itself, such as the number of units and their relationships with each other. More complicated (and realistic) hierarchical

[17] According to Simon (1962), complex systems are hierarchical when they can be divided into subsystems that, in turn, can be further divided into their own subsystems.

structures with multiple layers and intermediate units, and their role in managing interdependencies, have been largely overlooked. This paper fills in this gap.

I propose that a hierarchical structure improves three key elements of coordination: communication, information processing and decision making (Marschak & Radner, 1972). It allows for both specialization in information processing and communication, and integration in decision making. A hierarchical organization structure reduces the communication cost of a modular structure by organizing inter-module communication channels from a horizontal web into vertical conduits, and lowers the information processing cost of an integrated structure by allowing parallel aggregation. A hierarchical organization structure also allows intermediate units to manage interdependencies between subordinate units, thereby enhancing the overall quality of decision making for the firm.

Following prior literature (Baldwin & Clark, 2000; Ethiraj & Levinthal, 2004b; Ghemawat & Levinthal, 2000; Rivkin & Siggelkow, 2007; Siggelkow & Levinthal, 2003), I characterize systems of interdependent tasks along two dimensions: *Complexity*, which refers to the degree of interdependencies, and *decomposability*, which describes one particular distribution pattern of interdependencies. I argue that an integrated structure generates more coordination benefits since it helps coordinators to take into consideration the interactions between tasks. However, when their task systems are highly complex, firms have to adopt modular structures to divide the coordination responsibilities according to the cognitive capacity of individual units. When the task systems are highly complex or when they are not decomposable, organization modularization is suboptimal.

A hierarchical structure with intermediate coordinating units that manage the interdependencies between base units (modules) is needed.

Using a unique dataset of U.S. equipment manufacturers from 1993 to 2003, I show that both organization modularity and organization hierarchy have a U-shaped relationship with task complexity. In contrast, task decomposability has opposite impacts on organization modularity and hierarchy: While it increases organization modularity, it reduces organization hierarchy. These findings confirm the coordination role of hierarchical structures in managing inter-module interdependencies.

The rest of the paper is organized as follows. In Section 2, I elaborate on the relationship between task systems and organization structure and develop the theory and hypotheses. Section 3 describes the study setting and the research design. Section 4 presents the results. Section 5 discusses the limitations and concludes.

4.2. Theoretical background and hypothesis development

4.2.1. Task complexity and organization integration

A major benefit of an integrated structure is that it promotes coordination and ensures stability and fit among interdependent activities. Coordinating interdependent activities often implies joint decision making, which raises the *demand for information sharing and communication* among individual decision makers – about factors that affect each others' decisions and the decisions themselves when multiple equilibriums exist (Arrow, 1974; Becker & Murphy, 1992). Such communication is often rich, multilateral, and intense; it usually requires face-to-face discussion and direct observation (Wheelwright & Clark, 1992). Integration is a more efficient coordination form since it provides a more homogenous communication system (Arrow, 1974; Kogut & Zander, 1992; Monteverde, 1995), a common incentive regime for knowledge transfer (Teece, 1993), and a shared authority structure that reduces the need for multilateral communication (Conner & Prahalad, 1996; Demsetz, 1988).

As pointed out by Puranam (2001), these coordination advantages apply not only to the external but also internal boundaries of the firm – the boundaries of the organization units within firms: Employees in the same unit are subject to a more homogenous communication system than employees in other units (Lawrence & Lorsch, 1967); they are also subject to more homogenous incentive regimes (Zenger & Hesterly, 1997) and authority structure (Simon, 1947). Hence activities that are more interdependent with each other are more likely to be integrated in the same unit than to be separated into two units (Puranam, 2001; Thompson, 1967).

Despite the coordination advantages of an integrated structure as mentioned above, it has a major limitation: It places a significant amount of coordination workload on a few integrated units. Complexity raises the *demand for information processing*. Problems with multiple interdependent components are difficult to solve, mainly because of the proliferation of the interaction terms as the number of decision variables increases (Simon, 1962). At high level of complexity, the computation demand may exceed the cognitive capacity of any unit, and the coordination responsibility must be divided into multiple units.

In addition, because of the increased workload of communication and information processing, complexity raises the *probability of decision errors* (Levinthal, 1997; Rivkin, 2000; Sutherland, 1980). Decision errors are likely to occur when the set of strategic choices exceeds "the resolution power of available mathematical, statistical or logical algorithms, either in terms of the number of state variables that must be accommodated, or in terms of the degree of stochasticity of relationships or dynamic sequences" (Sutherland, 1980: 964). Complexity therefore results in: (1) escalation of computation load that prohibits global optimization, and (2) reduction in analytical precision (Sutherland, 1980).

Therefore, at low to medium level of complexity, an integrated structure gives rise to more coordination benefits than a modular structure. At high level of complexity, due to constraints in individual units' coordination capacity, firms will divide the coordination responsibilities among multiple units despite the potential interdependencies among them.

Hypothesis 4: Ceteris paribus, the degree of organization modularity (integration) first decreases (increases) then increases (decreases) with the complexity of the organization's tasks.

4.2.2. Task decomposability and organization modularity

Conditioned on the *degree* of interdependencies – complexity – of a task system, the extent to which an organization can set up a modular structure is dictated by the distribution *patterns* of the underlying inherent interdependencies between tasks (Baldwin & Clark, 2000; Ethiraj & Levinthal, 2004b; Ghemawat & Levinthal, 2000; Rivkin & Siggelkow, 2007; Siggelkow & Levinthal, 2003). One such pattern is the decomposability of the task system. It describes the degree to which the distribution of the inherent interactions, by nature, allows the designers to break up a task system into loosely coupled subsystems – whether the system is fully, nearly, or non-decomposable (Parnas, 1972; Simon, 1962).

A modular organization structure reduces the coordination burden of individual units via "information hiding" (Baldwin & Clark, 2000; Parnas, 1972). A modular organization structure enables a unit to focus on coordinating the interrelations among tasks within the unit, while be ignorant of interrelationships among tasks within other units (Baldwin, 2008). Figure 3 provides an illustration. In the figure, the nodes represent segments; the edges represent the inherent interdependencies between segments. Firms A and B have the same number of tasks and task-pairs that are interdependent with each other. Firm A's task system is fairly decomposable; the tasks can be grouped into three distinctive modules, each being coordinated by an organization unit. In contrast, Firm B has a much less decomposable task system; any segmentation of the tasks will leave out significant interrelationships between the modules. For firm B, a modular organization structure will not help coordination. Rather, it will cause the coordination efforts to be more fragmented than what the underlying task system demands, thereby sacrificing significant amount of coordination benefits between the units.

Hypothesis 5: Ceteris paribus, the degree of organization modularity increases with the decomposability of interdependencies among the organization's tasks.

4.2.3. Organization hierarchy

Despite their respective coordination advantages, both the integrated and the modular organization structures have their limitations. As discussed above, an integrated structure is limited by the cognitive capacity of the individual units. At the same time, a modular structure is limited by the fact that most real systems are nearly rather than fully decomposable (Simon, 1962), and inter-module interdependencies are ubiquitous within organizations (Thompson, 1967). When decision variables are densely interconnected, an overly fragmented structure leads to local search and prohibits broad-scope information processing (Ethiraj & Levinthal, 2004b; Rivkin & Siggelkow, 2003), which may cause decision errors. For example, the more divisionalized the firm, the less likely it will pursue an R&D strategy that would have broad implications for the firm (Argyres, 1995).

It is therefore necessary to think beyond the extreme cases of modular or integrated structures. There is the need to recombine the activities divided across organization units and ensure fit at the firm level (Puranam, 2001). A hierarchical structure allows hierarchical coordination (Sanchez & Mahoney, 1996). It emerges as a non-modular form to coordinate interactions between the modules (Langlois, 2002).

Compared to alternative organization structures, a hierarchy possesses coordination advantages in communication, information processing, and quality of decision making. It changes a horizontal web of inter-unit interconnections into vertical communication channels, which economize on *communication* (Arrow, 1974; Langlois, 2002; Zannetos, 1965). In addition, it enhances the organization's overall capacity for *information processing*. A structure where intermediate units compute independently and in parallel reduces the workload for each unit (Radner, 1993) and brings more information to bear for the firm as a whole (Galbraith, 1973, 1977). For example, it saves the CEO's energy for coordinating low-frequency, between-division interactions that yield firm-wide benefit, after high-frequency interactions have been dealt with by division managers within their respective divisions (Harris & Raviv, 2002).[18] Furthermore, by taking inter-unit interdependencies into account, a hierarchical structure reduces the *probability of decision errors*. Accurate decisions rely on complete information. When the interactions

[18] The higher the frequency of interactions is, the less likely that a formal hierarchical structure can be substituted with cross-functional project teams and committees, since these transitory structures will offer less adequate coordination and more confusion in authority (Galbraith & Lawler, 1993).

among decision variables are not decomposable, specialization in information processing will result in loss of information about significant interactions between variables across units. Decisions made based on incomplete information about these inter-unit interactions are not likely to be globally optimal (Marengo & Dosi, 2005; Siggelkow & Rivkin, 2006). In this regard, a hierarchical structure helps more comprehensive decision making. For example, the intermediate units may capture opportunities of joint cost saving that lower-level managers may have missed (Geanakoplos & Milgrom, 1991).

Given the underlying interdependencies among the tasks, the level of inter-unit interdependencies is a function of the degree of task partitioning, or specialization (Puranam, 2001; Simon, 1991). Organization modularization not only partitions the tasks, but also causes shifts in focus, knowledge generation, objectives, and incentives, and makes them more heterogeneous across units (Lawrence & Lorsch, 1967; March & Simon, 1958); this results in greater demand for higher-level coordination.

These arguments suggest that a hierarchical structure is needed when organization modularization at the base level is suboptimal due to constraints in cognitive capacity. When firms have to over-partition their organization structure relative to the underlying task systems due to cognitive constraints, there will be interdependencies left between the units at the base level that need to be handled by higher-level coordinators. According to H4 and H5, over-partitioning is more likely when the task systems are highly complex, or when they are less decomposable.

H6a: Ceteris paribus, the degree of organization hierarchy first decreases then increases with the complexity of the organization's tasks.

H6b: Ceteris paribus, the degree of organization hierarchy decreases with the decomposability of interdependencies among the organization's tasks.

4.3. Research design and methodology

4.3.1. Challenges and proposed solutions

There are very few econometric studies of the relationship between interdependencies in task systems and organization structure at the firm level. This is because these constructs are difficult to operationalize and measure. The current paper makes a few modest attempts to tackle these challenges.

Interdependencies in task systems

As summarized by Lenox, Rockart, and Lewin (2008), a real firm undertakes numerous tasks that may be interdependent along multiple dimensions and at multiple levels, such as business and corporate strategies (Levinthal, 1997; Porter, 1996; Rivkin, 2000; Siggelkow, 2001, 2002a), production technologies and managerial practices (Ichniowski *et al.*, 1997; Milgrom & Roberts, 1990, 1995), product design (Baldwin & Clark, 2000; Henderson & Clark, 1990), etc. It is therefore difficult to measure interdependencies systematically across a large sample of firms in different industries. For this reason, most of the prior work on system interdependencies keeps the concept at an abstract level and relies on computer simulations (Burton & Obel, 1980; Ethiraj, Levinthal, & Roy, 2008; Lenox *et al.*, 2006, 2007; Levinthal, 1997; Rivkin, 2000; Rivkin & Siggelkow, 2007) or case studies (Siggelkow, 2001, 2002a). The few exceptional econometric studies are limited to the product (Hoetker, 2006) or transaction level (Puranam, 2001), rather than at the firm level.

Lenox et al. (2006, 2007) offer some insights through their theoretical models. They argue that the NK model of system interdependencies (Kauffman, 1993; Levinthal, 1997; Rivkin, 2000) can be applied to a complex production function that includes not only capital and labor, but also a firm's specific activities; such productive interdependencies pose decision challenges for managers, and affect firm profits, entry, and survival.

Following such insight, I operationalized system interdependencies through the flow of work inputs (Wageman & Baker, 1997): Two tasks are interdependent if they supply significant inputs to one another. In addition, similar to recent theoretical as well as empirical papers (Lenox *et al.*, 2006, 2007; Siggelkow & Rivkin, 2005; Yayavaram & Ahuja, forthcoming), I treated interdependence as the inherent relationship between tasks that is dictated by the nature rather than chosen by the firm. In contrast, organization structure is treated as a firm decision rather than a state of nature.

Furthermore, I assumed that the potential interdependencies among all activities are the same at the economy level, but firms have a choice of whether to exploit a particular interrelationship. In other words, there is the exogenous potential for interdependencies among activities at the economy level, but firms can affect interdependencies in their specific systems by choice of activities (Lenox *et al.*, 2006, 2007). If a firm integrates two activities that can potentially supply significant amount of intermediate goods to one another, rather than transacting through the market, then I infer that inside this particular firm, the requirements of these two activities are specialized to each other, and the two activities are interdependent. In contrast, if the firm integrates only one activity and leaves the other outside its boundary, then I infer that the firm has chosen to standardize its requirement of the excluded activity, in order to make it procurable from the market and not interdependent with the integrated activity or activities.

Based on these assumptions, I treated each segment in a diversified manufacturing firm's business portfolio as a (highly-aggregated) task. Accordingly, for each firm-year in my sample I constructed a task network. I first denoted the firm's segments as nodes in the network. I then placed linkages between segment pairs where there is significant flow of inputs between them. The approach offers a few benefits. First, it is close to the theoretical representation of system interdependencies as a complex production function under task structure models like the NK model. Second, the construction of the task networks allows me to develop comprehensive measures of system interdependencies, such as their degree (complexity) and distribution (e.g., decomposability). Third, these task networks demonstrate more realistic distribution patterns that can accommodate a broader range of task structures than what is allowed by an NK model, which assumes each node to be interdependent with equal number of other nodes (Ghemawat & Levinthal, 2000). Finally, since firms' segments change over time, my approach allows me to build time-varying measures at the firm level, and to implement econometric analyses that partially address the problem of unobserved heterogeneity across firms.

Organization modularity and hierarchy

Operationalizing organization modularity and hierarchy is no less challenging. This is mainly due to the lack of detailed information on internal structures and measures that allow comparison across firms (Rajan & Wulf, 2006). As a result, historically, organization theorists have used personnel reporting data based on small-scale surveys to study various aspects of organization structure. Several reviewers have pointed out that this empirical literature has been plagued by lack of consistency in the choice of constructs and their operational definitions and measures, difference in levels of analysis, confusion between formal and informal structures, etc., which lead to weak and inconclusive results (Child, 1973; Donaldson, 2001; Pennings, 1992; Scott & Davis, 2006).

The data constraints have limited empirical studies on organization modularity to the external rather than internal boundaries of the firm (Hoetker, 2006; Schilling & Steensma, 2001). Similar to studies on interdependencies, a majority of the analyses on internal organization modularity have relied on computer simulations (Ethiraj & Levinthal, 2004a; Rivkin & Siggelkow, 2003; Siggelkow & Levinthal, 2003; Siggelkow & Rivkin, 2006). There are rare exceptions. For example, Argyres (1996) counts the number of product divisions and major manufacturing subsidiaries, and defines the degree of divisionalization as: $\frac{Number\_of\_divisions + 1.5 * Number\_of\_subsidiaries}{Total\_revenue}$. The concept of divisionalization is similar to modularization.[19]

As for organization hierarchy, again, prior work has largely relied on computer simulation of structures with two managers and a CEO (Rivkin & Siggelkow, 2003; Siggelkow & Rivkin, 2005, 2006). The focus of these studies is the delegation of decision rights or information processing responsibilities within a given hierarchical structure of one CEO and two managers, rather the design of the structure itself, such as the number of units and their relationships with each other. More complicated (and realistic) hierarchical structures with multiple layers and intermediate units, and their role in

[19] Puranam and his coauthors (Puranam, 2001; Puranam *et al.*, 2006) look at integration decisions after technology acquisitions, and define an acquired unit as being "integrated" into the acquirer's structure if it stops to be a profit center or operational unit. However, their level of the analyses is at the unit rather than the firm level.

managing interdependencies, have been largely overlooked. In addition, there are only a few empirical studies on the physical structure of organizations, mostly based on firms' organization charts.[20] Rothwell (1996) counts the number of levels in the longest line of control from the plant manager to the first line (lowest level) supervisor (LONG), and the number of people reporting to the plant manager (SPAN). He then constructs a measure of hierarchy as: $H = \sin\theta = LONG/(LONG^2 + SPAN^2)^{0.5}$. Argyres and Silverman (2004) check the presence of central R&D laboratories as opposed to divisional R&D units. Rajan and Wulf (2006) count the number of levels between division heads and the CEO.[21]

Following these studies, I measured organization structure based on organization charts. For organization modularity, I treated base units – units without subordinate units – as "modules" and count their numbers. In robustness checks, I used Argyres' (1996) measure – counting only the divisions and subsidiaries and weighting the subsidiaries by 1.5; results were similar.

For organization hierarchy, I took into account the number of layers in the organization structure. However, since I am interested in hierarchy as a mechanism to coordinate interrelations between organization base units, rather than a mechanism to delegate authority or empower workers, I used a measure that is different from the simple number of layers. In order to capture the coordination capacity of intermediate units –

[20] Using large-sample, confidential surveys, a separate group of studies examine the centralization and decentralization of authority, regardless of the physical shape of the organization structure. The typical survey questions include whether the firm is organized into profit centers (Acemoglu *et al.*, 2007), the degree of using work-teams and allocating decision rights or responsibility to workers (Bresnahan *et al.*, 2001; Foss & Laursen, 2005). Since these measures are about allocation of authority rather than partitioning and integration of organization units, they are less relevant to my construct.

[21] Similarly, Caroli and Van Reenen (2001) measure changes in the degree of hierarchy in French establishments by asking if they have removed managerial levels in their organization.

units situated between the CEO and base units, I counted the number of these units, and weighted them by their rank or seniority in the organization charts.

4.3.2. Empirical context

I tested my hypotheses on a sample of U.S. equipment manufacturers from 1993 to 2003. I chose this empirical setting primarily because equipment manufacturing entails multiple stages and requires large quantities of intermediate inputs, which provides large variation in firms' internal activities and system interdependencies across firms in the same primary industry. In addition to cross-sectional variations, firms in the equipment manufacturing sectors also have experienced significant scope changes over the last two decades. Many have been evolving toward "vertical disintegration," whereby a previously integrated production process is divided up between two sets of specialized firms in the same industry (Baldwin & Clark, 2005; Fine & Whitney, 1999; Macher *et al.*, 1998). These cross-sectional and longitudinal variations provide strong explanatory power to my empirical models.

4.3.3. Data and sample

I built a unique dataset of firms' internal activities and organization structures with data from various sources. These data have been available for a long time, but have not been fully exploited to the benefit of investigating the internal reality of firms.

First, I started with the Directory of Corporate Affiliations (DCA) offered by LexisNexis. DCA provides corporate reporting information on parent companies and their "units" (e.g., groups, departments, divisions, units, subsidiaries, etc.), down to the seventh level of corporate linkage. In addition, the dataset describes up to 30 segments (four-digit SIC level) for each unit. Several factors contribute to the reliability of the DCA data. According to LexisNexis, the dataset is compiled based on information gathered from the companies, as well as from annual reports and business publications in the LexisNexis database. In addition, each company is contacted directly for information verification (LexisNexis, 2004).

While the DCA dataset provides unique and more comprehensive information about firms' business segments and organization structures, it has several limitations. For example, it does not provide sufficient information for the units. An important piece of information that is missing is unit size or the level of firm activity in each segment. In robustness checks, I adjusted complexity by weighting each interdependent segment pair with the number of units operating in the pair; results were similar. Another limitation of the DCA dataset is that firms do not report their units consistently over time, resulting in some units disappearing from the dataset for a few years before they reappear in the dataset. If not corrected, this will lead to overestimation of changes in the task system and organization structure. For units that reappeared during the sample period, I interpolated the data for the missing years, assuming their segments and structure had remained unchanged during these years. This approach would not capture units that reappeared after my sample period. However, given that only 1% of the units in the dataset have gaps in their appearance over the entire sample period, and the average number of missing years for these units is only three years, I do not expect the impact of missing years to be significant for the entire sample.

I started with the DCA dataset for publicly traded firms from 1993 to 2003, which covers firms with revenues of more than $10 million and more than 300 employees

(LexisNexis, 2004). The dataset contains 9,850 parent companies and 120,113 units. 2,075 parent companies list their primary industries as in the equipment manufacturing sectors.

Second, to construct interrelationships among the business segments, I used the BEA Input-Output (IO) tables. The tables contain the value of pair-wise commodity flows among roughly 500 private-sector, intermediate industries. The tables are updated every five years. Since the IO industry code system was changed by BEA in 1997, to ensure comparability I used the tables for 1992.[22]

Finally, in order to obtain financial data for the parent companies, I augmented the dataset with Compustat Industrial Annual Financial and Compustat Segment datasets. I matched the datasets by parent company names first through a software program[23] and then through manual checks. Ambiguous matches were further verified via company Web sites. I matched 1,621 (78%) parent companies in the equipment manufacturing sectors. Since the focus of my study is coordination across business segments and organization units, I dropped 589 firms that report only one segment or only the parent company in their organization structure. In addition, I dropped 167 firms for which there were missing values in the Compustat financial data. My final sample contained 865 firms and 4,522 firm-years observations.

