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The Effects of History on Organization Design

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By
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I certify that the dissertation I have presented for examination for the Ph.D. degree of the University of London is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).[1]

Marlo M. M. Raveendran

[1] Specifically in chapters 2 and 3.

ABSTRACT

The Effects of History on Organization Design

Marlo M. M. Raveendran

In this dissertation, I address the central question: how does the established structure of an organization affect both the process of choosing a new design, as well as the content of that new design? I shift the focus away from the traditional view on organization design decisions as working off a blank canvas, and consider how established social relationships and established structures affect the choices regarding the new designs.

In chapter 2, I explore the organizational re-design decision theoretically. Building on the epistemic interdependence perspective, which I developed jointly with Thorbjørn Knudsen and Phanish Puranam, I propose that history affects the designer's process of task allocation, as well as his choice of new designs, and the implementation speed of new structures. In chapter 3, I examine the extent to which the process of division of labor is affected by the technological properties of the task in conjunction with individuals' perception of the task decomposability and history in the behavioral laboratory. I find that task division is significantly affected by the individuals' perception of the task, and task allocation is altered in the presence of history. The technological property of the task has an important impact on both, the task division as well as the task allocation. In chapter 4, I examine the impact of prior structures on reorganization decisions at the macro-level, with data on the global cell phone manufacturing industry. I use the corporate-level reorganizations across the entire industry over 25 years to examine the impact of the established structural emphasis on subsequent re-design choices. I find that firms show a systematic tendency of reversal between different structural foci. In addition, the rate of reversals is significantly and asymmetrically affected by the organization's current structural emphasis, which speaks to the question of the effect of history on the implementation speed of new structures.

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CHAPTER 1

Introduction

1.1 Background

Organization design refers to the choices about how the division of labor and the integration of effort are solved within the organization (Puranam, Raveendran, & Knudsen, 2012). These are choices regarding the task division and allocation, collocation, reporting and lateral relationships, standards, procedures, incentives, and information channels (March & Simon, 1958; Galbraith, 1973; Nalder & Tushman, 1997), and can be mandated by those with authority or have emerged through selection. Organization design lies at the core of corporate strategy - the CEO of a multi-business corporation effectively competes with the fund manager holding stakes in a portfolio of companies. While the fund manager can only decide which business to hold equity in, the CEO can reap synergies and gain real advantages by manipulating the way the corporation is structured.

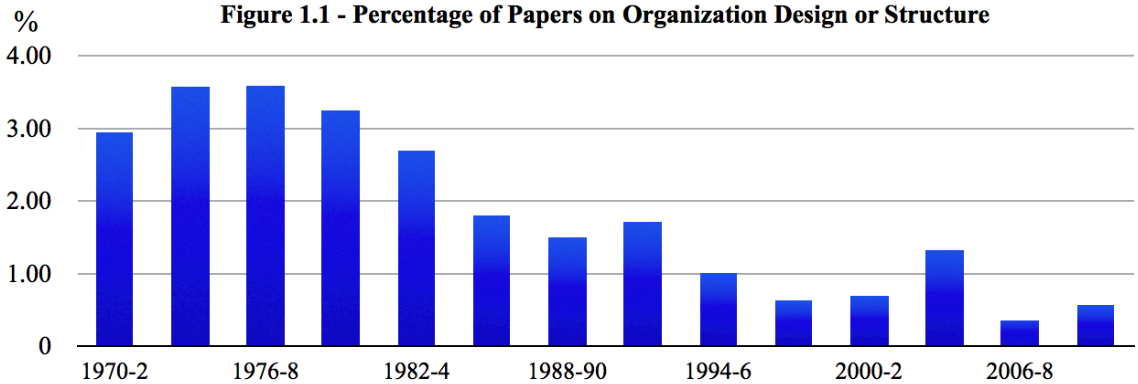
While we have strong foundations for the study of organization design (e.g. Barnard, 1938; March & Simon, 1958; Lawrence & Lorsch, 1967; Thompson, 1967; Galbraith 1973; Van de Ven, Delbeq, & Koenig, 1976; Mintzberg, 1979; Fligstein, 1985), recent research on this topic in its own right has been rather sparse (as noted by several scholars, e.g. Dunbar & Starbuck, 2006; Miller, Greenwood, Prakash, 2009). Figure 1.1 reflects this observation, showing the percentage of articles that mentioned "organization* (design OR structure)" in the abstract or title (or both) in four of the top journals in the field of strategy [1] from 1970 to 2011 (summarized into 3-year windows).

This relative lack of interest in the topic of organization design seems unwarranted. In a time where competitiveness and adaptability of corporations is a common expectation, the study of how organizations could be structured to address

[1] Academy of Management Journal, Academy of Management Review, Strategic Management Journal, Administrative Science Quarterly.

those demands seems pivotal to achieving long-term sustainable growth and performance. We can build on strong foundations in this field to address questions of appropriate structural forms (Chandler, 1962; Fligstein, 1985; Williamson, 1975; David & Lawrence, 1977), triggers of structural change (Kimberly & Miles, 1980; Egelhoff, 1982; Fligstein, 1985; Karim & Mitchell, 2000; Agarwal & Helfat, 2009) and obstacles to organizational renewal (Hannan & Freeman, 1984; Hannan, Polos, & Carroll, 2003). However, the fundamental impact that the established organizational structure has on the effectiveness of its current design and on the content and process of structural change going forward has received relatively little attention. Instead, the questions of organization design have traditionally been approached from a blank canvas condition, assuming an unconstrained set of structural choices.