4.3.4 Variable definitions and operationalization

Dependent variables

ORGANIZATION MODULARITY was defined as the number of base units, or units that have no subordinate units in the corporate hierarchy.

[22] Several authors have observed that the coefficients have been fairly stable over the years.
[23] I thank Minyuan Zhao for her help with the matching.

ORGANIZATION HIERARCHY was defined as the number of supervisory units, or units that have at least one subordinate unit, weighted by their rank or seniority in the corporate hierarchy.

Independent variables

I constructed measures of system interdependencies using DCA data and BEA IO tables. I defined two segments as interdependent if they on average contribute more than 1% of the inputs to one another based on the IO table. The few prior studies that measure interrelationships between two industries based on the IO tables choose either 5% (Matsusaka, 1993; Schoar, 2002; Villalonga, 2004), or 1% (Lemelin, 1982) as the threshold. I used 1% in my main analyses and 5% in robustness checks; results were similar. Once the interdependencies between segment pairs were dichotomized into 1s and 0s, a firm's portfolio can be represented by a network with the segments as nodes, and linkages in place wherever the interdependence between a segment pair (two nodes) is 1. I then constructed two measures that reflect, respectively, the degree of system interdependencies (COMPLEXITY) and the distribution of system interdependencies (DECOMPOSAILITY).

These networks are only rough proxies for the true underlying interrelationships between a firm's productive activities. They capture interdependencies at the industry rather than the firm level. Segments within a firm can choose to supply inputs to one other more or less than the average flow of inputs between two industries. This results in measurement errors, which, if correlated with the true value of the interdependency variables, cause an attenuation bias toward zero and make my results more conservative.

Despite the shortcoming, the measures have the major advantages of being exogenous to any individual firm's decision (other than the choice of segments), and are therefore less likely to be correlated with unobserved firm heterogeneity. For this reason, measures of inter-industry relationships in production inputs (Lemelin, 1982), human capital (Chang, 1996; Farjoun, 1998), or technology (Robins & Wiersema, 1995; Silverman, 1999) have been used by various scholars to proxy inter-segment relationships within firms. In particular, the use of IO-table coefficients as proxies for inter-segment relationships within diversified firms has been adopted by recent studies in both finance (Fan & Lang, 2000; Matsusaka, 1993; Schoar, 2002; Villalonga, 2004) and economics (Alfaro & Charlton, 2007).

COMPLEXITY(K) was measured using the share of segment pairs in a firm's portfolio that supplied significant (more than 1%) productive inputs to each other. The measure corresponds to the theoretical definition of complexity in the modularity literature, based on either task structure matrices (Baldwin & Clark, 2000) or NK models (Kauffman, 1993; Levinthal, 1997; Rivkin, 2000). It captures the prevalence of interactions among tasks or decisions. Similarly, Burton and Obel (1980) use a computer-simulated IO table to measure technological complexity and its impact on performance under an M-form structure.

DECOMPOSABILITY(DECOMP) was measured using a modularity index for the task network, computed using a program designed by physicists Guimerà *et al.* based on an algorithm of simulated annealing (2005a; 2005b; 2004), and further improved by biologists Wang and Zhang (2007).

The extent of decomposability (modularity) for a particular modular separation of a network is often measured by:

$$M = \sum_{x=1}^{N} [l_s / L - (k_s / 2L)^2] \quad (1),$$

where N is the number of modules, L is the total number of edges (links) in the network, l_s is the number of edges within modules, and k_s is the sum of the degrees of the nodes in module s (Guimerà & Amaral, 2005b; Newman & Girvan, 2004). The degree of a node is the number of edges that the node has. In essence, M is the difference between the observed and expected proportions of within-module edges in the network. Here, the expected proportion is computed from a non-modular network where edges are equally likely to be within and between modules.

The program first identifies the optimal modular separation of the actual network by maximizing M in Equation (1). Since the M values of two networks with different sizes or different average degrees cannot be compared directly, the program then randomly rewires – redistributes the edges in the network, retaining the number of nodes and edges and each node's degree. Finally, it compares the M value of the original network with the average M values of the randomized networks, and scales the difference between the two with the standard deviation of the M values of the randomized networks. The result is the modularity index for the actual task network.

Control variables

To control for other factors that may affect a firm's organization structure, I included in my regressions firm size (number of employees), firm age, number of segments and its squared term, geographic dispersion, among others. I included sector (two-digit SIC) and year dummies, and firm fixed or random effects. Since firms in more volatile environment and knowledge intensive industries tend to have less differentiated and less hierarchical structure (Lawrence & Lorsch, 1967; Rajan & Zingales, 2001; Smith *et al.*, 1991; Tushman & Nadler, 1978; Van Zandt, 2003), I added industry volatility measured by the absolute beta of industry average stock returns, and knowledge intensity measured by industry R&D expenditure per dollar of sales revenue.

4.3.4. Model specification

For H4 and H5 I ran the following specification:

$$B_{it} = \alpha_0 + \alpha_1 K_{it} + \alpha_2 K_{it}^2 + \alpha_3 DECOMP_{it} + \Lambda_{it} + \eta_{it} \qquad (2)$$

where,

B_{it}	is the logarithm of the number of base units for firm i in year t;
K_{it}	is task complexity calculated based on firm i's portfolio in year t;
$DECOMP_{it}$	is decomposability based on the modularity index;
Λ_{it}	is a vector of control variables for firm i in year t.

H4 predicts α_1<0 and α_2>0. H5 predicts α_3>0.

For H6 I ran the following specification:

$$S_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 K_{it}^2 + \beta_3 DECOMP_{it} + \Lambda_{it} + \eta_{it} \qquad (3),$$

where S_{it} is the logarithm of the number of supervisory units for firm i in year t, and other variables are the same as in equation (3). H6a predicts β_1<0 and β_2>0. H6b predicts β_3<0.

4.4. Results

4.4.1. Descriptive statistics

Table 7 provides descriptive statistics of the sample. The average firm has 2.05 (exp(0.72)) thousand employees.[24] An average firm operates in about six (exp(1.8)) segments and three countries, and is about 36 (exp(3.58)) years old. To control for the possibility that some units were established mainly for tax evasion purposes, for robustness checks I excluded units that were located in tax havens, or whose supervising units were in tax heavens; results were similar.[25]

An average firm has 7.4 (exp(2)) base units and 1.6 (exp(0.45)) supervisory units, distributed over two to nine layers of corporate hierarchy. On average, firms have 22% of segment pairs that are interdependent – supply more than 1% of productive inputs to one another.

4.4.2. Organization structure

Organization modularity

Table 8 estimates the degree of organization modularity, measured using the number of base units. Column (1) uses an ordinary least square model; Columns (2) to (5) include year dummies and firm fixed effects; Column (6) includes year dummies and firm random effects. Columns (1) and (2) include only the control variables. As expected, firm size is positively correlated with organization modularity. Business heterogeneity, both in terms of product diversity and geographic diversity, is also positively correlated with organization modularity. Industry characteristics do not always have a significant impact.

---

[24] The average sales revenue is 2.88 billion dollars.

[25] Tax havens are those listed by Hines and Rice (1994) and OECD (2002).

Columns (3) and (4) examine the impact of task complexity. Consistent with H4, organization modularity has a U-shaped relationship with task complexity. Column (5) investigates the impact of task decomposability. Since the decomposability of networks with fewer than five interconnected nodes are not very meaningful (they can be easily partitioned), I calculated the decomposability value for networks with five or more interdependent nodes. Only 2,368 networks (52% of the sample) have five or more interdependent nodes. I also found that the distribution of the decomposability value is highly skewed to the left. To avoid unduly influence of extreme values on my results, I used a dummy variable to show whether the calculated decomposability value is below or above sample average. Column (5) shows that firms with less decomposable portfolios have less modular organization structure. H5 is supported. In addition, results for H4 still hold. The inflection point, according to Column (5), is reached when 38% = (1.880/(2*2.473)) of the segment pairs are interdependent with each other; 38% is within one standard error from the mean value of task complexity based on the sample (Table 7). To investigate between-firm heterogeneity, Column (6) replaces firm fixed effects with firm random effects. Results for H4 are similar. But the result for H5 (decomposability) becomes insignificant.

Organization hierarchy

Table 9 estimates the degree of organization hierarchy, measured using the weighted number of supervisory units. Column (1) uses an ordinary least square model. Columns (2) to (5) are panel models. Columns (2) to (4) include year dummies and firm fixed effects; Column (5) includes year dummies and firm random effects. Columns (1) and (2) start with the control variables. Compared to Table 8, firm size has a less positive, and firm age has a more negative impact on organization hierarchy than on organization modularity, echoing some knowledge or problem-solving based models of hierarchy: Older or larger firms have more established routines that substitute for hierarchical coordination. Product and geographic diversification both have a positive impact on organization hierarchy, just as they do on organization modularity. The impact of industry volatility is again insignificant.

Column (3) includes task complexity. Similar to organization modularity in Table 8 and consistent with H6a, organization hierarchy has a U-shaped relationship with task complexity. Column (4) adds task decomposability. Similar to Table 8, the task decomposability value is only available for about half of the networks. Consistent with H6b, task decomposability has a negative impact on organization hierarchy. With the full model in Column (4), results for H6a still hold. The inflection point is reached when 31% of the segment pairs are interdependent with each other. To investigate between-firm heterogeneity, column (5) replaces firm fixed effects with firm random effects; results are similar and more statistically significant.

Overall, the results in Tables 8 and 9 show that, consistent with my hypotheses, both organization modularity and organization hierarchy have a U-shaped relationship with task complexity. In contrast, task decomposability has opposite impacts on organization modularity and hierarchy: While it increases organization modularity, it reduces organization hierarchy.

4.5. Discussion and conclusion

This study analyzes the role of organization modularity and hierarchy in coordinating systems of interdependent tasks. It operationalizes and quantifies four important constructs in recent studies of organization design: the complexity and decomposability of the task systems, and the modularity and hierarchy of organization structure. It argues that an integrated structure generates more coordination benefits since it helps coordinators to take into consideration the interactions between tasks. However, when their task systems are highly complex, firms have to adopt modular structures to divide the coordination responsibilities according to the coordination capacity of individual units. When the task systems are highly complex or when they are not decomposable, organization modularization is suboptimal. A hierarchical structure with intermediate coordinating units that manage the interdependencies between base units is needed. Consistently, my empirical results show that, both organization modularity and organization hierarchy have a U-shaped relationship with task complexity. In contrast, task decomposability has opposite impacts on organization modularity and hierarchy: While it increases organization modularity, it reduces organization hierarchy. These findings confirm the coordination role of hierarchical structures in managing inter-unit interdependencies.

The study has a few limitations. First, it treats the structure of the task systems as exogenous or predetermined. It does not further investigate why firms differ in their task systems in the first place, or why some firms choose to integrate complex tasks, whereas others outsource them. The literature provides several explanations for why some firms are more integrated than others. Firms may integrate to leverage its core competencies into adjacent value chain tasks (Leiblein & Miller, 2003). For example, as a pioneer of the automotive industry, Ford developed capabilities in making machine tools better than any suppliers, and decided to manufacture the tools in house (Argyres & Zenger, 2007;

Langlois & Robertson, 1995; Williams *et al.*, 1993). Firms may also integrate to facilitate coordination along certain dimensions (Chandler Jr., 1977; Monteverde & Teece, 1982; Scherer, 1980; Williamson, 1975). Finally, firms also may integrate to accommodate differential positioning strategy for its products (Argyres & Bigelow, 2007). The current study does not argue against these justifications for integration. Rather, it points out that the integration choices may have an impact on the subsequent design of organization structure. How firms endogenously design their task systems and organization structure is left for future study.

In addition, to apply theoretical models in the modularity literature, the study treats firms' tasks, activities, and domains interchangeable. They are viewed as tasks at different levels of aggregation: Firms chose business domains to operate in, then activities to carry out within each domain, and finally specific tasks to perform for each activity. This treatment is appropriate in the context of equipment manufacturing. For example, depending on the level of aggregation, iron casting, machine tooling, and final assembly can be viewed as different business domains (with different SIC codes), activities, or tasks in the making of a car (a transportation equipment). Whether this aggregative relationship between tasks, activities and business domains is generalizable to other contexts is left for future study. Furthermore, the measure of decomposability in this study is coarse. It is available for only half of the observations in the sample. It is worthwhile to check the sensitivity of my results to alternative measures of decomposability (Everitt, 1993; Fleming & Sorenson, 2001b; Yayavaram & Ahuja, forthcoming).

Finally, the study only examines formal organization structure and ignores the role of informal structure. Informal structure, through unofficial communication, trust, routines and networks, facilitates important functions that cannot easily be dedicated through a formal structure. However, as Nickerson and Zenger (2002) pointed out based on their review of the literature, formal structure strongly affects the shaping of the informal structure, since the latter often develops in response to the former; There is often a great deal of overlap between the two forms of structures. In addition, informal roles do not convey the same degree of formal empowerment and legitimacy to the coordinator (Galbraith & Lawler, 1993). Nevertheless, the role of informal structure in coordinating system interdependencies is worth of future study.

Despite the caveats, the study makes several contributions to the organization structure literature. First, it redirects our attention to the more realistic representation of organization structure as a multi-level hierarchy, and restores the importance of intermediate units in managing interdependencies and enhancing the overall coordination capacity of an organization. Hierarchical structures are created to meet the demand for "hierarchical coordination": Tradeoffs between specialization and coordination can be balanced not only through inter-temporal vacillation between modular and integrated structures depending on the specific contingencies (Siggelkow & Levinthal, 2003), but also through a hierarchical structure that allows for inter-unit coordination. In doing so, the paper also sets a boundary condition to "flatter organizations" that are well-received in popular press and academic research (Brickley *et al.*, 2003; Rajan & Wulf, 2006).

In addition, this paper provides some empirical evidence of organization design theories based on a unique dataset of firms' internal activities and organization structures.

Prior empirical studies of organization structure have suffered from lack of consensus in the choice of constructs and their operational definition and measure and, as a result, weak and inconclusive results (Child, 1973; Donaldson, 2001; Pennings, 1992; Scott & Davis, 2006). Consequently, scholars have resorted to formal modeling or computer simulation as their main method of enquiry. The current study quantifies the theoretical relationships between task complexity and organization structure by using a large sample of firms, and adopting state-of-the-art computational programs recently developed in physics and biology that calculate important features, such as decomposability, for task networks with unevenly distributed interdependencies.

Chapter 5

Delegation across Borders: The Case of Multinational Hierarchy

5.1. Introduction

Scholars in the law and finance and development economics fields have long argued that weak institutions, such as the lack of law and order, inefficient judicial systems, ambiguous property rights, and underdeveloped financial markets, hinder firm growth.[26] This is mainly because weak institutions increase firms' costs of sourcing inputs (including financial capital), distributing products and mobilizing resources within firms (North, 1990). However, despite their significantly negative impact on the growth of domestic firms, weak institutions do not impose an equally binding constraint on multinational corporations (MNCs). In fact, MNCs often employ their unique organizational form to arbitrage between differential institutional constraints and reallocate resources across national borders, effectively putting "sovereignty at bay" (Kobrin, 2001; Vernon, 1971: 3). Such arbitrage provides the basis of competitive

[26]For the impact of law and order, see (Johnson *et al.*, 2002a, 2002b; Kumar *et al.*, 2001). For the impact of financial constraints, see (Ayyagari *et al.*, 2006; Demirguc-Kunt & Maksimovic, 1998; Guiso *et al.*, 2004; Pissaridesa, Singer, & Svejnar, 2003; Rajan & Zingales, 1998). For both legal and financial constraints, see (Beck, Demirguc-Kunt, & Maksimovic, forthcoming). For the impact of corruption, see (Fisman & Svensson, 2007; Wei, 2000).

advantage of the MNC vis-à-vis its domestic competitors in both home and host countries.[27]

International arbitrage, which often involves resource reallocation across borders, creates demand for coordination (Kogut, 1983). Coordination is particularly demanding in countries with weak institutions. First, there is greater demand for resource reallocation within firm boundaries since external markets are weaker. In addition, alternative coordination mechanisms such as market disciplines and incentive contracts are less enforceable. How MNCs reduce coordination costs in countries with weak institutions that hinder the growth of local firms is therefore an intriguing question for both economists and strategists.

The academic research exploring how MNCs countervail weak institutions may be usefully partitioned into two related themes – location and ownership. While research on location choice seeks to understand how MNCs select locations with the greatest market or production opportunities but the least institutional constraints to create value, the ownership literature has sought to understand how MNCs employ governance modes (e.g., wholly-owned subsidiary vs. joint venture) to appropriate the value that they create. Both strategies, however, have their limitations. Location choices are limited primarily because arbitrage opportunities and institutional constraints often accompany each other: If MNCs only go to locations where institutions are strong, then their comparative advantage over domestic firms trading across borders will be significantly dampened. Ownership choices are insufficient mainly because ownership does not guarantee control

[27] For example, MNCs arbitrage in differential foreign exchange rates (Froot & Stein, 1991), tax regimes (Desai *et al.*, 2004a, 2006a; Kramer, McDermott, & Heston, 1993), disclosure requirements of stock exchanges (Saudagaran & Biddle, 1995), and capital account restrictions and financial market frictions (Baker, Foley, & Wurgler, 2005; Desai, Foley, & Forbes, 2005; Desai, Foley, & Hines, 2004b, 2006b).

due to agency problems (Berle & Means, 1932; Fama & Jensen, 1983). In addition, the weaker are the institutions, the more ownership rights will diverge from control benefits (Bertrand *et al.*, 2002), and thus the more need for control.

In this study, I aim to direct the lens at yet another important, but understudied, choice of MNCs – organization structure that facilitates coordination. Firm boundaries are demarcated by the comparative costs of transaction and integration (Williamson, 1985). While institutions affect transaction costs in the market, they also affect the costs of integration (North, 1990). If the primary function of MNCs is to exploit arbitrage opportunities across institutional environments, then institutional differences create coordination costs as well. Since organizations are designed to delimit coordination complexity (Thompson, 1967), to understand the growth of MNCs, we need to first apprehend the interplay between their organization structure and the institutional environments surround their operations. How do MNCs design their *organization structures* to manage coordination costs across institutional boundaries? While the question of coordination has been posed by prominent scholars in the field (Doz & Prahalad, 1984), there have been few follow-up studies.

The impact of institutions on the organization structure of MNCs is illustrated in Figure 4. When institutions are weak and a unit of a domestic firm is in need of capital for expansion, banks may not be willing to lend because of the risks associated with doing business in the country. For example, the bank may be concerned that the domestic firm lacks the capability to adjust its production adequately to business cycles and therefore faces a greater default risk. The bank may also be concerned that the local government or other parties expropriate the firm’s assets. Now consider another entity that is almost identical except that it belongs to a multinational firm that is headquartered in the United States and also has operations in host countries with strong institutions. The parent company can offer a guarantee against the local unit's default risk or use assets in a host country with strong institutions as collateral to obtain a loan from the bank, and then transfer the capital to the unit that is in need of capital. The arrangement, however, only solves the bank's problem: It is protected from lending to a unit in weak institutions. However, how does the MNC manage the risk of allocating resources to the unit in weak institutions? How does it solve the information and expropriation problems that the bank faced originally? Can MNCs manage the risk by changing the reporting and supervisory relationship with respect to the risky unit?

Institutions affect coordination costs via two important levers (Helpman, 1984). First, institutions shape the availability of complementary *information* which affects the cost of joint decision making. Second, institutions, via the prevailing rule of law and enforcement mechanisms, affect the clarity of *property rights* and consequently expropriation risk of assets that are valuable for joint tasks. Organization structure can be designed to reduce coordination costs by creating an *information* infrastructure within the firm and by differentially allocating *decision rights* to units. Reallocating supervisory responsibilities from local units in host countries with weak institutions to units in countries with strong institutions substitutes for scarce local information by integrating it with complementary regional and international data, and reduces expropriation risk by limiting the control rights of local units over corporate resources that are vulnerable to the influence of local entities such as a corrupt government. Therefore, my baseline hypothesis is that units in host countries with weaker institutions will be given less supervisory responsibility.

Since coordination is more important when activities are more interdependent, in addition to country-level differences in institutions, I explore two firm-level strategies that affect interdependencies among units across borders. First, the extent to which a unit in a host country is engaged in activities that are interdependent with the MNC's activities in other host countries captures interdependencies at the task level. Second, diversity in institutional environments across all countries in which the MNC operates captures interdependencies at the policy level. Greater task interdependencies and institutional diversity generate more opportunities for arbitrage and, consequently, greater demand for coordination. They therefore magnify the impact of institutions on the allocation of supervisory responsibilities.