Figure 1.1 - Percentage of Papers on Organization Design or Structure



Specifically, the question of appropriate organization design has been addressed in depth by the contingency theory (Burns & Stalker, 1961; Lawrence & Lorsch, 1967; Thompson, 1967; Donaldson, 2001). At its core this theory proposes that “there is no one best way to organize; however, any way of organizing is not equally effective.” (Galbraith, 1973: 2); in other words, there may be an efficiency frontier of organizational forms. The fundamental focus in this stream of literature is on finding structural configurations that allow the organization to maximize performance. This is achieved when the organization’s structure fits with its contingency factors, such as its strategy, the type of environment it faces, and its size (Burns & Stalker, 1961; Chandler, 1961; Lawrence & Lorsch, 1967; Kimberly & Miles, 1980). A set of structural variables is considered (e.g. the degree of centralization, span of control, and formalization) to determine which configuration of choices best suits a given set of contingencies. A new organization design is required if the contingency factors change, which results in a misfit between the organization's structure and those contingencies. However, the focus here is on aligning the internal structure with the external factors, disregarding the possible effects the established structure may have on the redesign decisions. Hence, a blank canvas is assumed for each reorganization.[2]

This traditional approach stands in stark contrast with reality. A CEO who decides to change the organizational structure faces a problem of re-design, where he or she has to work with (and can take advantage of) the organization's current design with all the constraints and opportunities it offers. The established grouping structures, reporting and lateral relationships, standards, procedures, incentives, and information channels will have a strong impact on the feasible set of choices regarding the new structure. It is this influence of 'history' of the current organization structure on the effectiveness of new design choices that I focus on.

1.2 Research Question

In this dissertation I examine the effects of history on organization design, specifically I address the central question: ***how does the established structure of an organization affect both the process of choosing a new design, as well as the content of that new design?*** I shift the focus away from the traditional view on organization design decisions as working off a blank canvas, and consider how established social relationships and established structures affect the choices regarding the new designs. In order to shed light on the micro-level processes that impact the individual decision-maker as well as the macro-level effects at the organization-level, I use a multi-method approach, generating insights from the behavioral laboratory as well as large-sample data analyses.

Studying the impact of history on organization design is important for the following reasons. First, it enhances our understanding of organization design choices and their determinants. I focus on the structure itself as an important factor that impacts design and re-design decisions and examine the way in which the established structure influences those re-design decisions. Second, a deeper understanding of the mechanisms

2 While congruence theory appears to fill that gap of the role of internal fit across structural options, the focus of that stream of literature merely extends the contingency principles and focuses on what configurational choices of the contingencies improve or hinder performance (Nadler & Tushman, 1997).

should help us build better prescriptive theory regarding the organization re-design choices. Third, by revisiting the micro-foundations of organization design, I contribute to updating our knowledge of the topic which is essential to progressing this central topic of corporate strategy to today's business world.

1.3 Literature Review

Organization design is the attempt to solve the problems that result from the division of labor inside an organization. March and Simon (1958) describe the division of work as "a problem of efficient allocation of activities among individuals and among organizational units" (1958: 179). By dividing an overall task into a number of sub-tasks and allocating those across various actors, two fundamental problems are created: interdependence between the divided tasks (and the actors those tasks are allocated to); and the need for integration of efforts in order to achieve the desired outcome (Smith, 1776; Lawrence & Lorsch, 1967; Thompson, 1967). Lawrence and Lorsch define integration as "the quality of the state of collaboration that exists among departments that are required to achieve unity of effort by the demands of the environment" (1967: pg.11). The purpose of organization design is to find effective solutions to these problems, by implementing organizational units, reporting and lateral relationships, standards, procedures, incentives, and information channels (March & Simon, 1958; Galbraith, 1973; Nalder & Tushman, 1997).

There are several factors at play that make this a non-trivial task:

- Actors are boundedly rational (Simon, 1945) and self-interested (Williamson, 1975), which imposes a natural limit on the number of actors that can be effectively grouped into one unit to achieve collaboration.
- Different divisions of labor generate different degrees of interdependence which will be more or less challenging to manage and integrate.
- By grouping actors into a number of different units that focus on different aspects of the overall task, their task environments develop in distinct ways (differentiate) which makes integration of efforts across those units more challenging.

1.3.1 Micro-Foundations of Organization Design

Interdependence, Information Processing and Coordination Mechanisms

Taking the division of labor as given, the analysis of organization designs must build on a clear understanding of why certain patterns of interdependence are harder to organize around than others. The most influential answer to this question comes from Thompson's work (1967) on interdependence in organizations.

Thompson (1967) identified three kinds of task interdependence: pooled, sequential, and reciprocal. In pooled interdependence, each actor renders a discrete contribution to the organization and is, in turn, supported by the organization. However, individuals do not necessarily depend upon or support each other in the process. The whole is a simple aggregation of autonomously submitted parts. In sequential interdependence, the output of one actor represents the input of another in a serial fashion. Each actor must interact closely with the ones that immediately precede and follow them in the orderly sequence of the work process. Finally, in reciprocal interdependence the output of one actor represents the input for another, and vice versa. Each actor must work with all the others to create a common product or service. According to Thomson (1967), pooled, sequential, and reciprocal interdependence constitute progressively higher degrees of task interdependence, and require increasingly more sophisticated coordination mechanisms (see also Van de Ven, Delbecq, & Koenig, 1976; Nadler & Tushman, 1997).