I test and find support for my hypotheses using data about the business segments and organization structures of U.S. multinational equipment manufacturers from 1993 to 2003. Over the last two decades, the equipment manufacturing industries have experienced the highest ratios – both in absolute level and year-over-year growth – of intra-firm trade to domestic sales and the highest level of outsourcing in emerging markets. Equipment manufacturing also entails multiple stages and requires large quantities of intermediate inputs, which provides the potential for large variation in firm scope.

The rest of the paper is organized as follows. In Section 2, I elaborate on the relationship between institutions and organization structure, and develop the theory and hypotheses. Section 3 describes the study setting and the research design. Section 4 presents the results. Section 5 discusses the limitations and concludes.

5.2. Theoretical background and hypothesis development

There is ample statistical evidence that the present-day MNCs are operating not just in rich countries with fairly homogeneous institutional environments, but are exposed to significant range of diversity on institutional features.[28] Such a diversity of institutional environments, coupled with increasing complexity of MNCs' overseas business activities, raises the salience of effective coordinate across the units of MNCs. Several studies have conjectured that coordination complexity arising from institutional diversity might reduce the benefits from international operations (Hitt, Hoskisson, & Kim, 1997; Sundaram & Black, 1992). Therefore, the ability of an MNC to operate in a web of locations with vastly different local environments depends critically on its ability to coordinate activities around the globe.

Viewing MNCs as global networks of production and distribution, an emerging strand of literature examines MNCs' internal organization of global activities as an explicit strategy. For example, Hanson, Mataloni, and Slaughter (2001) investigate MNC strategies in assigning production and distribution tasks either separately or collectively among affiliates. In addition to production and distribution, Alcacer (2006) includes R&D activities into his analyses. He examines firms' organization strategies to balance

[28] As summarized by Hanson, Mataloni, and Slaughter (2001), MNCs' global activities have grown considerably over the last few decades. Between 1982 and 1998, the sales revenue of majority-owned foreign affiliates of U.S. MNCs had almost doubled to $2 trillion, while the number of foreign affiliates of U.S. MNCs increased by 50%, their employment was up by 40%, and their capital stock had more than tripled.[28] In particular, FDI has changed from a rich country phenomenon to penetrate many developing countries with weak institutions. For example, in 1985 the developed countries contributed 97% of the world FDI outflow and 75% of the inflow (Hummels & Stern, 1994). By 1998, the non-OECD share of employment of U.S. MNCs had grown to 36%, the most rapid growth being in non-OECD Asian countries. Furthermore, MNCs have expanded the range of activities in weak-institution countries. In manufacturing, the ratio of foreign affiliates' exports (mostly to their U.S. parent or its affiliates in other host countries) to domestic sales is the highest in computers and office equipment, electronic equipment, and transportation equipment – industries commonly associated with high-level outsourcing by MNCs in emerging markets. The ratio for these industries also has risen the most sharply over time.

the tradeoff between agglomeration benefits and competitive pressure in making location choices. He suggests that MNCs colocate a centralized R&D unit with other firms to benefit from knowledge spillover, but disperse the production and marketing activities to less congested places to avoid competition. Zhao (2006) focuses on R&D activities and proposes that even R&D activities can be strategically disaggregated. She shows that MNCs can divide up R&D tasks and assign affiliates in weak IPR countries to work on innovations that are only valuable after being combined with innovations developed by affiliates in other countries, effectively reducing the independent value of the innovations developed in weak IPR countries and lowering expropriation risks. While innovative and insightful, these studies do not directly test the underlying organization structures that make task reassignments and coordination possible.

5.2.1. Local institutions and organization structure

Three key components of coordination are communication, information processing, and final decision making (Marschak & Radner, 1972). Holding the cost of communication between units in any two countries symmetric (i.e., the communication cost of a unit in Romania reporting to a unit in France is the same as the French unit reporting to the Romanian unit), the two varying elements of coordination costs are information processing costs and errors in decision making. MNCs, therefore, should allocate coordination responsibilities to minimize information processing costs and decision errors.

Information processing involves analyzing, evaluating, benchmarking, synthesizing, verifying, and aggregating discrete pieces of information. Institutions, by promoting or discouraging disclosure, affect the availability of complementary data needed for processing the acquired local information. Information scarcity in weak institutions creates uncertainty and coordination costs (Arrow, 1959; North, 1990).

Following Gelos and Wei (2005), I distinguish between government and corporate transparency. Government transparency concerns the availability and timely release of macro data by the government, as well as the clarity and predictability of government policies. When the government provides unreliable macro data, such as national or local GDP, industry and trade data, demographic statistics, it is difficult for firms to make sense of the discrete information they collect through local units. In the United States, the Federal Reserve Board frequently publishes national and regional economic indicators on consumption, production, capacity utilization, and inflation. Such data help firms smooth their production cycles across multiple plants, and synchronize procurement, production, and delivery. Without these complementary data, local information, such as that about a locally contained demand or supply shock, becomes less valuable. The same is true with regulatory changes. Whether a government will relax its overly protective trade policy is likely to be related to its plan about the privatization of state-owned enterprises. Without the complementary information, it will be hard to decipher piecemeal data about regulatory changes.

Corporate transparency, in contrast, is about the availability of corporate information that is either disclosed according to regulatory requirements or shared voluntarily among firms. Lack of (effective enforcement of) financial and accounting disclosure regulations, fair competition laws, and weak regimes for intellectual property rights protection encourages firms to practice trade secrecy, or to keep complementary information outside the host country so that local information by itself is of less appropriation value (Zhao, 2006). In addition to domestic government and corporate information, the availability of international information can also be affected by the institutions through censorship, which adds to the difficulty of making joint decisions for units across national boundaries.

As complementary information becomes less available, it becomes less efficient to delegate coordination responsibilities to units in the host country. Firms react to difficulty in information transmission in the external environment by creating an internal information infrastructure: Their organization structure stipulates the rules for specialization in information processing (Marschak & Radner, 1972). Supervisors in strong institution countries supplement local data with complementary information available in strong institution countries.

For example, when China first opened up its borders for foreign investment, there were few regulations that promoted information disclosure. Market intelligence was difficult to collect. When there is severe lack of information (or the perception of it), economic agents tend to herd in their behavior based on observed patterns of others rather than fundamentals (Bikhchandani, Hirshleifer, & Welch, 1992; Garcia-Pont & Nohria, 2002; Powell *et al.*, 2005). That was what happened in China. Domestic firms gambled with perceived business opportunities and followed each others' past successful moves, often into overly crowded markets with thin profit margins. Most reliable local information was gathered by expatriate consultants sent in by Anderson Consulting, Boston Consulting Group, or McKinsey. In addition, access to international business information was either prohibited or censored. Therefore, the expatriate consultants shared and processed the discrete local information against other local, regional, or global data in their regional offices in Hong Kong or Singapore. Based on these reports, their corporate clients planned and directed strategies for the Chinese market from regional offices in Hong Kong or Singapore, where better institutions provide more opportunities for knowledge and information sharing.

In addition to information, institutions also provide stable structure to guide human interactions (North 1990). Such structure is needed because the bounded rationality of human agents limits their ability to converge to a harmonized set of interactions. Institutions constrain human behavior through rule of law, clear property rights, and strong legal enforcement. Ambiguous property rights in weak institutions create coordination costs (Alchian, 1965; North, 1990), because the behavioral constraints are less binding. As a result, there is greater risk of expropriation, especially of firm resources by corrupt government agencies (Murphy, Shleifer, & Vishny, 1991). Again, firms can respond to weak property rights through organization structure, which reduces coordination costs by specifying decision rights within firms (March, 1994; Simon, 1947). Supervisors in strong institution countries restrict subordinates' set of actions that are susceptible to influences from local environment, and signal commitment to firm's global objectives to external players.

For example, according to a former Ford senior executive, a Brazilian politician once pushed Ford's Brazilian unit to sponsor a trip for him and his girlfriend to visit the U.S. for the purpose of studying the Ford plants in River Rouge. The local unit accommodated his request, but when the politician further requested that the couple be taken by Ford's corporate jet to Chicago for tours, the local unit was able to reject the request on the ground that it did not have the authority to use corporate jets. Here, the protection mechanism is to limit the resources at the disposal of the local unit, and isolate its coordination responsibilities. Although this strategy may reduce local units' ability to adapt quickly to local conditions, it nevertheless limits MNCs' exposure to expropriation risks.

Hypothesis 7: An MNC unit in host countries with weaker institutions is more likely to be supervised by a foreign unit in a strong institution country.

5.2.2. Task interdependence and organization structure

Because coordinators in MNCs are involved in information aggregation or joint decision making, they will affect not only local units in one host country, but also all interdependent units in other countries. Any decision error made by the coordinator due to lack of complementary information will have a more adverse effect on interdependent units than on unrelated ones. Similarly, any loss of corporate resources at one particular unit due to expropriation will be more harmful to interdependent units than to unrelated ones. Therefore, the proper allocation of coordination responsibilities is more salient for units that are interdependent with each other. Organization structure can be designed to reduce coordination costs when tasks are independent. Supervisors solve inter-related problems (Eisenmann & Bower, 2000; Mintzberg, 1994; Mulder, 1960), make joint decisions (Marschak & Radner, 1972), and exercise authority over assets of value for joint tasks (Hart & Moore, 2005).

Thompson (1967) defined three types of interdependencies, pooled, sequential, and reciprocal, which provides a useful lens to understand the coordination problems of MNCs. Units wi127th pooled interdependencies between them may share resources (e.g., the proprietary knowledge of the parent company) and the consequences of deploying them (e.g., global profits of the parent company). But other than that, they don't have much to do with each other. They each make a discrete contribution to the MNC, and are not interdependent in the production process. An example is units engaged in horizontal FDIs, which replicate home-country production overseas in order to access foreign markets (Krugman, 1983; Markusen, 1984). In contrast, units that are sequentially or reciprocally interdependent have intermediate tasks/products fed from one to another, or passed back and forth between them in successive stages of production. An example is units engaged in vertical FDIs, often to secure low-cost inputs (Helpman, 1984). In this case, the units co-specialize along the value chain in a global network of production and distribution (Hummels, Ishii, & Yi, 2001). Sequential and reciprocal interdependencies require more coordination than pooled interdependencies, since they often require mutual adjustments on a real-time basis. Failure in one unit can have a cascading effect on all dependent units.

For both information and expropriation concerns, units in weak institution countries will be given even less coordination responsibilities if their activities are interdependent with their parents' activities in other host countries

Hypothesis 8: An MNC unit is more likely to be supervised by a foreign unit in a strong institution country if its activities are interdependent with its parent's units in other countries.

Hypothesis 8a: The effect of H8 is stronger for MNC units in weak institution countries.

5.2.3. Institutional diversity and organization structure

In addition to task interdependencies, the scope for coordination increases when the MNC operates in multiple jurisdictions and institutional environments vary significantly across these jurisdictions. Trade barriers in some countries but not in others require MNCs to manage a global production and distribution network rather than simply trade across borders (Caves, 1996). Differences in tax regimes encourage MNCs to adopt ways to shift assets and profits among host countries (Desai *et al.*, 2004a, 2006a). Variations in degree of capital account control and local financial market development push MNCs to allocate resources through internal capital markets (Baker *et al.*, 2005; Desai *et al.*, 2005; Desai *et al.*, 2004b, 2006b). Disparity in IPR regimes entices MNCs to exert additional effort to design and configure innovation activities (Zhao, 2006).

Hong Kong's investor-friendly business environment, including its rule of law, free flow of capital, limited and transparent government regulations toward private sector, is in sharp contrast with its neighbors in the region. The difference allows MNCs, such as electronics and textile manufacturers, to ship raw materials through Hong Kong into cheap-labor countries for primitive production, and then back to Hong Kong for high value-added production. With greater potential for arbitrage, there comes greater need for coordination across borders. For example, global or regional headquarters must synchronize sales efforts such as pricing, promotion, after-sale services, etc. They must make sure corporate programs will be adapted to local conditions in each country, and at the same time the adaptation will not cannibalize regional policies across the countries (Rugman & Verbeke, 2004).

Because heterogeneity in institutional environments increases the demand for coordination, decisions made by units in different countries become interdependent at the corporate level. Institutional diversity not only creates arbitrage opportunities and thus demand for coordination, but also flexibility in structural design. For the same information and expropriation concerns described above, units in weak institution countries will be given even less coordination responsibilities if their parents arbitrage in more heterogeneous institutional environments.

Hypothesis 9: An MNC unit is more likely to be supervised by a foreign unit in a strong institution country if its parent operates in more diverse institutional environments.

H9a: The effect of H9 is stronger for MNC units in weak institution countries.

5.3. Empirical design

5.3.1. Empirical context

I tested my hypotheses on a sample of U.S. equipment manufacturers from 1993 to 2003. Together these firms produce fabricated metal products, industrial machinery and equipment, electrical and electronic equipment, transportation equipment, and instruments and related products.

I chose this empirical setting primarily because equipment manufacturing entails multiple stages and requires large quantities of intermediate inputs, which provides large variation in internal activities across firms in the same primary industry. In addition to cross-sectional variations, firms in the equipment manufacturing sectors have also experienced significant scope changes over the last two decades. Many have been evolving toward "vertical disintegration," whereby a previously integrated production process is divided up between two sets of specialized firms in the same industry (Baldwin & Clark, 2005; Fine & Whitney, 1999; Macher *et al.*, 1998). These cross-sectional and longitudinal variations provide strong explanatory power to my empirical models.

In addition, equipment manufacturing sectors are important in U.S. economy. According to data provided by the Bureau of Economic Analysis (BEA), equipment manufacturers produce about $1.6 trillion of output in terms of shipment value, or 30% of the output produced by all manufacturing sectors. When adjusted for inflation, their shipment value grew by 85% from 1993 to 2002, whereas the average growth rate for the entire manufacturing sector was only 32%. In addition, they contribute a signification portion of U.S. MNC activities abroad. In 1998, they accounted for about 31% of U.S. MNC employment and 25% of U.S. MNC sales overseas, or a little over 50% of U.S. MNC employment and sales overseas in all manufacturing sectors (Hanson, Mataloni, & Slaughter, 2001: Table 2).

Furthermore, equipment manufacturers are facing fierce global competition and intense pressure for outsourcing and restructuring, which makes their decisions about firm scope and structure critical to their growth. For example, in the automotive industry, Toyota just beat GM in 2007 first-quarter global car sales, ending an era that has seen GM dominate global car sales since 1930 (The Wall Street Journal, 4/25/2007). Sliding market share and profits have put U.S. automakers under tremendous pressure to restructure their overly cumbersome production system and outsource more components and processes. One of the key restructuring initiatives of Ford's new CEO, Alan Mulally, was to sell 17 component plants and six component facilities, which manufacture a wide range of components such as glass, fuel tanks, climate control systems, powertrains, chassis, and steering components (Ford, 1/25/2007). At Nissan-Renault, worse than expected earning reports raised so much skepticism about CEO Carlos Ghosn's ability to manage the company's complex global businesses that he had to give up responsibilities for North America markets to another executive and set up multiple regional offices to handle the Japanese market (The Wall Street Journal, 3/17/2007).

5.3.2. Data and sample

I built a unique dataset of firms' internal activities and their interrelationships with data from various sources. These data have been available for a long time, but have not been fully exploited to the benefit of investigating the internal reality of firms.

First, I started with the Directory of Corporate Affiliations (DCA) offered by LexisNexis. DCA provides corporate reporting information on parent companies and their "units" (e.g., groups, departments, divisions, subsidiaries, etc.), down to the seventh level of corporate linkage. In addition, the dataset describes up to 30 segments (four-digit SIC level) for each unit. Several factors contribute to the reliability of the DCA data. According to LexisNexis, the dataset is compiled from information reported by the companies, as well as from annual reports and business publications in the LexisNexis database. In addition, each company is contacted directly for information verification (LexisNexis, 2004).

I started with the DCA dataset for publicly traded firms from 1993 to 2003, which covers firms with revenues of more than $10 million and more than 300 employees (LexisNexis, 2004). The dataset contains 9,850 parent companies and 120,113 units. 2,075 parent companies list their primary industries as in the equipment manufacturing sectors.

Second, to construct interrelationships among the business segments, I used the BEA Input-Output (IO) tables. The tables contain the value of pair-wise commodity flows among roughly 500 private-sector, intermediate industries. The tables are updated every five years. Since the IO industry code system was changed by BEA in 1997, to ensure comparability I used the tables for 1992.[29]

Third, in order to obtain financial data for the parent companies, I augmented my dataset with Compustat Industrial Annual Financial and Compustat Segment datasets. I matched the datasets by parent company names first through a software program[30] and then through manual checks. Ambiguous matches were further verified via company Web sites. I matched 1,246 (60%) diversified companies in the equipment manufacturing sectors. I dropped 164 firms for which there were missing values in the Compustat financial data, and 285 domestic firms. I was left with 797 MNCs operating in 118 countries.

Finally, I collected macro-economic and institutions data about host countries from multinational organizations such as the World Bank for 75 of the 118 countries. 64 MNCs were dropped since they do not operate in any of these 75 countries. To control for the possibility that some units were established mainly for tax evasion purposes, I excluded units that were located in tax havens, or whose supervising units were in tax heavens. Tax havens are those listed by Hines and Rice (1994: Appendix 2) and OECD (2002).[31] My final sample included 719 MNCs with 7,889 base units – units with no subordinate units – in 67 foreign countries, for a total of 40,118 observations.

---

[29] Several authors have observed that the coefficients have been fairly stable over the years.
[30] I thank Minyuan Zhao for her help with the matching.
[31] The tax havens are, Andorra, Anguilla, Antigua and Barbuda, Aruba, Bahamas, Bahrain, Barbados, Belize, British Virgin Islands, Cayman Islands, Channel Islands, Cook Islands, Cyprus, Dominica, Gibraltar, Grenada, Guernsey, Hong Kong, Ireland, Isle of Man, Jordan, Lebanon, Liberia, Liechtenstein, Luxembourg, Macao, Maldives, Marshall Islands, Monaco, Montserrat, Nauru, Netherlands Antilles, Niue, Panama, Samoa, Seychelles, Singapore, St Christopher and Nevis, St Lucia, St Martine, St Vincent and the Grenadines, Switzerland, Tonga, Turks & Caicos, UK Caribbean Islands, US Virgin Islands, Vanuatu.

5.3.3. Variable definitions and operationalization

Dependent variable

COORDINATION RESPONSIBILITIES (CR*): The amount of coordination responsibilities delegated to units in a particular host country is not directly observable. In its place, I estimated the observed probability that a unit reports to another unit outside the host country. I checked the location of the supervisory units. The dummy variable, ForeignSuper, turns to 1 if a base unit in a host country reports to a foreign unit. In this case, less responsibilities of coordinating the base unit are assigned to supervisory units within the same host country, that is, there is more cross-border coordination.

Independent variables

WEAK INSTITUTIONS (I^w): Quality of institutions was measured using an average of the governance indicators developed by the World Bank (Kaufmann, Kraay, & Mastruzzi, 2006), from 1998 to 2003. The indicators include voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. Each of them is a composite index that is highly correlated with other commonly used institution indices. Each indicator has a value ranging from -1.8 to + 2.0 for countries in my sample. Since these indicators are highly correlated (ρ=0.68-0.95), I used their average value to measure a country's overall quality of institutions. To be consistent with my hypotheses, I used the opposite value of the quality of institutions as the measure for weak institutions.

To specifically test the impact of transparency on organization structure, in robustness checks I also used the transparency index developed by International Monetary Fund (Gelos & Wei, 2005), and the Opacity Index developed by PricewaterhouseCoopers

(Zhao, 2006). Since only about 30 countries are covered by these indices, my sample size was significantly reduced when these indices were used. However, results were similar.

TASK INTERDEPENDENCE (K): Interdependencies in the production process were constructed from BEA Input-Output (IO) tables. I used a dummy that shows whether the unit's primary segment is interdependent with the MNC's primary segment.

This was a measure based on flow of inputs between two industries. Two industries were considered interdependent if they on average contribute more than 1% of the inputs to one another, based on the BEA IO Tables. The few prior studies that measure interrelationships between two industries based on the IO tables choose either 5% (Matsusaka, 1993; Schoar, 2002; Villalonga, 2004), or 1% (Lemelin, 1982) as the threshold. I used 1% in my main analyses and 5% in robustness checks; results were similar.

A limitation of the measure is that it captures interdependencies at the industry rather than firm level. Segments within a firm can choose to supply inputs to each other more or less than the average flow of inputs between two industries. This results in a measurement error which, if correlated with the true value of the interdependencies variable, causes an attenuation bias toward zero and makes my results more conservative. Despite the shortcoming, the measure has a major advantage of being exogenous to any individual firm's decision and is therefore less likely to be correlated with unobserved firm heterogeneity. For this reason, measures of inter-industry relationships in production inputs (Lemelin, 1982), human capital (Chang, 1996; Farjoun, 1998), or technology (Robins & Wiersema, 1995; Silverman, 1999) have been used by various scholars to proxy inter-segment relationships within firms. In particular, the use of IO-table coefficients as proxies for inter-segment relationships within diversified firms has been adopted by recent studies in both finance (Fan & Lang, 2000; Matsusaka, 1993; Schoar, 2002; Villalonga, 2004) and economics (Alfaro & Charlton, 2007).

INSTITUTIONAL DIVERSITY (DIV): Institutional diversity is calculated as the distance between the quality of the best institutions and that of the worst institutions in the countries that the MNC operates in. To capture the reality that geographical distance matters in cross-border reporting, I used two geographically adjusted measures. The first measure is the institutional diversity among the host countries of the MNC that are located in the same continent as the focal unit. The second measure is the sum of institutional diversity within each time zone, weighted by the inverse of the absolute time lag between each time zone and the focal unit's time zone.

Control variables

I controlled for the total number of segments the focal unit operates, to indirectly measure the importance of the unit's operation. In robustness checks, I controlled for the number of the MNC's base units in the focal unit's primary segment and host country. I also included the unit's type – joint venture, internal unit, subsidiary or affiliate. Results were similar.

At the parent company level, I controlled for an MNC's overall coordination burden by counting the total number of segments and countries the MNC operates in worldwide, and the number of base units the MNC operates in each host country. I controlled for firm size in terms of total sales revenue.

At the country level, I included *FDI inflow* (from World Development Indicators) to control for general macro factors that affect MNC activities. In addition, I included *Tax* *rate* (from University of Michigan Office of Tax Policy Research), to control for the impact of taxation on organization forms. Furthermore, in robustness checks I included the following additional macro data; results were similar:

- *GDP in 2000 constant dollars*, from the World Development Indicators table, to control for size of demand in the host country
- *GDP per capital in constant dollars,* from the World Development Indicators table, to control for general living standard/labor costs in the host country
- *Trade*, measured using the sum of imports and exports as a percentage of GDP, from World Development Indicators

5.3.4. Model specification

I adopted a nodal (i.e., unit) level of analysis that takes into consideration the individual MNC unit's characteristics (Rau & Vermaelen, 1998). Since the amount of coordination responsibilities delegated to units in a particular host country is not directly observable, I estimated the probability of a base unit reporting to another unit outside the host country. I adopted a logit model:

$$E[ForeignSuper_{jict} = 1] = E[CR^*_{jict} = X'_{jict}\beta + e_{jict} < 0]$$
$$= \beta_0 + \beta_1 I^w_{ct} + \beta_2 K_{jict} + \beta_3 I^w_{ct} * K_{jict} + \beta_4 DIV_{jct} + \beta_5 I^w_{ct} * DIV_{jct} + U'_{jict}\Phi + F'_{it}\Gamma + C'_{ct}\Lambda \quad (1),$$

where,

$ForeignSuper_{jict}$ is a dummy variable that turns to 1 if unit j of MNC i in host country c and year t reports to another MNC unit outside country c;

CR^*_{jict} is the latent variable for the amount of responsibilities to coordinate unit j of MNC i in host country c, that is delegated to supervisory units in country c and year t;

e_{jict} has a standard logistic distribution.

I^w_{ct} is the quality of institutions in country c and year t;

K_{jict} is task interdependence between unit j in country c and its MNC parent i in year t;

DIV_{jct} is institutional diversity for MNC i in year t, adjusted for the geographical location of unit j's host country c;

U_{jict} are other unit-specific characteristics;

F_{it} are MNE firm-specific characteristics;

C_{ct} are other country-specific characteristics.

5.4. Results

5.4.1 Descriptive statistics

Table 10 presents the list of non-U.S. host countries ranked by the quality of their institutions in 2003, according to the World Bank Governance Indicators. Finland, Switzerland, Luxembourg, Sweden and New Zealand rank the highest on the list, while Indonesia, Venezuela, Congo, Nigeria and Zimbabwe rank the lowest.

Table 11 shows reporting relationships among all MNE units in the DCA dataset, including MNCs outside the equipment manufacturing sector, in a selective number of countries in 2003. The first two columns report the number of base units in a host country and the number of base units that report to a foreign supervisory unit. The last column calculates the percentage of local units reporting to a foreign supervisory unit. The lower the percentage of local units that are subject to foreign supervision, the more managerial responsibilities are assumed by units within the host country. With rare exceptions, countries with strong institutions rank higher than countries with weak institutions.

Summary statistics of the final sample are provided in Table 12. Panel (a) shows country-level statistics. There is large variation across countries in the institution indices. The comprehensive index has a mean of 0.38 and a standard deviation of 0.89. The individual indices also have large variation across countries. The corruption index (not shown in the Table) has a mean of 0.39 and a standard deviation of 1.15. Despite the large cross-sectional differences, institution environment does not change very much for each country over the years during the sample period. No country has changed their institutions by more than one standard deviation from the population mean, and only two countries have ever seen their institutional environment changed by more than half of the standard deviation: Argentina and Zimbabwe.[32] Since the index is relatively stable over time, I also run robustness checks by grouping countries into quantiles based on the mean value of their indices over the sample period; results are similar.

Panel (b) shows MNC parent-level statistics. The average size of the MNCs in the sample is US$428 million (exp(6.06)=428). These MNCs operate between two and 95 countries (including U.S.), with an average of 8 countries. They are engaged in between

[32] For example, Argentina's situation significantly worsened in 2002, toward the end of the economic crisis that started in 1999. To prevent bank-run, the government effectively froze all bank accounts in 2001. Street demonstrations and riots targeted at multinational firms erupted. President De la Rúa fled his residence on December 21, 2001. As inflation and unemployment soared, debates and political fights about the next election followed. International flights were stopped for various days during 2002. The situation came under control after a new President, Néstor Kirchner, was elected in May 2003.

one and 113 segments, with an average of 9 segments. On average, they have 24 units worldwide.

Panel (c) presents unit-level statistics. 93% of the units are supervised by a unit outside the host country. Each unit operates in between one and 12 segments, with an average of 1.2. 43% of the units operate in the same primary segment as their parents. They operate in as little as none and as many as 11, with an average of 0.44 segments that are interdependent with their parent's primary segment. In the meantime, their parents have on average 42 other units worldwide that operate in the same segments as they do. A small proportion of units (10%) report their number of employees. On average they have 1,238 employees per unit.

5.4.2 Cross-border supervision

Tables 15 and 16 investigate cross-border supervision. The first four columns in Table 13 estimate the likelihood that an MNC unit in a host country reports to a foreign supervisor in a strong institution country; the last four columns estimate the likelihood that it reports to any foreign supervisor. Results are similar for the two slightly different dependent variables. Columns (1) and (5) investigate the impact of the control variables. First, the number of base units in a host country is negatively associated with the probability of cross-border reporting, suggesting that the scale of local operation raises the importance of local coordination and decision making. Second, level of product diversification of the unit is positively associated with foreign supervision, suggesting that units with broader operations are more closely supervised by foreign units. Finally, the more countries an MNC operates in, the lower the probability of cross-border supervision.

The rest of the columns examine the impact of host country institutions. The quality of institutions is quantified using three measures: a continuous institution index, a dummy that shows whether the quality of institutions is higher than the average across all host countries, and the difference between the quality of institutions where the unit is located and the average quality of institutions across all host countries its MNC parent operates in. Results are robust with all three measures: The quality of a host country's institutions has a negative impact on the likelihood that the units in the country report to a foreign unit. H7 is supported.

Table 14 includes the two levels of interdependencies into the analysis. The first four columns in Table 14 estimate the likelihood that an MNC unit in a host country reports to a foreign supervisor in a strong institution country; the last four columns estimate the likelihood that it reports to any foreign supervisor. Results are similar for the two slightly different dependent variables. At the activity level, Columns (2) and (6) show that task interdependence is positively correlated with foreign supervision, and the impact of institutions on cross-border reporting is magnified by task interdependence. Both H8 and H8a are supported. At the policy level, Columns (3) and (7) show that institutional diversity is positively correlated with foreign supervision, and the impact of host-country institutions on cross-border reporting is magnified by institutional diversity across all host countries that the MNC operates in. H9 and H9a are supported. To control for unobserved heterogeneity across countries, Columns (4) and (8) add country dummies; results are similar.

Overall, the results in Tables 13 and 14 show that, consistent with my hypotheses, units in host countries with weaker institutions are more likely to report to a foreign supervisory unit (in a strong institution country), and this relationship is stronger if the unit's activities are highly interdependent with those of its MNC parent or if the MNC operates in more heterogeneous institutional environments.

5.5. Discussion and conclusion

This study has thought to examine the role of organization structure in accommodating the business activities of in host countries with weak institutions. It finds that organization structure, a critical mechanism for coordination and governance, is used by MNCs to achieve arbitrage across institutional environments and resource allocation among their global units.

The study makes several contributions to the international business literature. First, it unites differences in institutions with differences in organization structures to attempt a more complete theory of how and why MNCs differ in their scope and structure. It suggests that choices of organization structure can be an important vehicle to countervail institutional obstacles. This complements the work on location choices and ownership modes of MNCs (e.g., Gatignon & Anderson, 1988; Hennart, 1991; Kogut & Zander, 1993; Oxley, 1999). It extends a recent literature that starts to examine MNCs' global strategies in sidestepping institutional obstacles when location and ownership choices are limited (Alcácer, 2006; Zhao, 2006), and sheds further light on how MNCs leverage supervisory units of different ranks and locations to achieve a delicate balance of delegation and control.

In addition, the study suggests that the impact of institutions is contingent upon firm strategies; organization structure is designed differently according to the varying constraints imposed by institutions and strategies. Firms that operate in relatively homogenous institutional environment but diverse product markets or firms that perform independent activities may design more decentralized structures to facilitate local adaptation (Bartlett & Ghoshal, 1989; Porter, 1986). But firms that choose to actively arbitrage in institutional diversity and exploit interdependencies may design more centralized structures.

The study also has implications for policy makers, since it highlights the channel through which MNCs "redistribute" managerial responsibilities away from countries with weak institutions. Over the past two decades, governments in developing countries have been working to improve the "hard" conditions in their countries to attract foreign direct investments (FDI), such as building infrastructure, giving special tax breaks or subsidies to MNCs, and raising educational level of their labor force. While these incentives may attract FDI, MNCs in these countries may engage in fragmented business activities aimed mainly at the cheaper labor force, engineering talent or market potential, without delegating substantial corporate or regional responsibilities to local management teams.

A case in point is the emergence of foreign consulting and financial services companies in China. Although powerhouses like Andersen Consulting and Citibank had been present in China since the late 1980s to take advantage of the great business opportunities there that followed the economic reforms, most of these local units remained branches under tight supervision and control from parent companies or regional headquarters in Hong Kong or Singapore. As local staff developed the technical expertise and the business expanded further, many local units were promoted to subsidiaries and started to enjoy some autonomy. But they still reported to regional headquarters for important strategic decisions. Starting from the beginning of this century, as the legal environment in China improved (partly stimulated with its acceptance by the WTO), many MNCs have moved their regional headquarters from Hong Kong or Singapore to China. Supervising units in China start to actively participate in the strategic decisions regarding their parent companies' activities in Asia or even around the globe. Hence institutions not only affect capital investments and technological transfers from MNCs, as suggested by the literature, but may also affect MNCs' on-going decisions about resource allocation across national borders, which have an important impact on the long-term sustainability of the economic growth in the host country.

Chapter 6

Conclusion

The broad objective of the dissertation is to investigate coordination cost as a limit to firm growth, and organization structure as a design element to manage the coordination tasks. The common thread connecting the three empirical studies in the dissertation is the emphasis that a firm can be viewed as a system of interdependent activities, and that the firm's growth options and organization structure can be affected by the degree and distribution of the interrelations between its existing activities. Chapter III complements the dominant synergistic view of diversification by highlighting the cost of coordinating the interdependencies between the existing and the new businesses. It identifies the challenges that the complexity of existing businesses poses to firm growth. Chapter IV investigates the design of organization structure to enhance coordination capacity. It particularly highlights the role of a hierarchical structure in balancing the tradeoffs between specialization and coordination in managing systems of interdependent activities. Chapter V examines yet another dimension of organization structure – the delegation of coordination responsibilities within a multinational hierarchical structure. It connects organization structure with institutional imperfections that give rise to the firm in the first place.

This new perspective of the firm as an activity system contributes to existing theories of the firm and organization structure, and has important managerial as well as policy implications for firm growth.

6.1. Contributions to theory

The core theoretical contribution of the dissertation is the development of a broad framework that relates intra-firm activities with firm growth and organization structure, by emphasizing the firm as a system of interdependent activities. In doing so, it contributes to theories of the firm and organization structure.

First, this theoretic framework complements existing theories of the firm. Neoclassical economics offers technological constraint as a limit to plant size, but is silent about firm size. Transaction costs economics locates individual transactions within or outside firm boundary but does not explain the scope of the entire firm. Resource-based view (RBV) adds the effect of managers but emphasizes their experience and learning rather than coordination capacity. In addition, while the two economic theories focus on coordination and efficient allocation of existing resources between the market and the firm, RBV emphasizes growth and deployment of new resources within firms. The framework developed in this dissertation reunites these classic theories and investigate how coordination challenges could limit firm growth: Firm boundaries are not determined by technologies of a single plant or the "make-or-buy" decision of a single transaction but are a result of many choices regarding a variety of inter-related activities.

With this new perspective, the dissertation joins the recent discussions by several authors around the process of vertical disintegration, modularization, and segregation of supply chains (Arora, Fosfuri, & Gambardella, 2000; Baldwin & Clark, 2005; Fine &

Whitney, 1999; Jacobides, 2005; Langlois & Robertson, 1992; Macher, Mowery, & Hodges, 1998; Schilling & Steensma, 2001; Zenger & Hesterly, 1997), and suggests that an implication of the process could be broader horizontal scope in related markets.

Second, to the organization structure literature, the theoretical framework extends the recent debate about the benefits and limitations of modular vs. integrated structures. It rejuvenates Simon's insight of a match between the hierarchical structure of the activity system and that of the organization: Hierarchical structure enables hierarchical coordination (Sanchez & Mahoney, 1996). Tradeoffs between specialization and coordination can be balanced not only through inter-temporal vacillation between modular and integrated structures depending on the specific contingencies (Siggelkow & Levinthal, 2003), but also through a hierarchical structure that allows for inter-module coordination.

In addition, a hierarchical structure allows for differential delegation. Differential delegation helps to balance the tradeoff between adaptation and coordination. It enables MNCs to circumvent institutional constraints that limit the coordination capacity of domestic firms both at home and in host countries and consequently, their growth.

6.2. Contributions to management and policy

The dissertation has important implications for management scholars and practitioners at the interface of diversification, organization, and international business. To diversification strategists, Chapter III underscores a balanced cost-benefit analysis of diversification strategies. While related diversification offers potential synergies, firms need to actively coordinate activities to realize the synergies. This applies to both internal growth and acquisition strategies. While the merger and acquisition literature has emphasized synergy as a major source of value creation (Capron, Dussauge, & Mitchell, 1998; Seth, 1990; Singh & Montgomery, 1987) and growth (Danzon, Epstein, & Nicholson, 2004), empirical studies show zero to negative value-added for shareholders (Andrade, Mitchell, & Stafford, 2001) over the medium to long term, especially for acquires of growth potential (Rau & Vermaelen, 1998). As discussed in Chapter III, the same contradiction is also present in the diversification literature. It is therefore important for scholars to reconcile the evidence and theory, and investigate not only the benefits but also the costs of integration.

To organization designers, Chapter IV sets a boundary condition to "flatter organizations" that are well-received in popular press and academic research (Brickley *et al.*, 2003; Rajan & Wulf, 2006). By incorporating intermediate coordinating units into the analysis of specialization vs. coordination, the study reestablishes the importance of hierarchical structures in managing inter-unit interdependencies, thereby justifying its prevalence in real corporations.

To global strategists, Chapter V unites differences in institutions with differences in organization structures to attempt a more complete theory of how and why MNCs differ in their scope and structure. It suggests that choices of organization structure can be an important vehicle to countervail institutional obstacles. This complements existing work on location choices and ownership modes of MNCs (e.g., Gatignon & Anderson, 1988; Hennart, 1991; Kogut & Zander, 1993; Oxley, 1999). It extends a recent literature that starts to examine MNCs' global strategies in sidestepping institutional obstacles when location and ownership choices are limited (Alcácer, 2006; Zhao, 2006).

Finally, to policy makers, especially those focusing on developing countries, Chapter V expands the importance of institutions: Institutions affect not only capital investment and technological transfers from MNCs, as suggested by the literature, but also affect MNCs' organization structure. To the extent that organization structure affects decisions about resource allocation within firms, and MNCs' main strategic focuses include arbitraging and resource reallocation across national borders, quality institutions will have a profound impact on the sustainable development of economies in host countries.

6.3. Contributions to methodology

As mentioned in Chapters III and IV, it is a challenge to operationalize and measure with reliable data the key constructs covered in this dissertation – complexity and decomposability of interdependencies in activity systems, and the degree of modularity and hierarchy in organization structure. Not surprisingly, there are very few econometric studies of interdependencies in activity systems and organization modularity and hierarchy at the firm level. The prior work on system interdependencies and organization structure tends to employ abstract concepts and conducts computer simulations or case studies. This dissertation addresses some of these challenges.

First, I build a unique dataset of a large sample of firms' internal activities and organization structures with data from multiple sources. These data have been available for a long time, but have not been fully exploited to the benefit of investigating the internal reality of firms. Second, treating the firm's business portfolio as a system of activities supplying inputs to one another, I operationalize system interdependencies based on the flow of intermediate inputs between segments within diversified firms. This operationalization corresponds closely to the theoretical definitions of system interdependencies in the modularity literature, and allows me to capture both the degree and the distribution of interdependencies. Third, I adopt computational programs recently developed in physics and biology to quantify the decomposability of activity systems with non-randomly distributed interdependencies. To my knowledge, the dissertation is the first to comprehensively quantify the theoretical relationships between activity interdependencies, firm scope and organization structure on a large sample of actual organizations. It will hopefully encourage more empirical studies that will complement the extensive theoretical modeling efforts in the modularity and organization structure literatures.

6.4. Potential extensions

The dissertation opens up several opportunities for future research. First, the dissertation treats firms' scope choices as sequentially dependent, and studies the impact of existing activity system on subsequent diversification moves and organization structure. Further work is needed to model and test how firms simultaneously decide their vertical and horizontal scopes, and organization structure. Future work can also investigate how exogenous shocks to firms' activity systems (e.g., regulatory changes) or coordination capacity (e.g., technological changes) influence firms' scope and structure choices.

Second, the dissertation focuses on a form of organization design: formal reporting relationships among organization units. Future work is warranted to study more dimensions of organization design, such as incentive schemes, control systems, staffing of managerial positions in local units, internal networks, corporate culture, etc., with respect to coordinating interdependent activities.

Finally, the dissertation only starts to investigate the interplay between organization structure and institutions in influencing the relative magnitude of coordination vs. transaction costs. Current contract theories tend to view contracts as schedules of prices or quantities written between two calculative agents. In fact, contracts, especially long-term ones, are often initiated, negotiated, authorized, implemented, and renegotiated by decision makers of various ranks within multiple organizations under heterogeneous institutional environment. Future work can be aimed at investigating how organization structure, by affecting coordination costs, affects contracting costs and, consequently, firm scope.

In conclusion, the dissertation seeks to contribute to the literatures on firm scope and structure by presenting the firm as a system of interdependent activities. Using a unique dataset of business activities and organization structures within a large sample of actual business firms, I show the potential of this new perspective in analyzing firm scope and structure, and in operationalizing some of the key constructs in existing studies of modularity. I hope these efforts will deepen our understanding of the firm and its integration costs, and motivate future research that further exploits the rich and complex reality of the firm.

Figure 1. Cost-benefit analysis of diversification strategies

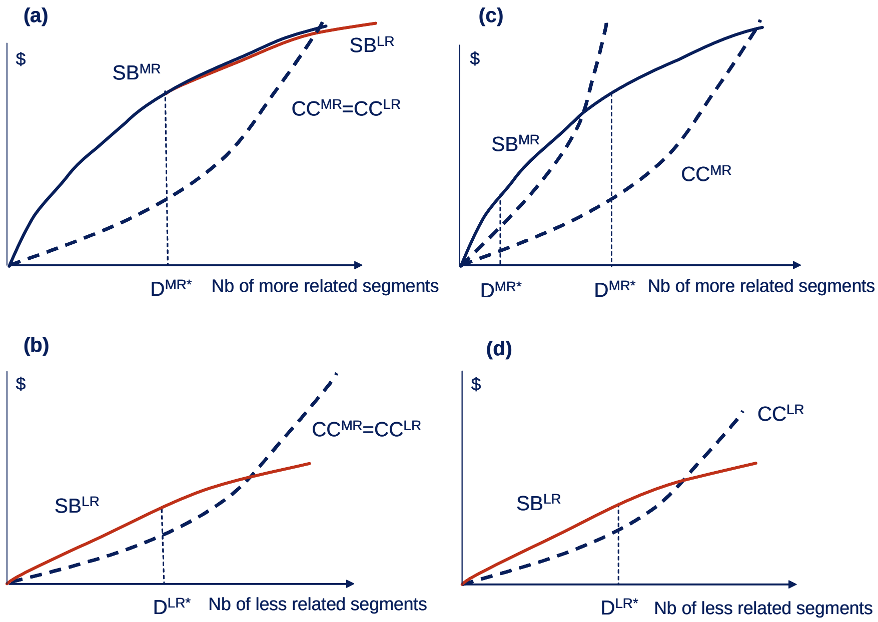

Figure 2. Interpreting coefficients in Table 5.