Given these different degrees of interdependence, the coordination mechanisms put in place to achieve the necessary integration of efforts vary (Galbraith, 1973). Pooled interdependence relies on work standardization, which involves establishing rules and routines in order to guide behavior towards outcomes that ensure consistency among those participating in the interdependent relationship. Sequential interdependence relies on planning, which involves establishing schedules to govern the relationship between interdependent units. March and Simon (1958) describe scheduling as the most common device for securing coordination among subprograms under the presence of a high degree of process specialization. "A schedule is simply a plan, established in advance, that determines what tasks will be handled and when." (pg. 182) According to the authors, "[t]he type of coordination (...) used in the organization stable and predictable the situation, the greater the reliance on coordination by plan." (pg. 182). Finally, reciprocal interdependence relies on mutual adjustment, which involves the exchange of information among interdependent actors, both vertically and horizontally across the hierarchy.

Just as pooled, sequential, and reciprocal denote increasingly complex forms of task interdependence, standardization, planning, and mutual adjustment evidence increasingly complex forms of coordination. As the direction and number of interdependent relationships increases, so does their complexity, and so does the need to deploy coordination mechanisms that provide the appropriate levels of information-processing, communication, and decision making.

Building on Thompson's (1967) seminal work, Galbraith (1973) elaborated on the link between information processing needs and coordination mechanisms by introducing the concept of task uncertainty as the "difference between the information required to perform a task and the information already possessed." (1973: 5). He outlined that increasingly sophisticated coordination mechanisms are invoked by organizations that face increasing environmental uncertainty, and hence, increasing information processing requirements (Tushman & Nadler, 1978). If the environment is relatively certain, and thus agents encounter relatively routine situations, the organization can function quite effectively with established rules and programs. This coordination mechanism is equivalent to the one Thompson described in addressing sequential interdependence.

However, the more task uncertainty the organization faces, the more exceptions need to be handled, which can only be resolved by implementing hierarchical referral in addition to the rules and programs in place. According to Galbraith (1973), layers of hierarchy and the role of the manager are created to deal with exceptions that are not covered by the rules and programs set in place. When task uncertainty is too high to be dealt with by the rules and plans in place, employees can escalate their issues upwards where a higher level of overview and authority is available to solve the problem and pass on the decisions back to the employees. Note that this mechanism is distinct from established plans and rules to the extent that the managers do not follow such rules in solving the exceptions brought to their attention. March and Simon are careful in pointing out that programs are distinct from hierarchy: "Hierarchy may be important in establishing and legitimizing programs, but the communication involved in the execution of highly programmed activities does not generally follow the "line of command"" (1958: 182). Nevertheless, the underlying solution maintains that someone in the hierarchy understands the problem sufficiently to impose a clear solution to the problem.

If the organization faces a situation where more and more of those referrals are being escalated upwards through the hierarchy, Galbraith argues that a further mechanism is needed to prevent overload (1973). Goal setting, where the outputs but not the actions for each of the subdivisions is specified is a viable solution to reduce the number of upward referrals, while coping with increased task uncertainty. Galbraith describes goal setting as the organization effectively bringing "the points of decision down to the points of action where the information originates. This can be accomplished by increasing the amount of discretion exercised by employees at lower levels of the organization." (pg.12) One solution is to increase the degree of professionalization of the organization. This implies the substitution of unskilled workers in places where the need for surveillance and supervision is great, with workers who work based on professional and craft standards, the assumption being that the latter workers will have "the appropriate skills and attitudes" (1973: 13) to make appropriate decisions. Professionalization is merely the necessary condition; Galbraith points out that interdependence between sub-tasks might make local preferences inefficient for the organization as a whole. "In order to deal with the problem, organizations undertake processes to set goals or targets to cover the primary interdependencies." (pg.13) More broadly defined, March and Simon (1958) referred to the latter mechanism as coordination by feedback, "To the extent that contingencies arise, not anticipated in the schedule, coordination requires communication to give notice of deviations from planned or predicted conditions, or to give instructions for changes in activity to adjust to these deviations." (pg. 182) The marked distinction between coordination by plans and coordination by feedback is that the former is based on pre-established schedules, whereas the latter "involves transmission of new information" (pg. 182).

Overall, the seminal works in the organization design literature propose that the interdependence generated by the division of labor and task uncertainty can take on increasing degrees of complexity, which lead to increasing levels of information processing needs, and therefore require increasingly complex coordination mechanisms. These coordination mechanisms of programming, hierarchy, and feedback can be interpreted as integration mechanisms that achieve linking between different organizational sub-units. As such, they complement the organizational structure put in place to facilitate coordination.

The Effects of Organizational Structure

The most powerful integration mechanism at the designer's disposal is the grouping of interdependent activities within the boundaries of the same organizational unit (Nadler & Tushman, 1997). Internal organizational boundaries create clear objectives (Simon, 1945; March & Simon, 1958), and as such facilitate collaboration between boundedly rational actors by reducing system-level objectives to simpler sub-system level objectives. By grouping highly interdependent actors into the same sub-unit, internal organizational boundaries facilitate the creation of both coordination and cooperation. Collocation translates into more effective and efficient communication processes (Arrow, 1974; Allen, 1977; Camerer & Knez, 1996) which enhances knowledge exchange and the alignment of actions (coordination); while authority is usually centralized at the sub-unit level, facilitating the alignment of interest (cooperation) by imposing tighter controls, schedules, and incentive systems (Nadler & Tushman, 1997).

While the grouping of employees into units facilitates within-unit collaboration, the integration of activities across those units is weaker by definition - in other words, "grouping decisions determine what the organization will be able to do well and deemphasize other work." (Nadler & Tushman, 1997: 73). In addition, the different task environments that each of the units is likely to face lead to their differentiation, which implies that the "members of each unit would become specialists in dealing with their particular tasks. Both because of their prior education and experience and because of the nature of their task, they would develop specialized working styles and mental processes." (Lawrence & Lorsch, 1967: 9). A high degree of differentiation in the organization - while beneficial for the activities within sub-units - makes the integration of actions and thus collaboration across units even more difficult.

1.3.2 Organization Design and History

Much of the literature on organization design rests on the premise that specific patterns of the division of labor give rise to specific patterns of interdependence, and that efficient organizational forms "solve" the problems of motivation and coordination that arise when integrating the efforts of interdependent actors (March and Simon, 1958; Thompson, 1967; Lawrence and Lorsch, 1967). These questions are generally addressed in a context that disregards the possible effects the established structure may have on the redesign decisions.

In contrast, other streams of literature examine the factors that facilitate or hinder effective organizational change at a macro-level, and highlight why organizations show strong inertial tendencies (while leaving the micro-foundational issues of the division of labor and integration aside). For instance, Miner, Amburgey and Stearns (1990) study the institutional drivers of organizational change among Finnish newspapers, while Delacroix and Swaminathan (1991) focus on the effect of market volatility on the rate of change. In these and other studies in this research stream, organizational change is conceptualized as necessary and value enhancing, and organizations are assumed to be action-oriented (e.g. Haveman, 1993) - i.e. to monitor the environment in order to react to market opportunities.

In contrast, population ecologists suggest that a firm's inertial tendencies are beneficial rather than detrimental to its survival (Hannan & Freeman, 1977; 1984). By maintaining the organizational core intact, the firm is able to build and maintain high levels of accountability and reliability, which improves its survival chances. In this stream of literature, changes in organizational form are achieved through a selection mechanism rather than adaptation. However, both these streams of literature are predominantly concerned with understanding the factors and (survival) consequences of organizational change, and leave the choice of the type of new structure largely unexplored.

Another macro-level theory of organizational change places more emphasis on the types of organization design adopted. In particular, life-cycle theory proposes that every organization will adopt certain structural types as it grows in size and age. While a small firm does not require much formal structure, as it grows the control systems in this literature has linked the adoption of the M-form to the natural development of organizational change as the firm grows and expands (Kimberly & Miles, 1980; Child & Kieser, 1981; Cafferata, 1982; Fligstein, 1985). The necessary increase in formalization of structure as a firm grows and expands is certainly accurate; however, the closer mapping of organizational types to life-cycle stages as firms adopt more complex structure has found little empirical support (Barnett & Carroll, 1995).

While academic research on organizational change exhibits a strong focus on the macro-level, research on the informal organization complements the organization design literature by focusing on the impact of individual relationships and networks on organizational performance and collaboration. The informal organization can be defined as the emergent patterns of interactions (Barnard, 1938; Roethlisberger & Dickson, 1939). This literature highlights the role that social networks and norms have on firm performance and collaboration effectiveness, over and above the structure that is imposed on the organization from the top (for a review, see Smith-Doerr & Powell, 2005). For example, Ibarra (1993) studied the link between innovation, power and networks. She found that under certain circumstances, the informal structure becomes more important than the formal structure, based on power-attributes. Some studies in this domain have alluded to the link between formal and informal structure specifically; Hall (1991) pointed out that forms of informal organization such as coalitions "begin from the established organizational order and then become variations from that order." (p.116). During the last few decades, several studies have shown that there is a strong interdependence between the formal and the informal organization, and various papers have investigated the influence the formal organization can have on the informal structure (e.g. Tichy, 1980; Shrader, Lincoln & Hoffman, 1989; Stevenson, 1990; Nickerson & Zenger, 2002; Gulati & Puranam, 2009). Ibarra (1992) shows empirically that a large overlap exists between the formal structure of authority and the informal network of communication and influence. This literature on the informal organization - while not answering the question about the process of choosing a new design as well as the content of that new design directly - constitutes an important building block in furthering our understanding of the question addressed in this dissertation.

1.3.3 Conclusions from Literature Review

Overall, the literature on organization design, change, and inertia provides insights into which organizational structures fit well with different contingency factors and why organizational change is challenging or even impossible. However, the different ways in which the established structures and interaction patterns between employee may affect the process of organizational change and the content of new design choices remains relatively unexplored; I build on the existing literature and extend the theory of organization design by exploring these aspects in greater detail.

1.4 Structure of Dissertation

In this dissertation I focus on how history - the established interaction patterns between employees and the given structure - influences the process of choosing a new design as well as the content of that new design. In order to shed greater light on this question, I develop theory that examines the effects of history on the effectiveness of new design decisions. Building on the conclusions from the theory developed in chapter 2, I develop two empirical studies that allow me to observe the process and content of re-design decisions explicitly; in a behavioral laboratory study, I examine the process of change, and a large-sample analysis provides insights into the content of change. Below, I provide a brief overview of each chapter.