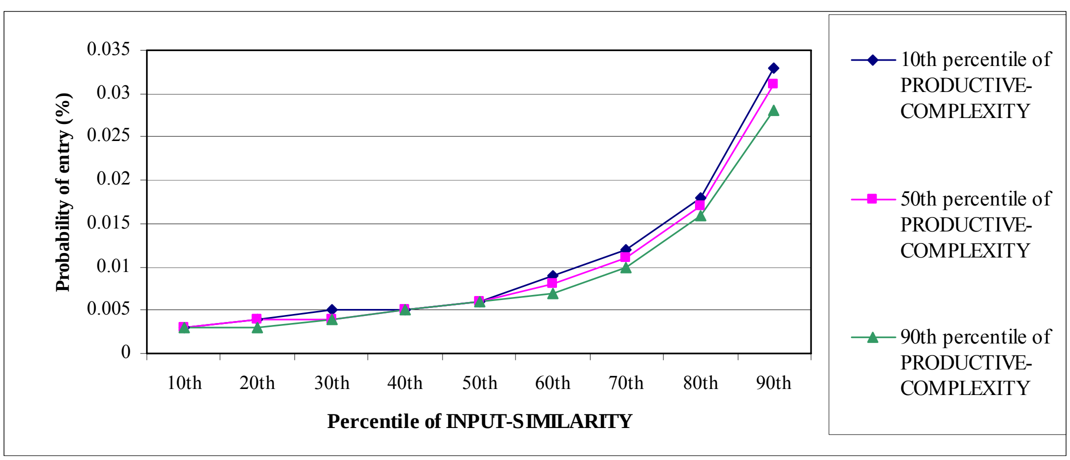

Figure 3. More vs. Less modular portfolios

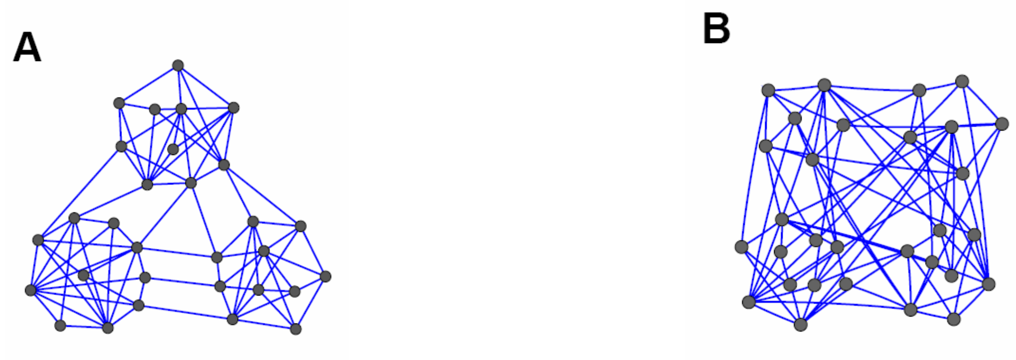

Figure 4. MNC structures under different institutional environment

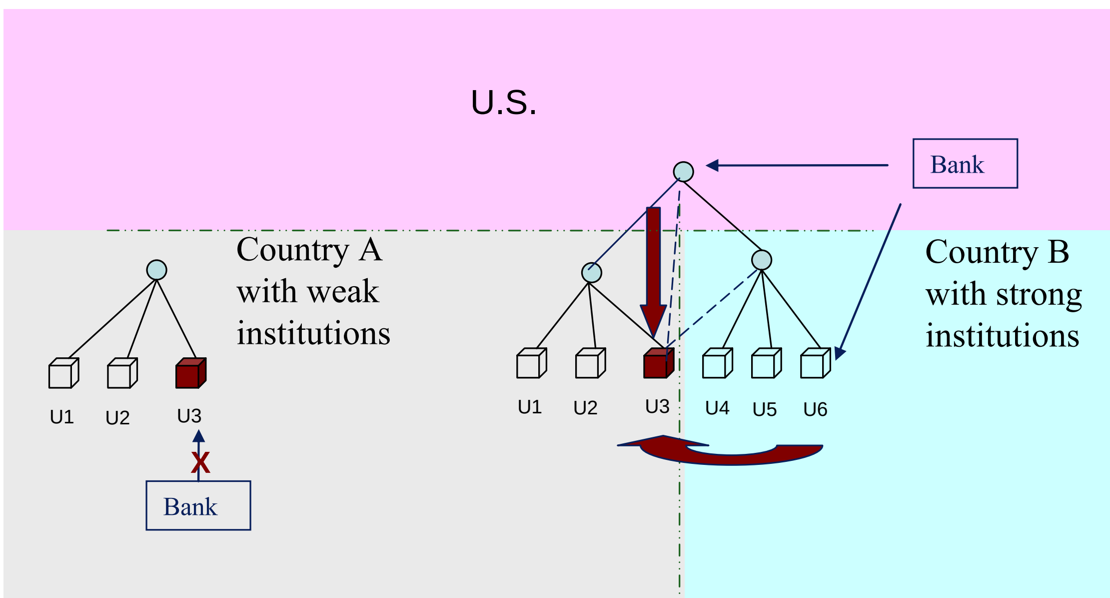

Table 1. Industries in which U.S. automakers operate

Description	SIC codes
Primary industry:	
Motor vehicles and passenger car bodies	**3711**
Other industries in the transportation equipment sector	
Truck and bus bodies	*3713*
Motor vehicle parts and accessories	*3714*
Truck trailers	*3715*
Motor homes	*3716*
Industries in other sectors:	
Apparel and other textile products	2399
Rubber and miscellaneous plastics products	3052 3089
Stone, clay, glass, and concrete products	3211
Primary metal industries	3325
Fabricated metal products	3411 3462 3499
Industrial machinery and equipment	3519 3531 3537 3541 3544 3545 3568 3585 3599
Electrical and electronic equipment	3621 3647 3651 3663 3669 3679 3692 3694
Instruments and related products	3827
Miscellaneous manufacturing industries	3993 3999
Communications	4833 4841 4899
Electric, gas, and sanitary services	4953 4959
Wholesale trade--durable goods	5012 5013 5015 5051 5065 5082 5084 5088
Wholesale trade--nondurable goods	5112
Automotive dealers and gasoline service stations	5511 5531 5599
Miscellaneous retail	5947
Depository institutions	6082
Nondepository credit institutions	6141 6153 6159 6162
Security, commodity brokers, and services	6211 6282
Insurance carriers	6311 6331 6399
Insurance agents, brokers, and service	6411
Real estate	6531 6552
Holding and other investment offices	6719 6788
Business services	7311 7319 7353 7359 7371 7382 7389
Automotive repair, services, and parking	7513 7514 7515 7539 7549
Engineering and management services	8711 8731 8734 8741 8742 8748

Source: Directory of Corporate Affiliations.

Table 2. Summary statistics (Chapter III)

	mean	sd	min	max
Firm/Primary-industry variables[a]				
Firm age: years since establishment	43.86	32.47	1	170
Firm size: log (sales)	5.46	1.94	-4.27	12.12
Share of sales from the primary industry (four-digit SIC)	0.86	0.20	0.11	1.00
Firm size: log (employees '000)	0.36	1.83	-4.83	6.61
Capital intensity: CAPEX/sales	0.05	0.06	0.00	0.89
R&D intensity: R&D expenditure/sales	0.08	0.09	0.00	0.99
Horizontal and vertical scope: number of industries (four-digit SIC) (N)	7.27	9.22	2	105
Geographic dispersion: number of countries	4.93	7.77	1	91
COMPLEXITY: Number of interdependent segment pairs	40.46	140.12	0	3100
Share of interdependent segment pairs	0.47	0.35	0.00	1.00
Growth rate in the primary industry	0.05	0.16	-0.59	0.70
Concentration in the primary industry – HHI	596	492	1	2717
Destination-industry variables[b]				
INPUT-SIMILARITY: coefficient between the primary and destination industries	0.28	0.21	0.00	1.00
Growth rate in the destination industry	0.01	0.12	-0.60	0.78
Concentration in the destination industry – HHI	726	655	1	2999
Avg. growth rate in shipment value in the destination industry	0.03	0.05	-0.10	0.13
Capital intensity of the destination industry	0.08	0.11	0.00	0.99
Absolute difference in capital intensity between the firm and the destination industry	0.12	0.17	0.00	1.00
R&D intensity of the destination industry	0.07	0.14	0.00	0.98
Absolute difference in R&D intensity between the firm and the destination industry	0.21	0.25	0.00	1.00

^ log value.
[a]N=5,311 firm-year observations.
[a]N=1,973,939 firm-year-destination-industry observations.

Table 3. Trends in complexity and diversifying entry

	Observations (Potential entries)	Nb. of segments[a]	Complexity[a]	Percentage of actual entry
Two-digit SIC				
34 – Fabricated metal products	122,139	9.86	0.310	0.08%
35 – Industrial machinery and equipment	568,745	6.95	0.534	0.0005
36 – Electrical and electronic equipment	580,796	6.50	0.572	0.0005
37 – Transportation equipment	216,407	12.70	0.321	0.0013
38 – Instruments and related products	485852	5.90	0.453	0.0004
Year				
1994	204,895	7.50	0.517	0.0005
1995	199,719	7.48	0.518	0.0008
1996	203,584	7.52	0.499	0.0007
1997	197,515	7.73	0.485	0.0007
1998	203,194	7.56	0.482	0.0005
1999	196,266	7.37	0.468	0.0005
2000	175,538	7.22	0.478	0.0011
2001	186,819	6.91	0.479	0.0002
2002	175,881	6.99	0.477	0.0010
2003	230,528	7.34	0.474	0.0002
Mean		**7.27**	**0.47**	**0.0006**

[a]Lagged value.

Table 4. Correlation matrix (Chapter III)

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	Entry (1,0)	1.00								
(2)	INPUT-SIMILARITY	0.03	1.00							
(3)	COMPLEXITY	0.03	-0.02	1.00						
(4)	INPUT-SIMILARITY*COMPLEXITY	0.04	0.17	0.78	1.00					
(5)	Firm Size: number of employees ('000)^	0.02	0.00	0.48	0.36	1.00				
(6)	Horizontal and vertical scope: number of industries (four-digit SIC) (N)	0.03	-0.01	0.88	0.70	0.59	1.00			
(7)	Geographic dispersion	0.02	0.00	0.40	0.32	0.59	0.49	1.00		
(8)	Firm age ^	0.01	0.03	0.24	0.20	0.33	0.35	0.27	1.00	
(9)	Growth rate in the primary industry	0.00	0.01	-0.05	-0.04	0.01	-0.05	0.05	-0.10	1.00
(10)	Growth rate in the destination industry	0.01	0.04	-0.01	0.00	0.02	0.00	0.02	0.02	0.09
(11)	Concentration in the primary industry – HHI	0.01	-0.10	0.20	0.08	0.20	0.18	0.05	0.05	-0.02
(12)	Concentration in the destination industry – HHI	-0.01	-0.05	0.00	-0.01	0.00	0.00	0.00	0.00	0.00
(13)	Capital intensity of the firm	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.02	0.01
(14)	Capital intensity of the destination industry	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.02
(15)	Absolute difference in capital intensity between the firm and the destination industry	0.00	-0.01	-0.01	-0.01	-0.01	-0.02	0.01	-0.03	0.06
(16)	R&D intensity of the firm	0.00	0.01	-0.01	0.00	-0.04	-0.01	-0.02	-0.02	0.00
(17)	R&D of the destination industry	0.00	0.07	0.00	0.01	-0.01	0.00	-0.01	0.00	-0.02
(18)	Absolute difference in R&D intensity between the firm and the destination industry	0.00	0.02	-0.03	-0.02	-0.05	-0.04	0.00	-0.07	0.04

(cont'd)

		(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(10)	Growth rate in the destination industry	1.00								
(11)	Concentration in the primary industry – HHI	0.00	1.00							
(12)	Concentration in the destination industry – HHI	-0.03	0.00	1.00						
(13)	Capital intensity of the firm	0.00	0.01	0.00	1.00					
(14)	Capital intensity of the destination industry	0.01	0.00	0.01	0.00	1.00				
(15)	Absolute difference in capital intensity between the firm and the destination industry	0.01	-0.01	0.01	0.00	0.86	1.00			
(16)	R&D intensity of the firm	0.00	0.01	0.00	0.19	0.00	0.00	1.00		
(17)	R&D of the destination industry	0.03	0.00	0.06	0.00	0.32	0.27	0.00	1.00	
(18)	Absolute difference in R&D intensity between the firm and the destination industry	0.01	-0.01	0.04	0.00	0.19	0.40	0.02	0.58	1.00

$p>0.01$ for $|r|>0.014$; ^ log value.

Table 5. Direction of diversification: Probability of entry

	(1) Logit	(2) Logit	(3) Logit	(4) Logit	(5) Logit	(6) RELogit	(7) RELogit
INPUT-SIMILARITY		4.703***	4.697***	5.047***	5.244***	5.047***	5.243***
		[0.129]	[0.129]	[0.148]	[0.153]	[0.153]	[0.181]
COMPLEXITY			-0.002***	-0.001*	0.000	-0.001*	0.000
			[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
INPUT-SIMILARITY*COMPLEXITY				-0.002***	-0.003***	-0.002***	-0.003***
				[0.470]	[0.472]	[0.395]	[0.395]
Firm size: number of employees (Mil)^	0.423***	0.461***	0.473***	0.467***	0.479***	0.468***	0.479***
	[0.029]	[0.029]	[0.029]	[0.029]	[0.029]	[0.029]	[0.029]
Horizontal and vertical scope: number of industries (four-digit SIC) (N)	0.080***	0.067***	0.061***	0.066***	0.064***	0.066***	0.064***
	[0.008]	[0.008]	[0.008]	[0.008]	[0.008]	[0.010]	[0.011]
N^2	-0.001***	-0.001***	0.000	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Geographic dispersion: number of countries^	-0.167***	-0.164***	-0.128***	-0.120***	-0.126***	-0.120***	-0.126***
	[0.039]	[0.040]	[0.040]	[0.040]	[0.041]	[0.045]	[0.045]
Firm age^	0.011	-0.035	-0.038	-0.042	-0.051	-0.043	-0.052
	[0.044]	[0.043]	[0.043]	[0.043]	[0.043]	[0.045]	[0.046]
Growth rate in the primary industry	-0.337	-0.228	-0.251	-0.251	-0.826***	-0.248	-0.818***
	[0.215]	[0.214]	[0.209]	[0.209]	[0.250]	[0.183]	[0.263]
Growth rate in the destination industry	1.203***	1.408***	1.408***	1.400***	1.321***	1.414***	1.342***
	[0.099]	[0.119]	[0.119]	[0.119]	[0.149]	[0.076]	[0.108]
Concentration in the primary industry – HHI	-0.000***	0.000*	0.000**	0.000	0.000	0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Concentration in the destination industry – HHI	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Capital intensity of the firm	-4.600***	-5.662***	-6.020***	-6.331***	-6.807***	-6.302***	-6.772***
	[1.040]	[1.069]	[1.073]	[1.080]	[1.098]	[1.015]	[1.040]
Capital intensity of the destination industry	0.123	0.136	0.130	0.129	0.096	0.122	0.088
	[0.106]	[0.102]	[0.103]	[0.102]	[0.102]	[0.121]	[0.118]

	(1) Logit	(2) Logit	(3) Logit	(4) Logit	(5) Logit	(6) RELogit	(7) RELogit
Absolute difference in capital intensity between the firm and the destination industry	-0.151	-0.124	-0.118	-0.118	-0.083	-0.103	-0.066
	[0.105]	[0.100]	[0.100]	[0.100]	[0.100]	[0.122]	[0.118]
R&D intensity of the firm	-4.363***	-4.742***	-4.493***	-4.507***	-3.917***	-4.483***	-3.894***
	[0.892]	[0.873]	[0.867]	[0.867]	[0.879]	[0.864]	[0.888]
R&D of the destination industry	0.092***	0.054***	0.054***	0.053***	0.053***	0.051***	0.052**
	[0.019]	[0.017]	[0.017]	[0.017]	[0.018]	[0.019]	[0.021]
Absolute difference in R&D intensity between the firm and the destination industry	-0.064***	-0.048***	-0.048***	-0.046***	-0.045**	-0.044**	-0.043**
	[0.019]	[0.017]	[0.017]	[0.016]	[0.018]	[0.019]	[0.022]
Constant	-7.821***	-9.984***	-9.956***	-10.146***	-10.023***	-10.132***	-10.004***
	[0.212]	[0.224]	[0.224]	[0.229]	[0.259]	[0.244]	[0.264]
Sector dummies (two-digit SIC)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	No	No	No	Yes	No	Yes
Observations	1,973,939	1,973,939	1,973,939	1,973,939	1,973,939	1,973,939	1,973,939
Log-likelihood	-7949.18	-7301.72	-7293.49	-7281.47	-7149.22	n.a.	n.a.
Log-likelihood ratio test		$\chi^2(1)$ vs. model 1 =1294.92***	$\chi^2(1)$ vs. model 2 =16.44***	$\chi^2(1)$ vs. model 3 =24.05***	$\chi^2(10)$ vs. model 4 =264.49***		

Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ log value.

Table 6. Direction of diversification: Robustness Checks

	(1) RELogit	(2) RELogit	(3) RELogit
INPUT-SIMILARITY			
=====Between the primary and the new businesses		4.602***	4.724***
		[0.166]	[0.215]
=====Between all existing businesses and the new business	5.266***		
	[-0.002]***		
COMPLEXITY			
=====Number of interdependent segment pairs	0.000		
	[0.000]		
=====Share of interdependent segment pairs		-0.026***	
		[0.175]	
=====Share of interdependent segment pairs weighted by number of units			0.311
			[0.382]
=====Number of interdependent segment pairs (5% as the threshold for interdependence)			
INPUT-SIMILARITY*COMPLEXITY	-0.002***	-0.588*	-1.067*
	[0.000]	[0.355]	[0.566]
All control variables in Table 5, Column (1)	Yes	Yes	Yes
The constant term	Yes	Yes	Yes
Sector dummies (two-digit SIC)	Yes	Yes	Yes
Observations	1,973,939	1,973,939	1,973,939

Standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 7. Summary statistics and correlation matrix (Chapter IV)

		mean	sd	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Number of supervisory units^	0.45	0.73	1.00						
(2)	Number of supervisory units (weighted by rank)^	2.49	0.68	1.00	1.00					
(3)	Number of average levels for all units^	0.66	0.15	0.81	0.80	1.00				
(4)	Number of average levels for base units^	0.76	0.12	0.80	0.79	0.83	1.00			
(5)	Number of base units^	2.00	1.22	0.64	0.64	0.77	0.36	1.00		
(6)	Complexity: Share of interdependent segment pairs	0.22	0.27	-0.22	-0.22	-0.29	-0.18	-0.29	1.00	
(7)	Decomposability	20.65	19.65	-0.32	-0.32	-0.40	-0.23	-0.43	0.20	1.00
(8)	Firm size: number of employees (‘000)^	0.72	1.81	0.59	0.59	0.60	0.39	0.71	-0.17	-0.39
(9)	Horizontal and vertical scope: number of industries (four-digit SIC) (N) ^	1.80	0.80	0.70	0.71	0.65	0.47	0.69	-0.31	-0.67
(10)	Geographic dispersion: number of countries^	1.15	1.05	0.48	0.48	0.54	0.24	0.79	-0.24	-0.24
(11)	Firm age ^	3.58	0.78	0.32	0.32	0.31	0.17	0.35	-0.09	-0.33
(12)	Environment volatility – absolute beta of industry stock returns	1.21	0.66	-0.07	-0.07	-0.08	-0.06	-0.06	0.10	0.05
(13)	Industry R&D intensity	1.39	5.53	-0.05	-0.04	-0.04	-0.04	-0.03	-0.03	0.07
(14)	Growth rate in the primary industry	0.07	0.20	-0.08	-0.08	-0.07	-0.08	-0.02	0.03	0.09

		mean	sd	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(8)	Firm size: number of employees (‘000)^	0.72	1.81	1.00						
(9)	Horizontal and vertical scope: number of industries (four-digit SIC) (N) ^	1.80	0.80	0.65	1.00					
(10)	Geographic dispersion: number of countries^	1.15	1.05	0.57	0.42	1.00				
(11)	Firm age ^	3.58	0.78	0.32	0.43	0.22	1.00			
(12)	Environment volatility – absolute beta of industry stock returns	1.21	0.66	-0.06	-0.09	0.01	-0.10	1.00		
(13)	Industry R&D intensity	1.39	5.53	-0.05	-0.09	0.03	-0.10	-0.05	1.00	
(14)	Growth rate in the primary industry	0.07	0.20	-0.04	-0.12	0.04	-0.13	-0.01	0.08	1.00

p>0.01 for |r|>0.04; ^ log value.