In chapter 2, I explore the organizational re-design decision theoretically. I establish that the organization design choices of a designer are fundamentally different in a new system (in which neither the agents nor the designer have any knowledge of anyone else in the system) compared to a system with history (in which the designer and the agents have worked with each other before), which depends on both, the designer's as well as the employees' knowledge repositories.

In chapter 3, I examine the process of re-design in detail. In particular, I set up a laboratory study in which I observe a group's choices about the division of labor of a task and how those choices differ if (1) they have never worked together before, and (2) they have previously worked together on a similar task.

In chapter 4, I study how established corporate structures affect the content and timing of redesign decisions at the macro-level. I test my arguments on a large-sample data set of the corporate reorganizations in the cell phone manufacturing industry. I gather data on each of the 34 firms over the life-span of the industry, from 1983 to 2008. This setup allows me to observe content changes and the impact of prior structures on new design choices over an extended period of time.

In chapter 5 I draw conclusions from the empirical studies on our understanding of the impact of history on organization design.

CHAPTER 2

The Effects of History on Organization Design: An Epistemic Interdependence Perspective

The theory developed in this chapter is based on joint work with Thorbjørn Knudsen and Phanish Puranam which has been published in the *Academy of Management Review* under the title "Organization Design: The Epistemic Interdependence Perspective", Vol. 37, Issue 3, pp. 419-440. Sections 2.2, 2.3, and 2.4 are largely reproduced from the paper. The notation used in section 2.5 builds on the work presented in the Technical Appendix in the same publication. The conceptual nature of the work for this project makes it impossible to pinpoint exact contributions by each of the authors. While the theory was developed jointly, I conducted most of the literature review by myself.

2.1 Introduction

An extensive literature treats the design of organizations specifically as a means to meet the information processing requirements generated by individuals and groupings of individuals undertaking interdependent activities (e.g. Simon, 1945; March & Simon, 1958; Thompson, 1967; Van de Ven, Delbeq, & Koenig, 1976; Tushman & Nadler, 1978; Galbraith, 1973, 1977; Burton & Obel, 1984b). Rooted in the notion of bounded rationality (Simon, 1945), this perspective frames organizations as systems of coordinated activity, and focuses on the costly information processing required to coordinate activities under uncertainty (Galbraith, 1973). This entails "communication and decision making" (Thompson, 1967: 57) as well as the "gathering, interpreting and synthesis of information in the context of organizational decision making" (Tushman & Nadler, 1978: 614).

The premise that the degree of task interdependence fully determines the required level of costly information processing activities holds true under the central assumption that task interdependence is not affected by the system it resides in, i.e. it is exogenously given (Thompson, 1967). In this chapter I highlight that a more careful distinction between task interdependence and agent interdependence, as well as the consideration of other design choices significantly affects the degree of information processing required, and the choice of organization design. Specifically, the theoretical arguments build on one central insight: interdependence between tasks need not imply interdependence between the agents performing these tasks; and interdependence between agents in turn does not imply a need for information processing between them. This implies that the designer of the system has more than one lever at his or her disposal to alter the design in order to minimize (cognitively) expensive information processing activities between the agents. One of these levers is the established patterns of interaction between agents which significantly impacts the set of feasible design choices.

In the following sections I outline the Epistemic Interdependence theory I jointly developed with Thorbjørn Knudsen and Phanish Puranam. Subsequently, I draw implications of that theory on the effects of history on organization design.

2.2 Prior Conceptualizations of the Links Between Interdependence and Information Processing

I take as uncontroversial the central premise in the prior literature that modes of organizing differ in their capacities to process information, as this defines the information processing perspective on organization design (e.g. Simon, 1945; March & Simon, 1958; Thompson, 1967; Galbraith, 1977; Tushman & Nadler, 1978). Rather, the suggested refinement focuses on the link between interdependence and information processing. This link is treated explicitly in a number of papers on the theory of organization design, but a key limitation is that interdependence between tasks is typically treated as synonymous with (or as fully determining) the need for information processing between agents performing the tasks.

I take a “task” as the fundamental unit of analysis. It may be thought of as a production technology - it is a transformation of inputs into outputs in a finite time period. For the purpose of this analysis, it can also be thought of as an action or a choice to be made by an agent. Since tasks have inputs and outputs, they have an associated value (determined by the difference between the benefits of the outputs and the cost of the inputs - as seen by the designer of the system). Whether the task is a design task or a production task will not influence the rest of this discussion (see also Ethiraj & Levinthal, 2004a, b), though I am mindful that there are qualitative empirical differences between them (Baldwin & Clark, 2000).

Task Interdependence[1] - Two tasks are interdependent when the value generated from performing each is different when the other task is performed versus when it is not. The tasks are independent if the value to performing each is the same whether the other task is performed or not. As a consequence the combined value created when independent tasks are performed is the same as the sum of the values created by performing each task alone (e.g. pooled interdependence in Thompson, 1967, where each task makes a discrete contribution to the whole).