Table 8. Organization structure: Degree of organization modularity

DV=Number of base units^	(1)	(2)	(3)	(4)	(5)	(6)
Task complexity			-0.215*	-1.054***	-1.880***	-0.911**
			[0.112]	[0.256]	[0.591]	[0.385]
Task complexity squared				0.846***	2.473***	1.087**
				[0.248]	[0.772]	[0.501]
Above-average task decomposability (1,0)					0.062*	0.042
					[0.038]	[0.037]
Firm size: number of employees ('000)^	0.112***	0.094***	0.091***	0.087***	0.054*	0.063***
	[0.016]	[0.023]	[0.023]	[0.023]	[0.032]	[0.022]
Product diversification: number of segments	0.514***	0.569***	0.539***	0.558***	0.822***	0.766***
	[0.031]	[0.060]	[0.061]	[0.061]	[0.106]	[0.080]
Geographic dispersion: number of countries^	0.640***	0.797***	0.797***	0.792***	0.579***	0.595***
	[0.023]	[0.045]	[0.045]	[0.045]	[0.073]	[0.048]
Firm age: years since establishment^	0.051**	-0.008	-0.018	-0.014	0.072	-0.012
	[0.025]	[0.099]	[0.101]	[0.098]	[0.140]	[0.032]
Growth rate in the primary industry	0.054	0.031	0.03	0.027	0.094*	0.082
	[0.059]	[0.032]	[0.032]	[0.031]	[0.055]	[0.053]
Environment volatility – absolute beta of industry stock returns	-0.056***	-0.011	-0.01	-0.011	-0.006	-0.005
	[0.020]	[0.013]	[0.013]	[0.013]	[0.015]	[0.014]
Industry R&D intensity	-0.002	0.000	0.000	0.000	-0.003***	-0.003***
	[0.002]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Constant	0.149	0.08	0.214	0.256	-0.335	-0.016
	[0.099]	[0.343]	[0.354]	[0.341]	[0.543]	[0.163]
Year dummies	No	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	Yes	Yes	No
Firm random effects	No	No	No	No	No	Yes
Observations	4522	4522	4522	4522	2368	2368
Number of firms	865	865	865	865	444	444
R2	0.8	0.59	0.59	0.60	0.62 (within) 0.77(between)	0.61(within) 0.79(between)
F-stats/Chi2		49.11	49.04	47.29	25.14	1443.78

Heteroskedasticity consistent standard errors that correct for clustering at the firm level appear in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ log value.

Table 9. Organization structure: Degree of organization hierarchy

DV=Weighted number of supervisory units ^	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Task complexity			-1.492***	-1.413***	-0.962***
			[0.473]	[0.471]	[0.274]
Task complexity squared			2.416***	2.250***	1.543***
			[0.766]	[0.747]	[0.414]
Above-average task decomposability (1,0)				-0.075**	-0.126***
				[0.035]	[0.032]
Number of base units^	0.087	0.085*	0.069	0.073*	0.084**
	[0.054]	[0.045]	[0.043]	[0.042]	[0.035]
Firm size: number of employees ('000)^	0.047***	0.018	0.029	0.028	0.039***
	[0.017]	[0.025]	[0.024]	[0.024]	[0.014]
Product diversification: number of segments^	0.711***	0.621***	0.640***	0.677***	0.719***
	[0.067]	[0.074]	[0.071]	[0.076]	[0.054]
Geographic dispersion: number of countries^	0.063*	0.110**	0.113**	0.113**	0.078**
	[0.034]	[0.051]	[0.047]	[0.047]	[0.032]
Firm age: years since establishment^	-0.031	-0.275**	-0.273**	-0.276**	-0.025
	[0.031]	[0.125]	[0.122]	[0.124]	[0.031]
Growth rate in the primary industry	-0.146	-0.017	-0.027	-0.029	-0.051
	[0.100]	[0.043]	[0.043]	[0.043]	[0.041]
Environment volatility – absolute beta of industry stock returns	-0.028	-0.030*	-0.029*	-0.029*	-0.031**
	[0.024]	[0.016]	[0.016]	[0.015]	[0.015]
Industry R&D intensity	0	0.001	0.001	0.001	0.001
	[0.003]	[0.002]	[0.002]	[0.002]	[0.002]
Constant	0.856***	1.923***	2.018***	1.960***	0.916***
	[0.162]	[0.500]	[0.495]	[0.501]	[0.148]
Year dummies	No	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	Yes	No
Firm random effects	No	No	No	No	Yes
Observations	4522	4522	4522	2368	2368
Number of firms	865	865	865	444	444
R2	0.58	0.23	0.24	0.35(within) 0.52(between)	0.34(within) 0.63(between)
F-stats/Chi2		9.3	8.94	11.38	749.06

Heteroskedasticity consistent standard errors that correct for clustering at the firm level appear in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ log value.

Table 10. World Bank Governance Indicators

Rank	Country	Quality of institutions	Rank	Country	Quality of institutions	Rank	Country	Quality of institutions
1	FINLAND	1.932	33	LITHUANIA	0.810	65	TURKEY	-0.200
2	SWITZERLAND	1.840	34	GREECE	0.790	66	MOROCCO	-0.200
3	LUXEMBOURG	1.812	35	COSTA RICA	0.787	67	SAUDI ARABIA	-0.247
4	SWEDEN	1.805	36	CZECH REPUBLIC	0.783	68	BOLIVIA	-0.255
5	NEW ZEALAND	1.797	37	LATVIA	0.765	69	INDIA	-0.300
6	DENMARK	1.792	38	SLOVAKIA	0.673	70	PERU	-0.313
7	NORWAY	1.712	39	POLAND	0.625	71	ARGENTINA	-0.322
8	NETHERLANDS	1.707	40	URUGUAY	0.607	72	PHILIPPINES	-0.382
9	CANADA	1.623	41	UNITED ARAB EMIRATES	0.598	73	GABON	-0.420
10	AUSTRALIA	1.608	42	SOUTH KOREA	0.557	74	LEBANON	-0.493
11	AUSTRIA	1.585	43	OMAN	0.477	75	CHINA	-0.497
12	UNITED KINGDOM	1.568	44	ISRAEL	0.463	76	EGYPT	-0.498
13	SINGAPORE	1.548	45	BAHRAIN	0.388	77	VIETNAM	-0.543
14	IRELAND	1.460	46	QATAR	0.373	78	HONDURAS	-0.547
15	GERMANY	1.455	47	MALAYSIA	0.368	79	RUSSIA	-0.613
16	BELGIUM	1.403	48	SOUTH AFRICA	0.362	80	UKRAINE	-0.618
17	LIECHTENSTEIN	1.345	49	TRINIDAD & TOBAGO	0.303	81	ECUADOR	-0.643
18	MALTA	1.257	50	KUWAIT	0.273	82	GUATEMALA	-0.680
19	PORTUGAL	1.245	51	CROATIA	0.222	83	COLOMBIA	-0.683
20	CHILE	1.192	52	MONACO	0.205	84	BOSNIA AND HERZEGOVINA	-0.708
21	FRANCE	1.190	53	BULGARIA	0.203	85	KENYA	-0.718
22	SPAIN	1.168	54	PANAMA	0.118	86	SYRIA	-0.830
23	BAHAMAS	1.167	55	THAILAND	0.117	87	ALGERIA	-0.843
24	BARBADOS	1.138	56	BRAZIL	0.108	88	PARAGUAY	-0.925
25	JAPAN	1.135	57	MEXICO	0.058	89	PAKISTAN	-0.925
26	BERMUDA	1.113	58	TUNISIA	0.053	90	INDONESIA	-0.927
27	ESTONIA	1.008	59	JORDAN	0.052	91	VENEZUELA	-1.033
28	SLOVENIA	1.005	60	ROMANIA	-0.040	92	CONGO	-1.190
29	CYPRUS	0.928	61	GHANA	-0.115	93	NIGERIA	-1.205
30	HUNGARY	0.890	62	JAMAICA	-0.147	94	ZIMBABWE	-1.588
31	TAIWAN	0.860	63	EL SALVADOR	-0.187			
32	ITALY	0.827	64	DOMINICAN REPUBLIC	-0.193			

Table 11. Supervision across borders (2003)

Host country	Number of base units in the host country (1)	Number of base units supervised by a foreign unit (2)	% of base units supervised by a foreign unit (3)=(2)/(1)
New Zealand	126	90	71.4%
Canada	1375	1092	79.4%
Norway	102	83	81.4%
Mexico	357	319	89.4%
Germany	690	621	90.0%
Japan	452	407	90.0%
U.K.	1233	1114	90.3%
Sweden	156	143	91.7%
China	179	165	92.2%
Australia	436	408	93.6%
France	514	483	94.0%
Austria	96	91	94.8%
Chile	63	60	95.2%
Argentina	90	86	95.6%
Brazil	237	230	97.0%
India	124	121	97.6%
Venezuela	95	94	98.9%
Colombia	65	65	100.0%
Indonesia	56	56	100.0%
Malaysia	91	91	100.0%
Philippines	63	63	100.0%
Poland	58	58	100.0%
Russia	41	41	100.0%

Table 12. Summary statistics and correlation matrix (Chapter V)

Panel (a) host-country statistics

		N	mean	sd	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1)	Quality of institutions	644	0.38	0.89	1.00						
(2)	Human capital	644	2.12	1.15	0.77	1.00					
(3)	GDP in constant 2000 U.S. dollars^	644	25.08	1.76	0.50	0.51	1.00				
(4)	Trade (as % of GDP)	644	67.12	32.56	0.15	0.12	-0.27	1.00			
(5)	Tax rate	644	32.75	6.63	-0.11	0.05	0.01	-0.03	1.00		
(6)	GDP per capita in constant 2000 U.S. dollars^	644	8.31	1.39	0.88	0.80	0.60	0.09	-0.06	1.00	
(7)	FDI inflow^	644	7.18	2.14	0.55	0.47	0.77	0.01	-0.17	0.56	1.00

Note: These are statistics for the 67 non-U.S., non-tax-haven countries that MNCs in my sample operate in.

Panel (b) MNC statistics

		N	mean	sd	(1)	(2)	(3)	(4)
(1)	MNC size: log (sales)	4,049	6.06	1.92	1.00			
(2)	MNC geographic dispersion: Number of countries	4,049	7.70	9.00	0.54	1.00		
(3)	MNC product diversification: Number of segments	4,049	9.20	11.79	0.61	0.43	1.00	
(4)	Number of all units an MNC has in all host countries (including U.S.)	4,049	23.95	44.90	0.55	0.79	0.68	1.00

Note: These are statistics for the 917 MNCs in my sample.

Panel (c) MNC base unit statistics

		N	mean	sd	(1)	(2)	(3)	(4)	(5)	(6)
(1)	Subject to cross-border supervision (1,0)	40,118	0.93	0.26	1.00					
(2)	Number of segments a unit operates in	40,118	1.20	0.62	0.02	1.00				
(3)	Unit operates in MNC's primary segment (1,0)	40,118	0.43	0.49	0.06	-0.10	1.00			
(4)	Number of segments a unit operates in that are interdependent with MNC's primary segment	40,118	0.44	0.59	-0.02	0.39	-0.54	1.00		
(5)	Number of other units of the same MNC that operate in the same primary segment of the focal unit	40,118	42.2	88.84	0.04	-0.13	0.32	-0.19	1.00	
(6)	Number of employees	5,853	1,236	4902	-0.02	0.13	0.21	-0.05	0.12	1.00

Note: These are statistics for the 7,791 non-U.S., base units of the 917 MNCs in my sample. ^ log value.

Table 13. MNC organization structure: Cross-border reporting and the impact of host-country institutions

	(1) Logit	(2) Logit	(3) Logit	(4) Logit	(5) Logit	(6) Logit	(7) Logit	(8) Logit
Weak institutions in host countries								
Negative value of institutions		0.875***				0.871***		
		[0.212]				[0.216]		
Below-average institutions (1,0)			1.396***				1.364***	
			[0.435]				[0.439]	
Negative difference between host-country institutions and the average host-country institutions for the MNC parent				0.651***				0.635***
				[0.196]				[0.197]
Number of base units in the country^	-0.819***	-0.797**	-0.812***	-0.803***	-0.831***	-0.810***	-0.823***	-0.814***
	[0.314]	[0.310]	[0.295]	[0.307]	[0.318]	[0.313]	[0.299]	[0.311]
Unit product diversification: Number of segments	1.169***	1.132***	1.182***	1.249***	1.164***	1.127***	1.175***	1.241***
	[0.222]	[0.231]	[0.223]	[0.226]	[0.226]	[0.234]	[0.226]	[0.230]
MNC size: log (sales)	0.159	0.158	0.16	0.176	0.139	0.138	0.14	0.156
	[0.116]	[0.121]	[0.120]	[0.118]	[0.114]	[0.119]	[0.118]	[0.116]
MNC product diversification: Number of segments	0.001	0.002	0.000	0.000	0.003	0.004	0.003	0.002
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
MNC geographic dispersion: Number of countries^	-0.640***	-0.685***	-0.681***	-0.650***	-0.649***	-0.693***	-0.689***	-0.658***
	[0.086]	[0.088]	[0.086]	[0.085]	[0.087]	[0.088]	[0.087]	[0.085]
Host country FDI inflow^	-0.073	0.052	-0.017	0.018	-0.08	0.044	-0.025	0.009
	[0.116]	[0.114]	[0.111]	[0.116]	[0.119]	[0.117]	[0.114]	[0.119]
Host country tax rate	-0.016	0.003	-0.002	-0.003	-0.016	0.003	-0.003	-0.003
	[0.017]	[0.019]	[0.018]	[0.018]	[0.017]	[0.019]	[0.018]	[0.018]
Constant	7.110***	6.861***	9.107***	5.763***	7.286***	7.042***	9.233***	5.973***
	[1.659]	[1.592]	[1.495]	[1.662]	[1.690]	[1.622]	[1.515]	[1.700]
Observations	40118	40118	40118	40118	40118	40118	40118	40118
Log-likelihood	-8003	-7779	-7818	-7877	-7860	-7643	-7686	-7743

DV=Reporting to a foreign supervisor in strong institution country (1,0) in Columns (1) – (4), DV=Reporting to a foreign supervisor (1,0) in Columns (5) – (8). Heteroskedasticity consistent standard errors that correct for clustering at the country/MNC level appear in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. ^ log value.

Table 14. MNC organization structure: Cross-border reporting and the impact of interdependence and institutions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Weak institutions	0.615***	0.398***	0.569***	1.655***	0.596***	0.396***	0.553***	1.655***
	[0.058]	[0.102]	[0.066]	[0.539]	[0.058]	[0.104]	[0.067]	[0.539]
Task interdependence (1,0)	0.547***	0.577***	0.535***	0.743***	0.557***	0.585***	0.543***	0.812***
	[0.123]	[0.124]	[0.123]	[0.140]	[0.125]	[0.126]	[0.125]	[0.141]
Weak institutions_X_Task Interdependence	0.546***	0.562***	0.545***	0.681***	0.576***	0.589***	0.573***	0.752***
	[0.086]	[0.086]	[0.086]	[0.098]	[0.087]	[0.088]	[0.087]	[0.098]
Institutional diversity								
Diversity in MNC regional host institutions		0.282***				0.287***		
		[0.085]				[0.087]		
Diversity in MNC global host institutions weighted by the inverse of the time differences			0.017***	0.024***			0.017***	0.022***
			[0.004]	[0.005]			[0.004]	[0.005]
Weak institutions_X_Institutional diversity		0.121**	0.005*	0.010***		0.105*	0.005*	-0.009***
		[0.056]	[0.003]	[0.003]		[0.056]	[0.003]	[0.003]
Number of base units in the country^	-0.815***	-0.846***	-0.781***	-0.531***	-0.831***	-0.868***	-0.797***	-0.544***
	[0.031]	[0.033]	[0.031]	[0.038]	[0.031]	[0.033]	[0.032]	[0.038]
Unit product diversification: Number of segments	1.153***	1.084***	0.998***	0.782***	1.150***	1.066***	0.991***	0.791***
	[0.040]	[0.045]	[0.046]	[0.050]	[0.040]	[0.045]	[0.046]	[0.050]
MNC size: log (sales)	0.173***	0.177***	0.183***	0.177***	0.155***	0.159***	0.165***	0.160***
	[0.043]	[0.043]	[0.043]	[0.043]	[0.043]	[0.044]	[0.044]	[0.043]
MNC product diversification: Number of segments	0.003**	0.003***	0.004***	0.002	0.005***	0.005***	0.006***	0.004***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
MNC geographic dispersion: Number of countries^	-0.698***	-0.693***	-0.701***	-0.673***	-0.707***	-0.701***	-0.711***	-0.684***
	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]	[0.019]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Host country FDI inflow^	0.049***	0.048***	0.033*	-0.008	0.041**	0.040**	0.024	-0.01
	[0.017]	[0.017]	[0.017]	[0.025]	[0.017]	[0.017]	[0.018]	[0.025]
Host country tax rate	0.003	0.002	0.001	0.013*	0.003	0.001	0.001	0.012*
	[0.005]	[0.005]	[0.005]	[0.007]	[0.005]	[0.005]	[0.005]	[0.007]
Constant	6.702***	6.505***	7.141***	19.157***	6.883***	6.728***	7.350***	20.350***
	[0.284]	[0.302]	[0.304]	[1.092]	[0.288]	[0.307]	[0.309]	[0.807]
Country fixed-effects	No	No	No	Yes	No	No	No	Yes
Observations	40118	40118	40118	34178	40118	40118	40118	34151
Log-likelihood	-7750	-7743	-7727	-7358	-7610	-7601	-7587	-7251

DV=Reporting to a foreign supervisor in strong institution country (1,0) in Columns (1) – (4), DV=Reporting to a foreign supervisor (1,0) in Columns (5) – (8).
* significant at 10%; ** significant at 5%; *** significant at 1%. ^ log value.

Bibliography

Acemoglu D, Aghion P, Lelarge C, Van Reenen J, Zilibotti F. 2007. Technology, Information and the Decentralization of the Firm. *Quarterly Journal of Economics* **122** (4): 1759-1799.

Alcácer J. 2006. Location Choices across the Value Chain: How Activity and Capability Influence Collocation. *Management Science* **52**(10): 1457-1471.

Alchian AA. 1965. Some Economics of Property Rights. *Il Politico* **30**: 816-829.

Alchian AA, Demsetz H. 1972. Production, Information Costs, and Economic Organization. *The American Economic Review* **62**(5): 777-795.

Alfaro L, Charlton A. 2007. Intra-Industry Foreign Direct Investment. NBER Working Paper 13447.

Alonso R, Dessein W, Matouschek N. forthcoming. When Does Coordination Require Centralization? *American Economic Review*.

Anderson RC, Reeb DM. 2003. Founding-Family Ownership and Firm Performance: Evidence from the S&P 500. *The Journal of Finance* **LVIII**(3): 1301-1328.

Andrade G, Mitchell M, Stafford E. 2001. New Evidence and Perspectives on Mergers. *The Journal of Economic Perspectives* **15**(2): 103-120.

Argyres N. 1996. Capabilities, Technological Diversification and Divisionalization. *Strategic Management Journal* **17**(5): 395-410.

Argyres N, Bigelow L. 2007. Competitive Positioning, Dominant Design and Vertical Integration over the Industry Lifecycle. *Working paper*.

Argyres N, Zenger T. 2007. Capabilities, Transaction Costs, and Firm Boundaries: A Dynamic Perspective and Integration. Working paper.

Argyres NS. 1995. Technology Strategy, Governance Structure and Interdivisional Coordination *Journal of Economic Behavior & Organization* **28**(3): 337-358.

Argyres NS, Silverman BS. 2004. R&D, Organization Structure, and the Development of Corporate Technological Knowledge. *Strategic Management Journal* **25**(8-9, Special Issue: The Global Acquisition, Leverage, and Protection of Technological Competencies.): 929 - 958.

Arora A, Fosfuri A, Gambardella A. 2000. Markets for Technology and Their Implications for Corporate Strategy. *Industrial and Corporate Change* **10**(2): 419-451.

Arrow KJ. 1959. Rational Choice Functions and Orderings. *Economica* **26**(102): 121-127.

Arrow KJ. 1974. *The Limits of Organization*. W. W. Norton & Company.

Ayyagari M, Demirguc-Kunt A, Maksimovic V. 2006. How Important Are Financing Constraints? The Role of Finance in the Business Environment *World Bank Policy Research Working Paper No. 3820*.

Bailey EE, Friedlaender AF. 1982. Market Structure and Multiproduct Industries. *Journal of economic literature* **XX**: 1024-1048.

Baker M, Foley CF, Wurgler J. 2005. Multinationals as Arbitrageurs? The Effect of Stock Market Valuations on Foreign Direct Investment. Harvard University.
Balasubramanian N, Sivadasan J. forthcoming. Capital Liquidity, Productivity Dispersion and Market Structure. *Review of Economics and Statistics*.
Baldwin CY. 2008. Modularity, Transactions, and the Boundaries of Firms: A Synthesis. *Industrial and Corporate Change* **17**(1): 155-196.
Baldwin CY, Clark KB. 2000. *Design Rules, Volume 1: The Power of Modularity*. MIT Press: Cambridge, MA.
Baldwin CY, Clark KB. 2005. Designs and Design Architecture: The Missing Link Between "Knowledge" And The "Economy", *Working paper, NBER*. Harvard Business School.
Baldwin CY, Clark TB. 2006. Where Do Transactions Come From? A Network Design Perspective on the Theory of the Firm: 45. HBS.
Barney J. 1991. Firm Resources and Sustained Competitive Advantage. *Journal of Management Studies* **17**: 99-120.
Bartlett CA, Ghoshal S. 1989. *Managing across Borders: The Transnational Solution*. Harvard Business School Press: Boston, MA.
Baumal W, Panzar J, Willig R. 1982. *Contestable Markets and the Theory of Industry Structure*. Harcourt Brace Jovanovich: New York.
Beck T, Demirguc-Kunt A, Maksimovic V. forthcoming. The Influence of Financial and Legal Institutions on Firm Size. *Journal of Banking and Finance*.
Becker GS, Murphy KM. 1992. The Division of Labor, Coordination Costs, and Knowledge. *The Quarterly Journal of Economics* **107**(4): 1137.
Berger PG, Ofek E. 1995. Diversification's Effect on Firm Value. *Journal of Financial Economics* **37**(1): 39-65.
Berle A, Means G. 1932. *The Modern Corporation and Private Property*. Macmillan: New York, NY.
Bernard AB, Jensen JB, Schott PK. 2006. Trade Costs, Firms and Productivity. *Journal of Monetary Economics* **53**(5).
Bernardo AE, Chowdhry B. 2002. Resources, Real Options, and Corporate Strategy. *Journal of Financial Economics* **63**(2): 211-234.
Bertrand M, Mehta P, Mullainathan S. 2002. Ferreting out Tunneling: An Application to Indian Business Groups. *The Quarterly Journal of Economics* **117**(1): 121-148.
Bolton P, Dewatripont M. 1994. The Firm as a Communication Network. *The Quarterly Journal of Economics* **109**(4): 809-839.
Breschi S, Lissoni F, Malerba F. 2003. Knowledge-Relatedness in Firm Technological Diversification. *Research Policy* **32**(1): 69.
Bresnahan TF, Brynjolfsson E, Hitt LM. 2001. Information Technology, Workplace Organization, and the Demand for Skilled Labor: Firm-Level Evidence. *The Quarterly Journal of Economics* **117**(1): 339-376.
Brickley JA, Smith Jr. CW, Zimmerman JL, Willett J. 2003. *Designing Organizations to Create Value: From Structure to Strategy*. McGraw-Hill: New York.
Buckley PJ, Casson M. 1981. The Optimal Timing of a Foreign Direct Investment. *The Economic Journal* **91**(361): 75.
Burns T, Stalker GM. 1961. *The Management of Innovation*. Tavistock Institute: London, U.K.

Burton RM, Obel B. 1980. A Computer Simulation Test of the M-Form Hypothesis. *Administrative Science Quarterly* **25**(3): 457-466.

Calvo GA, Wellisz S. 1978. Supervision, Loss of Control, and the Optimum Size of the Firm. *The Journal of Political Economy* **86**(5): 943-952.

Capron L, Dussauge P, Mitchell W. 1998. Resource Redeployment Following Horizontal Acquisitions in Europe and North America, 1988-1992 *Strategic Management Journal* **19**(7): 631-661.

Caroli E, Van Reenen J. 2001. Skill-Based Organizaitonal Change? Evidence from a Panel of British and French Establishments. *The Quarterly Journal of Economics* **116**(4): 1449-1492.

Caves RE. 1996. *Multinational Enterprise and Economic Analysis (Cambridge Surveys of Economic Literature)* (2nd ed.). Cambridge University Press: Cambridge.

Chandler AD. 1990. *Scale and Scope: The Dynamics of Industrial Capitalism*. Belknap Press.

Chandler ADJ. 1962. *Strategy and Structure: Chapters in the History of the American Industrial Enterprise*. The MIT Press: Cambridge, Massachusetts.

Chandler Jr. AD. 1977. *The Visible Hand : The Managerial Revolution in American Business*. Harvard University Press: Cambrdge, MA.

Chang SJ. 1996. An Evolutionary Perspective on Diversification and Corporate Restructuring: Entry, Exit, and Economic Performance During 1981-89. *Strategic Management Journal* **17**(8): 587-611.

Child J, Mansfield R. 1972. Technology, Size, and Organization Structure *Sociology* **6**(3): 369-393.

Coase RH. 1960. The Problem of Social Cost. *Journal of Law and Economics*.

Coase RH. 1988. *The Firm, the Market and the Law*. University of Chicago Press: Chicago.

Coase RH. 1993. The Nature of the Firm: Influence. In OE Williamson, SG Winter (Eds.), *The Nature of the Firm: Origins, Evolution, and Development*: 244. Oxford University Press: New York.

Conner KR, Prahalad CK. 1996. A Resource-Based Theory of the Firm: Knowledge Versus Opportunism. *Organization Science* **7**(5): 477-501.

Crémer J, Garicano L, Prat A. 2007. Language and the Theory of the Firm. *Quarterly Journal of Economics* **122**(1): 373-407.

Cyert RM, March JG. 1963. *A Behavioral Theory of the Firm*. Prentice-Hall: Englewood Cliffs, NJ.

Danzon PM, Epstein A, Nicholson S. 2004. Mergers and Acquisitions in the Pharmaceutical and Biotech Industries. NBER.

Davis R, Duhaime IM. 1992. Diversification, Vertical Integration, and Industry Analysis: New Perspectives and Measurement. *Strategic Management Journal* **13**(7): 511.

Demirguc-Kunt A, Maksimovic V. 1998. Law, Finance, and Firm Growth. *The Journal of Finance* **LIII**(6).

Demsetz H. 1988. The Theory of the Firm Revisited. *Journal of Law, Economics, & Organization* **4**(1): 141-161.

Denis DJ, Denis DK, Sarin A. 1997. Agency Problems, Equity Ownership, and Corporate Diversification. *Journal of Finance* **52**(1): 135-160.

Desai MA, Foley CF, Forbes KJ. 2005. Financial Constraints and Growth: Multinational and Local Firm Responses to Currency Depreciations. *Review of Financial Studies, Forthcoming*.
Desai MA, Foley CF, Hines JJR. 2004a. Foreign Direct Investment in a World of Multiple Taxes. *Journal of Public Economics* **88**(12): 2727.
Desai MA, Foley CF, Hines JJR. 2006a. The Demand for Tax Haven Operations. *Journal of Public Economics* **90**(3): 513-531.
Desai MA, Foley CF, Hines JR. 2004b. A Multinational Perspective on Capital Structure Choice and Internal Capital Markets. *The Journal of Finance* **59**(6): 2451-2487.
Desai MA, Foley CF, Hines JR. 2006b. Capital Controls, Liberalizations, and Foreign Direct Investment. *Review of Financial Studies*: 1433-1464.
Dessein W, Santos T. 2006. Adaptive Organizations. *Journal of Political Economy* **114**: 956–995.
Donaldson L. 2001. *The Contingency Theory of Organizations (Foundations for Organizational Science)*. Sage Publications, Inc.
Doz Y, Prahalad CK. 1984. Patterns of Strategic Control within Multinational Corporations. *Journal of International Business Studies* **15**: 55-72.
Ethiraj SK, Levinthal D. 2004a. Bounded Rationality and the Search for Organizational Architecture: An Evolutionary Perspective on the Design of Organizations and Their Evolvability. *Administrative Science Quarterly* **49**: 404-437.
Ethiraj SK, Levinthal D. 2004b. Modularity and Innovation in Complex Systems. *Management Science* **50**(2): 159-173.
Ethiraj SK, Levinthal D, Roy RR. 2008. The Dual Role of Modularity: Innovation and Imitation. *Management Science* **54**(5): 939-955.
Everitt BS. 1993. *Cluster Analysis* (3rd ed.). Edward Arnold: London.
Fama EF, Jensen MC. 1983. Separation of Ownership and Control. *Journal of Law and Economics* **26**: 301-325.
Fan JPH, Lang LHP. 2000. The Measurement of Relatedness: An Application to Corporate Diversification. *The Journal of Business* **73**(4): 629-660.
Farjoun M. 1994. Beyond Industry Boundaries: Human Expertise, Diversification and Resource-Related Industry Groups. *Organization Science* **5**(2): 185-199.
Farjoun M. 1998. The Independent and Joint Effects of the Skill and Physical Bases of Relatedness in Diversification. *Strategic Management Journal* **19**(7): 611.
Feenstra RC, Hanson GH. 2005. Ownership and Control in Outsourcing to China: Estimating the Property-Rights Theory of the Firm. *Quarterly Journal of Economics* **120**(2): 729-761.
Financial Accounting Standards Board. 1976. *Statement of Financial Accoutnign Standards No. 14: Financial Reporting for Segments of a Business Enterprise*. FASB: Norwalk, CT.
Fine CH, Whitney DE. 1999. Is the Make-Buy Decision Process a Core Competence? In M Muffatto, K Pawar (Eds.), *Logistics in the Information Age, Servizi Grafici Editoriali, Padova, Italy*: 31-63.
Fisman R, Svensson J. 2007. Are Corruption and Taxation Really Harmful to Growth? Firm Level Evidence. *Journal of Development Economics* **83**(1): 63-75.
Fleming L, Sorenson O. 2001a. The Dangers of Modularity. *Harvard Business Review*.

Fleming L, Sorenson O. 2001b. Technology as a Complex Adaptive System: Evidence from Patent Data. *Research Policy* **30**(7): 1019-1039.

Ford. 1/25/2007. Ford Motor Company Report 2006 Fourth-Quarter and Full-Year Results, *Ford Press Release*.

Foss N. 2003. Selective Intervention and Internal Hybrids: Interpreting and Learning from the Rise and Decline of the Oticon Spaghetti Organization. *Organization Science* **14**: 331-349.

Foss NJ, Laursen K. 2005. Performance Pay, Delegation and Multitasking under Uncertainty and Innovativeness: An Empirical Investigation. *Journal of Economic Behavior & Organization* **58**(2): 246-276.

Friebel G, Raith M. 2006. Resource Allocation and Firm Scope. University of Rochester and University of Southern California.

Froot KA, Stein JC. 1991. Exchange Rates and Foreign Direct Investment: An Imperfect Capital Markets Approach. *The Quarterly Journal of Economics* **106**(4): 1191-1217.

Galbraith JR. 1973. *Designing Complex Organizations*. Addison-Wesley: Reading, MA.

Galbraith JR. 1977. *Organization Design*. Addison-Wesley Publishing Company: Reading, Massachusetts.

Galbraith JR, Lawler EE. 1993. *Organizing for the Future*. Jossey-Bass.

Galunic DC, Eisenhardt KM. 2001. Architectural Innovation and Modular Corporate Forms. *Academy of Management Journal* **44**(6): 1229-1249.

Garey MR, Johnson DS. 1979. *Computers and Intractability: A Guide to the Theory of Np-Completeness*. W. H. Freeman and Company: New York.

Gary MS. 2005. Implementation Strategy and Performance Outcomes in Related Diversification. *Strategic Management Journal* **26**(7): 643-664.

Gatignon H, Anderson E. 1988. The Multinational Corporation's Degree of Control over Foreign Subsidiaries. *Journal of Law, Economics and Organization.* **4**(2): 305-336.

Geanakoplos J, Milgrom P. 1991. A Theory of Hierarchies Based on Limited Managerial Attention. *Journal of the Japanese and International Economies* **5**(3): 205-237.

Gelos RG, Wei S-J. 2005. Transparency and International Portfolio Holdings. *The Journal of Finance* **LX**(6): 2987-3020.

Ghemawat P, Levinthal D. 2000. Choice Structures and Business Strategy. Working paper.

Gomes J, Livdan D. 2004. Optimal Diversification: Reconciling Theory and Evidence. *The Journal of Finance* **59**(2): 507-535.

Gompers PA, Joy IL, Metrick A. 2003. Corporate Governance and Equity Prices. *The Quarterly Journal of Economics* **118**(1): 107-155.

Grant RM, Jammine AP, Thomas H. 1988. Diversity, Diversification, and Profitability among British Manufacturing Companies, 1972-84. *Academy of Management Journal* **31**(4): 771-801.

Guimerà R, Amaral LAN. 2005a. Cartography of Complex Networks: Modules and Universal Roles. *Journal of Statistical Mechanics: Theory and Experiment* **P02001**.

Guimerà R, Amaral LAN. 2005b. Functional Cartography of Complex Metabolic Networks. *Nature* **433**: 895-900.

Guimerà R, Sales-Pardo M, Amaral LAN. 2004. Modularity from Fluctuations in Random Graphs and Complex Networks *Physical Review E* **70**(025101(R)).
Guiso L, Sapienza P, Zingales L. 2004. Does Local Financial Development Matter? *Quarterly Journal of Economics*: 929-969.
Gupta AK, Govindarajan V. 2000. Knowledge Flows within Multinational Corporations. *Strategic Management Journal* **21**: 473-496.
Hanson GH, Mataloni J, Raymond J., Slaughter MJ. 2001. Expansion Strategies of U.S. Multinational Firms. *NBER Working Paper No.8433*.
Harris M, Raviv A. 2002. Organization Design. *Management Science* **48**(7): 852-865.
Hart O, Moore J. 2005. On the Design of Hierarchies: Coordination Versus Specialization. *Journal of Political Economy* **113**: 675-702.
Helfat C, Lieberman M. 2002. The Birth of Capabilities: Market Entry and the Importance of Pre-History. *Industrial and Corporate Change* **11**: 725-760.
Helfat CE, Eisenhardt KM. 2004. Inter-Temporal Economies of Scope, Organizational Modularity, and the Dynamics of Diversification. *Strategic Management Journal* **25**(13): 1217-1232.
Helfat CE, Raubitschek RS. 2000. Product Sequencing: Co-Evolution of Knowledge, Capabilities and Products. *Strategic Management Journal* **21**(10): 961-979.
Helpman E. 1984. A Simple Theory of International Trade with Multinational Corporations. *The Journal of Political Economy* **92**(3): 451-471.
Helpman E, Melitz MJ, Yeaple SR. 2004. Export Versus Fdi with Heterogeneous Firms. *The American Economic Review* **94**(1): 300-316.
Henderson R, Clark K. 1990. Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly* **35**(1): 9-30.
Henderson R, Cockburn I. 1994. Measuring Competence? Exploring Firm Effects in Pharmaceutical Research. *Strategic Management Journal* **15**(8): 63-84.
Henisz W. 2000. The Institutional Environment for Multinational Investment. *Journal of Law, Economics and Organization* **16**(2): 334-364.
Hennart J-F. 1991. The Transaction Costs Theory of Joint Ventures: An Empirical Study of Japanese Subsidiaries in the United States. *Management Science* **37**(4): 483-497.
Hines JR. 1994. No Place Like Home: Tax Incentives and the Location of R&D by American Multinationals. In JM Poterba (Ed.), *Tax Policy and the Economy*: 65-104. MIT Press: Cambridge, MA.
Hitt MA, Hoskisson RE, Kim H. 1997. International Diversification: Effects on Innovation and Firm Performance in Product-Diversified Firms. *The Academy of Management Journal* **40**(4): 767-798.
Hoetker G. 2006. Do Modular Products Lead to Modular Organizations? *Strategic Management Journal* **27**(6): 501-518.
Holmstrom B. 1999. The Firm as a Subeconomy. *The Journal of Law, Economics, and Organization* **15**(1): 74-102.
Holmstrom B, Milgrom P. 1991. Multitask Principal-Agent Analyses: Incentive Contracts, Asset Ownership, and Job Design. *Journal of Law, Economics, & Organization* **7**(Special Issue: [Papers from the Conference on the New Science of Organization, January 1991]): 24-52.

Holmstrom BR, Tirole J. 1989. The Theory of the Firm. In R Schmalensee, R Willig (Eds.), *Handbook of Industrial Organization*, Vol. 1: 947. Elsevier Science Publishers B.V.: Amsterdam, The Netherlands.
Hoshi T, Kashyap A, Scharfstein D. 1991. Corporate Structure, Liquidity, and Investment: Evidence from Japanese Industrial Groups. *The Quarterly Journal of Economics* **106**(1): 33-60.
Hoskisson RE. 1987. Multidivisional Structure and Performance: The Contingency of Diversification Strategy. *Academy of Management Journal* **30**(4): 625-644.
Huckman RS, Strick EP. 2005. Glaxosmithkline: Reorganizing Drug Discovery (a). *Harvard Business School Case 9-605-074*.
Hummels D, Ishii J, Yi K-M. 2001. The Nature and Growth of Vertical Specialization in World Trade. *Journal of International Economics* **54**(1): 75-96.
Hummels DL, Stern RM. 1994. Evolving Patterns of North American Merchandise Trade and Foreign Direct Investment, 1960-1990. *The World Economy* **17**(1): 5-19.
Ichniowski C, Shaw K, Prennushi G. 1997. The Effects of Human Resource Management Practices on Productivity: A Study of Steel Finishing Lines. *American Economic Review* **87**(3): 291-313.
Inderst R, Müller HM, Wärneryd K. 2005. Influence Costs and Hierarchy. *Economics of Governance* **6**(2): 177-197.
Jacobides MG. 2005. Industry Change through Vertical Disintegration: How and Why Markets Emerged in Mortgage Banking. *Academy of Management Journal* **48**(3): 465-498.
Jacobides MG, Hitt LM. 2005. Losing Sight of the Forest for the Trees? Productive Capabilities and Gains from Trade as Drivers of Vertical Scope, Vol. 26: 1209-1227.
Jensen M. 2003. The Role of Network Resources in Market Entry: Commercial Banks' Entry into Investment Banking, 1991-1997. *Administrative Science Quarterly* **48**(3): 466-497.
Jensen MC, Meckling WH. 1976. Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure. *Journal of Financial Economics* **3**(4): 305-360.
John CHS, Harrison JS. 1999. Manufacturing-Based Relatedness, Synergy, and Coordination. *Strategic Management Journal* **20**: 129-145.
Johnson S, McMillan J, Woodruff C. 2002a. Courts and Relational Contracts. *Journal of Law, Economics and Organization* **18**(1): 221-277.
Johnson S, McMillan J, Woodruff C. 2002b. Property Rights and Finance. *The American Economic Review* **92**(5): 1335-1356.
Kaplan SN, Zingales L. 1997. Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints? *The Quarterly Journal of Economics* **112**(1): 169-215.
Kauffman SA. 1993. *The Origins of Order: Self-Organization and Selection in Evolution* Oxford University Press: USA.
Kaufmann D, Kraay A, Mastruzzi M. 2006. Governance Matters V: Governance Indicators for 1996-2005. *World Bank Policy Research Working Paper Series*.
Keren M, Levhari D. 1979. The Optimum Span of Control in a Pure Hierarchy. *Management Science* **25**(11): 1162-1172.

Khanna T, Palepu K. 2000. Is Group Affiliation Profitable in Emerging Markets? An Analysis of Diversified Indian Business Groups. *Journal of Finance* **LV**(2): 867-891.
Kim D-J, Kogut B. 1996. Technological Platforms and Diversification. *Organization Science* **7**(3, Special Issue Part 1 of 2: Hypercompetition): 283-301.
King G, Zeng L. 2001a. Explaining Rare Events in International Relations *International Organization* **55**(3): 693-715.
King G, Zeng L. 2001b. Logistic Regression in Rare Events Data. *Political Analysis* **9**(2): 137-163.
Klepper S, Simons KL. 2000. Dominance by Birthright: Entry of Prior Radio Producers and the Competitive Ramifications in the U.S. Television Receiver Industry. *Strategic Management Journal* **21**: 997-1016.
Kobrin SJ. 2001. Sovereignty @ Bay: Globalization, Multinational Enterprise, and the International Political System. In AM Rugman, TL Brewer (Eds.), *The Oxford Handbook of International Business*. Oxford University Press: Oxford.
Kogut B. 1983. Foreign Direct Investment as a Sequential Process. In CP Kindleberger, D Audretsch (Eds.), *The Multinational Corporation in the 1980s*: 38-56. MIT press: Cambridge, Massachusetts.
Kogut B, Zander U. 1992. Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science* **3**(3, Focused Issue: Management of Technology): 383-397.
Kogut B, Zander U. 1993. Knowledge of the Firm and the Evolutionary Theory of the Multinational Corporation. *Journal of International Business Studies* **24**(4): 625-645.
Kramer A, McDermott W, Heston J. 1993. An Overview of Current Tax Impediments to Risk Management. *Continental Bank Journal of Applied Corporate Finance*.
Krishnan V, Gupta S. 2001. Appropriateness and Impact of Platform-Based Product Development. *Management Science* **47**(1): 52-68.
Krugman P. 1983. The New Theories of International Trade and the Multinational Enterprise. In DB Audretsch, C Kindleberger (Eds.), *The Multinational Corporation in the 1980s*. MIT Press: Cambridge, MA.
Kumar KB, Rajan RG, Zingales L. 2001. What Determines Firm Size? *CEPR Working Paper*.
Langlois R, Robertson P. 1995. *Firms, Markets and Economic Change: A Dynamic Theory of Business Institutions*. Routledge.
Langlois RN. 2002. Modularity in Technology and Organization. *Journal of Economic Behavior & Organization* **49**: 19-37.
Langlois RN, Robertson PL. 1992. Networks and Innovation in a Modular System: Lessons from the Microcomputer and Stereo Component Industries. *Research Policy* **21**(4): 297-313.
Lawrence PR, Lorsch JW. 1967. Differentiation and Integration in Complex Organizations. *Administrative Science Quarterly* **12**: 1-47.
Lazear EP, Rosen S. 1981. Rank-Order Tournaments as Optimum Labor Contracts. *The Journal of Political Economy* **89**(5): 841.