This definition encompasses a range of prior conceptualizations of task interdependence. For instance, tasks can be jointly dependent on the same limited inputs (e.g. Burton & Obel, 1984b; Malone & Crowston, 1994). In this case, performing each task alone will result in different levels of consumption of the input (and therefore output and value) than performing both tasks (economies of scope display this property). Tasks can also be interdependent with respect to their outputs - which may be complements or substitutes (Milgrom & Roberts, 1995). By definition, the existence of complementarity or substitution relationships between the outputs implies that performing each task alone will result in different values for each than when performing both tasks. Such complementarity/substitution relationships are explicitly modeled in super- (or sub-) modular production functions (e.g. Milgrom & Roberts, 1990). They are implicit as epistatic interactions in fitness landscapes (e.g. Levinthal, 1997) and dependencies between (design) tasks in (Design) Task Structure Matrices (Steward, 1981; Eppinger, 1991; Baldwin & Clark, 2000).

Finally, task 1's output may form the input to task 2 (e.g. sequential and reciprocal interdependence in Thompson, 1967). In this case, task 2 will be asymmetrically interdependent with task 1, but the converse need not be true (it will depend on whether the value of task 1 changes with the performance of task 2 or not).

1 The term "interdependence" in the organization design literature encompasses both asymmetric (one-sided) and symmetric (two-sided) dependence (e.g. sequential interdependence). I follow conventional usage, and use interdependence for both, but specify whether I refer to symmetric or asymmetric interdependence when the difference matters.

Thus, different kinds of interdependencies between tasks can be represented analytically in terms of the different ways that each task's inputs and outputs enter a combined value function, but the defining feature of interdependence between two tasks is that the value of performing one task is different when the other task is performed.

Agent Interdependence - In contrast to task interdependence, interdependence between agents has the following general form: given an allocation of tasks to agents A and B, there is asymmetric interdependence of A on B if the reward to A from A's actions depends on the actions taken by B but B's reward does not depend on A's actions. Symmetric interdependence exists when the reward to A from A's actions depends on B's actions and vice versa. This conceptualization appears explicitly in the analysis of reward interdependence (Kelley & Thibaut, 1978), power (Emerson, 1962; Pfeffer & Salancik, 1978) and in game theory in general (e.g. von Neuman & Morgenstern, 1944).

Notwithstanding this conceptual distinction between inter-task and inter-agent interdependence, the two are typically treated synonymously in the information processing literature on organization design (Thompson, 1967; Mohr, 1971; Van de Ven et al., 1976; McCann & Ferry, 1979). Other approaches, which model task interdependencies as constraints in linear programs (e.g. Burton & Obel, 1984b) or through Design Structure Matrices (e.g. Baldwin & Clark, 2000) distinguish conceptually between task and agent interdependencies, but assume these are isomorphic. This assumption is valid only for a fairly specific set of circumstances as shown below.

2.2.1 Decoupling Task from Agent Interdependence

Before I analyze when interdependence results in greater information processing needs, let us consider the relationship between agent and task interdependence more closely. Since ultimately it is agents, not tasks, who process information, it is useful to ask whether interdependence between tasks implies interdependence between the agents performing the tasks. Two examples suffice to show that interdependence between tasks is neither necessary nor sufficient for interdependence between agents to exist. Consider an allocation of tasks 1 and 2 to agents A and B:

First, let us consider the case when the tasks are independent - the value of each task is the same, whether the other is also performed or not. Drawing on an example with an illustrious heritage (Smith, 1776), imagine A and B must each make 100 pins (i.e. no specialization) in a pin factory. The value of 200 pins to the factory owner (presumed to be the designer of this system) is no different from the sum of the value of 100 + 100 pins. Assume however that each agent is paid their daily wage only if both tasks are performed - i.e. if the owner sees 200 pins produced by the end of the day. Then, for each agent, the reward for their efforts to meet their individual target of 100 pins depends on the other's efforts, because A may still get no wages despite producing 100 pins if B fails to do so, and vice versa. In this situation, by definition, there is interdependence between the agents. They will need to observe each other's progress and communicate -process information- in order to minimize the dangers of putting in efforts but failing to receive any rewards, even though each agent's production of pins (the task) is independent of the other's. Thus task interdependence is not necessary for interdependence between agents to exist. Reward interdependence is sufficient.

Next consider the case where the tasks are interdependent. With specialization in the pin factory, A now makes 300 pin heads and B makes 300 pin tails, which can be soldered together to produce 300 pins by the end of the day. The tasks are interdependent, because 300 pin heads alone or 300 pin tails alone are worthless, whereas 300 pins are worth something to the factory owner. Assume however that the factory owner agrees to pay each worker their daily wage as long as he is satisfied that each has produced 300 heads and 300 tails, respectively. Then for each agent the reward to their efforts to meet their individual target of 300 heads or tails does not depend on the other's efforts, because A will still get her wages as long as she produces 300 heads, even if B fails to produce a single tail. In this situation, by definition, there is no interdependence between the agents. They have no need to observe each other's progress or communicate and can in fact work in ignorance of the very existence of the other. Therefore task interdependence is not sufficient for interdependence between agents to exist.