Leiblein MJ, Miller DJ. 2003. An Empirical Examination of Transaction- and Firm-Level Influences on the Vertical Boundaries of the Firm. *Strategic Management Journal* **24**(9): 839 - 859.
Lemelin A. 1982. Relatedness in the Patterns of Interindustry Diversification *The Review of Economics and Statistics* **64**(4): 646-657.
Lenox MJ, Rockart SF, Lewin AY. 2006. Interdependency, Competition, and the Distribution of Firm and Industry Profits. *Management Science* **52**(5): 757-772.
Lenox MJ, Rockart SF, Lewin AY. 2007. Interdependency, Competition, and Industry Dynamics. *Management Science* **53**(4): 599-615.
Lenox MJ, Rockart SF, Lewin AY. 2008. Does Interdependency Affect Industry Profitability? An Empirical Test. *Working paper*.
Levinthal D, Wu B. 2006. The Rational Tradeoff between Corporate Scope and Profit Margins: The Role of Capacity-Constrained Capabilities and Market Maturity. Wharton School, University of Pennsylvania.
Levinthal DA. 1997. Adaptation on Rugged Landscapes. *Management Science* **43**(7): 934-950.
LexisNexis. 2004. Faq's.
Lichtenberg FR. 1991. The Managerial Response to Regulation of Financial Reporting for Segments of a Business Enterprise. *Journal of Regulatory Economics* **3**: 241-249.
Lippman SA, Rumelt RP. 1982. Uncertain Imitability: An Analysis of Interfirm Differences in Efficiency under Competition. *The Bell Journal of Economics* **13**(2): 418-438.
Lucas RE, Jr. 1978. On the Size Distribution of Business Firms. *The Bell Journal of Economics* **9**(2): 508-523.
MacDonald JM. 1985. R&D and the Directions of Diversification. *The Review of Economics and Statistics* **67**(4): 583-590.
MacDuffie JP. 2006. Modularity and the Automobile: What Happened When the Concept Hit the Road. *Working paper*.
Macher JT, Mowery DC, Hodges DA. 1998. Reversal of Fortune? The Recovery of the U.S. Semiconductor Industry. *California Management Review* **41**(1): 107-136.
Maksimovic V, Phillips G. 2002. Do Conglomerate Firms Allocate Resources Inefficiently across Industries? Theory and Evidence. *The Journal of Finance* **57**(2): 721.
Malone TW, Crowston K. 2001. The Interdisciplinary Study of Coordination. In GM Olso, TW Malone, JB Smith (Eds.), *Coordination Theory and Collaboration Technology (Volume in the Computers, Cognition, and Work Series)*: 816. Lawrence Erlbaum.
Mansi SA, Reeb DM. 2002. Corporate Diversification: What Gets Discounted? *Journal of Finance* **57**(5): 2167-2183.
March JG. 1994. *Primer on Decision Making: How Decisions Happen*. Free Press: New York.
March JG, Simon HA. 1958. *Organizations*. Wiley: New York.
Marengo L, Dosi G. 2005. Division of Labor, Organizational Coordination and Market Mechanisms in Collective Problem-Solving. *Journal of economic behavior & organization* **58**: 303-326.

Markides CC. 1995. Diversification, Restructuring and Economic Performance. *Strategic Management Journal* **16**(2): 101-118.
Markusen JR. 1984. Multinationals, Multi-Plant Economies, and the Gains from Trade. *Journal of International Economics* **16**(3-4): 205-226.
Marschak J, Radner R. 1972. *Economic Theory of Teams*. Yale University Press: New Haven and London.
Matsusaka JG. 1993. Takeover Motives During the Conglomerate Merger Wave. *The RAND Journal of Economics* **24**(3): 357-388.
Matsusaka JG. 2001. Corporate Diversification, Value Maximization, and Organizational Capabilities. *The Journal of Business* **74**(3): 409-431.
Milgrom P, Roberts J. 1990. The Economics of Modern Manufacturing: Technology, Strategy, and Organization. *The American Economic Review* **80**(3): 511-528.
Milgrom P, Roberts J. 1995. Complementarities and Fit Strategy, Structure, and Organizational Change in Manufacturing. *Journal of Accounting and Economics* **19**: 179-208.
Monteverde K, Teece DJ. 1982. Supplier Switching Costs and Vertical Integration in the Automobile Industry. *The Bell Journal of Economics* **13**(1): 206-213.
Montgomery CA. 1994. Corporate Diversification *The Journal of Economic Perspectives* **8**(3): 163-178.
Montgomery CA, Hariharan S. 1991. Diversified Expansion by Large Established Firms. *Journal of economic behavior & organization* **15**: 71-89.
Murphy KM, Shleifer A, Vishny RW. 1991. The Allocation of Talent: Implications for Growth. *The Quarterly Journal of Economics* **106**(2): 503-530.
Nelson RR, Winter SG. 1982. *An Evolutionary Theory of Economic Change*. Harvard University Press: Cambridge, MA.
Newman MEJ, Girvan M. 2004. Finding and Evaluating Community Structure in Networks. *Physical Review E* **69**(2): 026113.
Nickerson JA, Zenger TR. 2002. Being Efficiently Fickle: A Dynamic Theory of Organizational Choice. *Organization Science* **13**(5): 547-566.
Nocke V, Yeaple S. 2006. Globalization and Endogenous Firm Scope. NBER.
North DC. 1990. *Institutions, Institutional Change, and Economic Performance*. Cambridge University Press: New York.
Novak S, Eppinger SD. 2001. Sourcing by Design: Product Complexity and the Supply Chain. *Management Science* **47**(1, Design and Development): 189-204.
Novak S, Stern S. 2007. Complementarity among Vertical Integration Decisions: Evidence from Automobile Product Development. *NBER Working Paper No. W13232*
OECD. 2002. Towards Global Tax Co-Operation.
Oxley JE. 1999. Institutional Environment and the Mechanisms of Governance: The Impact of Intellectual Property Protection on the Structure of Inter-Firm Alliances. *Journal of Economic Behavior & Organization* **38**(3): 283-309.
Panzar JC, Willig RD. 1981. Economies of Scope. *American Economic Review* **71**(2): 268-272.
Parnas DL. 1972. On the Criteria to Be Used in Decomposing Systems into Modules. *Communications of the ACM* **15**(12): 1053 - 1058.
Patacconi A. 2005. Optimal Coordination in Hierarchies. University of Oxford.

Penrose E. 1959. *The Theory of the Growth of the Firm*. Oxford University Press: Oxford.
Pissaridesa F, Singer M, Svejnar J. 2003. Objectives and Constraints of Entrepreneurs: Evidence from Small and Medium Size Enterprises in Russia and Bulgaria. *Journal of Comparative Economics* **31**(3): 503-531.
Pitelis C (Ed.). 2002. *The Growth of the Firm: The Legacy of Edith Penrose*. Oxford University Press: Oxford.
Porter M. 1986. *Competition in Global Industries*. Harvard Business School press: Boston.
Prahalad CK, Bettis RA. 1986. The Dominant Logic: A New Linkage between Diversity and Performance. *Strategic Management Journal* **7**(6): 485-501.
Puranam P. 2001. A Knowledge Based Perspective on the Internal Boundaries of the Firm. The Case of Technology Grafting Acquisitions. *Strategic and International Management Working Paper*.
Puranam P, Singh H, Zollo M. 2006. Organizing for Innovation: Managing the Coordination-Autonomy Dilemma in Technology Acquisitions. *Academy of Management Journal* **49**(2): 263-280.
Qian Y. 1994. Incentives and Loss of Control in an Optimal Hierarchy. *The Review of Economic Studies* **61**(3): 527.
Radner R. 1992. Hierarchy: The Economics of Managing. *Journal of economic literature* **30**(3): 1382-1415.
Radner R. 1993. The Organization of Decentralized Information Processing. *Econometrica* **61**(5): 1109-1146.
Radner R. 1996. Bounded Rationality, Indeterminacy, and the Theory of the Firm. *The Economic Journal* **106**(438): 1360-1373.
Rajan RG, Wulf J. 2006. The Flattening Firm: Evidence from Panel Data on the Changing Nature of Corporate Hierarchies. *Review of Economics and Statistics, forthcoming.* **88**(4): 759-773.
Rajan RG, Zingales L. 1998. Financial Dependence and Growth. *American Economic Review* **88**(3): 559-586.
Rajan RG, Zingales L. 2001. The Firm as a Dedicated Hierarchy: A Theory of the Origins and Growth of Firms. *The Quarterly Journal of Economics* **116**(3): 805-851.
Rau PR, Vermaelen T. 1998. Glamour, Value and the Post-Acquisition Performance of Acquiring Firms. *Journal of Financial Economics* **49**(2): 223-253.
Rivkin JW. 2000. Imitation of Complex Strategies. *Management Science* **46**(6): 824-844.
Rivkin JW, Siggelkow N. 2003. Balancing Search and Stability: Interdependencies among Elements of Organizational Design. *Management Science* **49**(3): 290-311.
Rivkin JW, Siggelkow N. 2007. Patterned Interactions in Complex Systems: Implications for Exploration. *Management Science* **53**(7): 1068-1085.
Robertson D, Ulrich K. 1998. Planning for Product Platforms *Sloan management review* **39**(4): 19.
Robins J, Wiersema MF. 1995. A Resource-Based Approach to the Multibusiness Firm: Empirical Analysis of Portfolio Interrelationships and Corporate Financial Performance. *Strategic Management Journal* **16**(4): 277.
Robinson A. 1934. The Problem of Management and the Size of Firms. *The Economic Journal* **44**(174): 242-257.

Rosenkopf L, Nerkar A. 2001. Beyond Local Search: Boundary-Spanning, Exploration, and Impact in the Optical Disc Industry. *Strategic Management Journal* **22**(4): 287.

Rothwell G. 1996. Organizational Structure and Expected Output at Nuclear Power Plants. *The Review of Economics and Statistics* **78**(3): 482-488.

Rugman AM, Verbeke A. 2004. A Perspective on Regional and Global Strategies of Multinational Enterprises. *Journal of International Business Studies* **35**: 3-18.

Rumelt RP. 1974. *Strategy, Structure and Economic Performance*. Harvard University Press: Cambridge, MA.

Rumelt RP. 1982. Diversification Strategy and Profitability. *Strategic Management Journal* **3**(4): 359-369.

Sanchez R, Mahoney JT. 1996. Modularity, Flexibility, and Knowledge Management in Product and Organization Design. *Strategic Management Journal* **17**(Special Issue: Knowledge and the Firm): 63-76.

Saudagaran SM, Biddle GC. 1995. Foreign Listing Location: A Study of Mncs and Stock Exchanges in Eight Countries. *Journal of International Business Studies* **26**(2): 319-341.

Scherer F. 1980. *Industrial Market Structure and Economic Performance* (2nd ed.). Rand McNally: Chicago.

Schilling MA, Steensma HK. 2001. The Use of Modular Organizational Forms: An Industry-Level Analysis. *Academy of Management Journal* **44**(6): 1149-1168.

Schlingemanna FP, Stulz RM, Walkling RA. 2002. Divestitures and the Liquidity of the Market for Corporate Assets. *Journal of Financial Economics* **64**(1): 117-144.

Schoar A. 2002. Effects of Corporate Diversification on Productivity. *The Journal of Finance* **57**(6): 2379-2403.

Seth A. 1990. Sources of Value Creation in Acquisitions: An Empirical Investigation. *Strategic Management Journal* **11**(6): 431-446.

Siggelkow N. 2001. Change in the Presence of Fit: The Rise, the Fall, and the Renaissance of Liz Claiborne. *The Academy of Management Journal* **44**(4): 838.

Siggelkow N. 2002a. Evolution toward Fit. *Administrative Science Quarterly* **47**(1): 125-159.

Siggelkow N. 2002b. Misperceiving Interactions among Complements and Substitutes: Organizational Consequences. *Management Science* **48**(7): 900-916.

Siggelkow N, Levinthal DA. 2003. Temporarily Divide to Conquer: Centralized, Decentralized, and Reintegrated Organizational Approaches to Exploration and Adaptation. *Organization Science* **14**: 650-669. .

Siggelkow N, Rivkin JW. 2006. When Exploration Backfiles: Unintended Consequences of Multilevel Organizational Search. *Academy of Management Journal* **49**(4): 779-795.

Silverman BS. 1999. Technological Resources and the Direction of Corporate Diversification: Toward an Integration of the Resource-Based View and Transaction Cost Economics *Management Science* **45**(8): 1109-1124.

Simon H. 1957. A Behavioral Model of Rational Choice, *Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting*. Wiley: New York.

Simon H. 1962. The Architecture of Complexity. *Proceedings of the American Philosophical Society* **106**: 467-482.
Simon HA. 1947. *Administrative Behavior: A Study of Decision-Making Processes in Administrative Organizations*. The Free Press: New York.
Simon HA. 1971. *Computers, Communications and the Public Interest*. The Johns Hopkins Press.
Simon HA. 1973. Applying Information Technology to Organization Design. *Public Administration Review* **33**(3): 268.
Simon HA. 1991. Organizations and Markets. *Journal of Economic Perspectives* **5**(2): 25-44.
Simon HA. 2002. Near Decomposability and the Speed of Evolution. *Industrial and Corporate Change* **11**(3): 587-599.
Singh H, Montgomery CA. 1987. Corporate Acquisition Strategies and Economic Performance. *Strategic Management Journal* **8**(4).
Smith KG, Grimm CM, Gannon MJ, Chen M-J. 1991. Organizational Information Processing, Competitive Responses, and Performance in the U.S. Domestic Airline Industry. *The Academy of Management Journal* **34**(1): 60-85.
Stigler GJ. 1951. The Division of Labour Is Limited by the Extent of the Market. *Journal of Political Economy* **59**(3): 185-193.
Stimpert JL, Duhaime IM. 1997. Seeing the Big Picture: The Influence of Industry, Diversification, and Business Strategy on Performance. *The Academy of Management Journal* **40**(3): 560-583.
Sundaram AK, Black JS. 1992. The Environment and Internal Organization of Multinational Enterprises. *The Academy of Management Review* **17**(4): 729-757.
Sutherland JW. 1980. A Quasi-Empirical Mapping of Optimal Scale of Enterprise. *Management Science* **26**(10): 963-981.
Sutton J. 1991. *Sunk Costs and Market Structure*. The MIT Press: Cambridge, MA.
Svejnar J, Smith SC. 1984. The Economics of Joint Ventures in Less Developed Countries. *The Quarterly Journal of Economics* **99**(1): 149-167.
Teece D. 1980. Economies of Scope and the Scope of the Enterprise. *Journal of Economic Behavior & Organization.* **1**(3): 223-247.
Teece DJ. 1982. Towards an Economic Theory of the Multiproduct Firm. *Journal of Economic Behavior & Organization* **3**(1): 39-63.
Teece DJ. 1993. Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy. *Research Policy* **22**(2): 112.
Teece DJ, Rumelt R, Dosi G, Winter S. 1994. Understanding Corporate Coherence: Theory and Evidence. *Journal of economic behavior & organization* **23**: 1-30.
Thompson JD. 1967. *Organizations in Action*. McGraw Hill: New York.
Tomz M, King G, Zeng L. 1999. *Relogit: Rare Events Logistic Regression, Version 1.1*. Harvard University: Cambridge, MA, http://gking.harvard.edu/.
Tushman ML, Nadler DA. 1978. Information Processing as an Integrating Concept in Organizational Design. *The Academy of Management Review* **3**(3): 613.
Ulrich KT, Eppinger SD. 2000. *Product Design and Development* (2nd ed.). Irwin McGraw-Hill: New York.
Van Zandt T. 1999a. Decentralized Information Processing in the Theory of Organizations. In M Sertel (Ed.), *Contemporary Economic Issues*, Vol. 4:

Economic Design and Behavior, Chapter 7: 125-160. MacMillan Press Ltd: London.
Van Zandt T. 1999b. Real-Time Decentralized Inforamtion Processing as a Model of Organizations with Boundedly Rational Agents. *Review of Economic Studies* **66**: 633-658.
Van Zandt T. 2003. Real-Time Hierarchical Resource Allocation. INSEAD.
Vernon R. 1971. *Sovereignty at Bay*. Basic Books: New York.
Villalonga B. 2004. Diversification Discount or Premium? New Evidence from the Business Information Tracking Series. *Journal of Finance* **59**(2): 475-502.
Viner J. 1932. Cost Curves and Supply Curves. *Zeitschrift fur national-okonomie* **3**: 23-46.
Wageman R, Baker G. 1997. Incentives and Cooperation: The Joint Effects of Task and Reward Interdependence on Group Performance. *Journal of Organizational Behavior* **18**(2): 139-158.
Waldman M. 1984. Job Assignments, Signalling, and Efficiency. *The RAND Journal of Economics* **15**(2): 255.
Wall Street Journal, 3/17/2007. Nissan's Ghosn Gives up U.S. Duties in Reshuffle.
Wall Street Journal, 4/25/2007. GM Slips into Toyota's Rearview Mirror.
Wang Z, Zhang J. 2007. In Search of the Biological Significance of Modular Structures in Protein Networks. *PLoS Compututational Biology* **3**(6): 1011-1021.
Wei S-J. 2000. How Taxing Is Corruption on International Investors? *The Review of Economics and Statistics* **82**(1): 1.
Wei S-J, Javorcik BS. 2002. Corruption and Cross-Border Investment: Firm-Level Evidence. *WDI Working Paper*.
Wernerfelt B. 1984. A Resource-Based View of the Firm. *Strategic Management Journal* **5**(2): 171-180.
Wernerfelt B, Montgomery CA. 1988. Tobin's Q and the Importance of Focus in Firm Performance. *The American Economic Review* **78**(1): 246-250.
Wheelwright SC, Clark KB. 1992. *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency and Quality*. Free Press: New York.
Williams K, Haslam C, Williams J, Adcroft A, Johal S. 1993. The Myth of the Line: Ford's Production of the Model T at Highland Park, 1909-16. *Business History* **35**(3): 66 - 87.
Williamson OE. 1967. Hierarchical Control and Optimum Firm Size. *The Journal of Political Economy* **75**(2): 123-138.
Williamson OE. 1975. *Markets and Hierarchies: Analysis and Antitrust Implications*. The Free Press: New York.
Williamson OE. 1979. Transaction Cost Economics: The Governance of Contractual Relations. *Journal of Law & Economics*: 3-61.
Williamson OE. 1985. *The Economic Institutions of Capitalism*. The Free Press.
Winter SG, Szulanski G. 2001. Replication as Strategy. *Organization Science* **12**(6): 730-743.
Wu B. 2007. Capacity-Constrained Capabilities, Market Maturity, and Corporate Diversification: Evidence from the Cardiovascular Medical Device Industry, 1976-2004. Wharton School, University of Pennsylvania.

Yayavaram S, Ahuja G. forthcoming. Technological Search and Decomposability in Knowledge Structures: Impact on Invention Utility and Knowledge-Base Malleability. *Administrative Science Quarterly*.
Yoffie DB. 1993. Foreign Direct Investment in Semiconductors. In KA Froot (Ed.), *Foreign Direct Investment*. University of Chicago Press: Chicago.
Zannetos ZS. 1965. On the Theory of Divisional Structures: Some Aspects of Centralization and Decentralization of Control and Decision Making. *Management Science* **12**(4, Series B, Managerial): B49-B68.
Zenger TR, Hesterly WS. 1997. The Disaggregation of Corporations: Selective Intervention, High-Powered Incentives, and Molecular Units. *Organization Science* **8**(3): 209-222.
Zhao M. 2006. Conducting R&D in Countries with Weak Intellectual Property Rights Protection. *Management Science* **52**: 1185-1199.