For an example of the decoupling between task and agent interdependence in a less stylized setting, consider the cell phone industry. For the case of independent tasks and interdependent units, assume that unit A is the division responsible for developing a cell phone's hardware components and unit B develops the operating system (OS). While the two unit managers could be rewarded primarily on the firm's overall sales, their individual non-specialized products can be sold on separate external markets. For example, the hardware unit could sell the phones using a competitor's operating system (e.g. Nokia selling its smart phones with Microsoft's Windows Phone 7 OS) and the software unit could offer their product to other cell-phone manufacturers (e.g. Nokia's Symbian OS runs on some Sony Ericsson phones). While the handsets and the operating system will be compatible (Nokia's basic models run the Symbian OS), the tasks of producing each are independent to the extent that the sum of the products' value in the external market is identical to the value generated from selling them as a bundle (this assumption is reasonable as historically, Symbian was developed through a partnership between different cell phone manufacturers and is thus not a native Nokia product).

On the other hand, Apple Inc. and Research in Motion (RIM) are examples of cell phone manufacturers whose hardware and software units face interdependent tasks - the iPhone is only sold with iOS (Apple's cell phone OS) and all BlackBerries run BlackBerry OS (RIM's OS), and in neither case are the handsets or the OS sold separately in the external market. While this conforms to the definition of interdependent tasks (their joint value is different from the sum of the separate output values because of co-specialization), the unit-heads of the two units creating these products could in theory be independent, if they are rewarded primarily on some measure of their own unit's performance that does not depend on the other units behavior (Argyres, 1995); for instance on design quality of handsets for the hardware unit, and total number of 'bugs' (or rather lack thereof) for the software unit. (If such measures cannot be found, then de facto they are interdependent.)

Thus, task interdependence is neither necessary nor sufficient to produce interdependence between the agents performing the tasks. Rather, interdependence between agents depends entirely on a key feature of their reward structure - ***incentive breadth***. This refers to the level of aggregation at which an agent’s actions (or their results) are measured and rewarded. In the case of two agents, narrow incentives correspond to the reward of individual actions or their results in a manner that makes them independent of the other agent’s actions. For instance in the specialized pin factory example, when each worker is paid as long as she produces her 300 heads or 300 tails respectively, the workers face a narrow incentive structure. Broad incentives correspond to the reward of individual actions or their results in a manner that makes them at least partly dependent on the other agent's actions. If one of the workers in the example above was paid only on delivering 300 complete pins made by assembling the heads she makes with the tails the other worker makes, she is in effect facing broad incentives. If both are paid their wages only on delivery of 300 complete pins, both face broad incentives (Kretschmer & Puranam, 2008).

Agents are interdependent when they face broad incentives, but are independent when they face narrow incentives. Put differently, interdependence between tasks is assessed by examining the value function representing the combined system of tasks, while interdependence between agents depends on the reward function of the agents. Since in general these will not be identical, there will be a corresponding divergence between task and agent interdependence.[2]

Once we acknowledge that interdependence between tasks and agents are orthogonal constructs, the efforts in the classical literature to link task interdependence to the need for information processing between agents (e.g. Thompson, 1967) appear puzzling, unless a broad incentive structure was implicitly assumed. However, even this assumption cannot have been universal: Consider the case of pooled task interdependence, which involves a situation where each action makes an independent contribution to the whole (Thompson, 1967). Yet, the agents performing these tasks will be interdependent if they face broad incentives. To make pooled interdependence correspond to a situation where minimal or no information processing were required between the agents, we would need to assume a narrow incentive structure.

2.2.2 From Agent Interdependence to Information Processing

Even with appropriate assumptions about the incentive structure, knowing the nature of task and agent interdependence is still insufficient to precisely specify whether information processing will be necessary between agents. For instance, the most significant stream of work in information processing and organization design has relied

[2] The reason why it is difficult to observe these differences between agent and task interdependence at the inter-firm level is due to the fact that it is difficult to decouple the value to the agent from the value to a system designer when the firm is the agent.

on the directionality of workflows between tasks to understand implications for information processing among agents (Thompson, 1967; Van de Ven et al., 1976; McCann & Ferry, 1979). It is easy to show that the direction of information flow between agents needed to coordinate activities does not necessarily correspond to the direction of workflow. For example, if A and B were a biotechnology and pharmaceutical company forming a Joint Venture, where A specialized in research while B specialized in development and distribution and they formed a profit sharing agreement, A would require information from B to produce a drug that fits into B's product portfolio. On the other hand, B could wait for the finished product before she starts her development and distribution efforts. Thus while A and B are interdependent, A needs to process information about B but not vice versa, even though B's task is dependent on A's for inputs, and both agents are interdependent with each other because of the incentive structure.

This asymmetric pattern of information processing requirements does not arise from the pattern of task interdependence per se but rather depends on the sequence of actions. Assume that A and B are two teams of consultants in a consulting company that are working for the same client; team A is tasked to design a more effective organizational structure while team B is asked to rebrand the logo for the client. While the tasks are independent, each team may only be paid the annual bonus if both teams deliver projects that satisfy the client. Assume team A finishes first. Given the reward dependence between the teams, team A will not want to expend a lot of (fruitless) effort if team B ends up doing a sub-standard job - thus, team A needs to choose its effort level based on its expectation – which may be formed through communication and information processing - of whether team B will put in more or less effort.

These examples illustrate that in a dyad of interdependent agents, whether information processing is necessary and by whom depends on scheduling - the sequence of actions; interdependence between agents is not sufficient to create a need for information processing between them. To be precise, what matters for information processing is whether the agents act before or after knowing the other's actions, not on chronological time per se. In the consulting company example above, if the client's reactions are not widely known, team B may still need to engage in information processing to learn how team A did in order to assess if they should put in a lot of effort themselves, even if team A's project is complete.

It is of course well known that the timing of actions has critical implications for how easy or difficult it is for agents to coordinate their actions (Schelling, 1960). Van de Ven et al. recognized this when they added team interdependence, which exists when "there is no measurable temporal lapse in the flow of work between unit members" (1976: 325) to the top of Thompson's Guttman scale featuring pooled, sequential and reciprocal interdependence. However, by combining these onto a common scale, they effectively treated inter-agent and inter-task interdependencies as equivalent.

In sum, I have shown that i) task interdependence is neither necessary nor sufficient for interdependence between the agents performing the tasks, and ii) interdependence between agents is necessary but not sufficient to create a need for information processing between them. Neither conception of interdependence, individually or jointly, is sufficient to understand information processing requirements for a given allocation of tasks among agents. In the following section I argue that information processing will be primarily necessary in the presence of coordination problems between agents, for which the scheduling of tasks plays a critical role. Given that neither conception of interdependence discussed above results in such coordination problems per se, I identify and define a third kind of interdependence that gives rise to coordination problems and requires information processing activities to be solved.

2.3 Epistemic Interdependence and Information Processing

The classical literature on organization design has emphasized that information processing activities help to coordinate the activities of agents in organizations (e.g. Simon, 1945; March & Simon, 1958; Thompson, 1967; Galbraith, 1977; Tushman & Nadler, 1978). Coordination problems have of course been extensively studied across a range of social sciences, and not only in the field of organization design. Coordination failures occur when interacting individuals are unable to anticipate each other's actions and adjust their own accordingly. Coordination failures are manifested as delay, misunderstanding, poor synchronization, and ineffective communication. These ideas are well entrenched in game theory (Schelling, 1960), linguistics (Clark, 1996), social psychology (Heath & Staudenmayer, 2000) and organization theory (March & Simon, 1958; Weick, 1993). In contrast, cooperation failures occur when interdependent individuals are not motivated to achieve the optimal collective outcome because of conflicting incentives. Coordination failures can occur quite independently of cooperation failures – even when incentives are fully aligned (Simon, 1945; March & Simon, 1958; Schelling, 1960; Grant, 1996; Holmstrom & Roberts, 1998; Heath & Staudenmayer, 2000; Camerer, 2003).

For us to understand the need for information processing neither task nor agent interdependence (individually or jointly) suffices, as shown in the preceding section. I therefore introduce a new conceptualization of interdependence that helps to precisely identify the need for information processing between agents. This conceptualization has three key elements:

1. For two agents A and B, if the optimal action of each agent depends on a prediction of what the other agent will do, there is ***epistemic interdependence*** between them.
2. Given epistemic interdependence, for the agents to coordinate their actions requires ***predictive knowledge***. A's predictive knowledge about B enables A to act *as if* he could accurately predict B's actions.
3. Predictive knowledge can be formed through information processing activities-communication, mutual observation, learning and (joint) decision making by the agents.

The construct of epistemic interdependence is valuable because it allows us to see what is common to all coordination problems, irrespective of their surface dissimilarities. The potential for a coordination problem to arise between two agents exists if at least one of the agents requires predictive knowledge about the other. A coordination failure is thus a failure to predict the actions of another in situations where such a prediction is essential for optimal action by oneself. In other words, a coordination failure occurs when there is epistemic interdependence but the agent(s) do not hold the necessary predictive knowledge. The agents may possess incomplete or imperfect predictive knowledge so that coordination can be less likely, but not necessarily impossible.

Predictive knowledge and how it is formed is theoretically interesting only because of bounded rationality - an important assumption in this theory. If agents (and the designer) were omniscient, coordination problems would be trivial. Both epistemic interdependence as well as the need for predictive knowledge are the consequences in reality (visible to us, as the modelers) of the choices and actions of the designer and the agents, based on their imperfect knowledge. This analytical approach is identical to that employed in other models of organizations featuring boundedly rational agents – adaptation on rugged landscapes (Levinthal, 1997), exploration-exploitation trade-offs (March 1991), and opportunity identification problems (Davis, Eisenhardt, & Bingham, 2009). In each case, the agents in the model take actions in an environment they do not fully understand or have an imperfect representation of, but both the consequences of the actions and the agent's environment are of course understood by the modeler who constructed it.

The need to predict, rather than the ability to observe another's action can arise either because of sequencing (the other party has not acted yet, or is acting simultaneously with one's own actions) or because of communication and information transmission constraints (which prevents one agent from learning how the other has acted). While the former is salient in empirical accounts of coordination in "real time" settings (surgical teams, fire-fighters - Edmondson, Dillion, & Roloff 2007; Weick, 1993), the latter is more often highlighted in descriptions of "realistic time" settings (new product development, strategic alliances, post merger integration - Gulati & Singh, 1998; Puranam, Singh, Chaudhuri, 2009). Communication itself can be seen as a coordination problem, as indeed the modern view of linguistics does: when communicating, I need to predict which among several possible meanings you chose to attach to the words you used (e.g. Clark, 1996).

The phrase "as if" is important in the definition of predictive knowledge, because I intend to define it broadly enough to accommodate situations ranging from one in which A acts on the basis of a carefully reasoned prediction about B's actions, as well as those in which through mutual adaptation, A and B have learnt to act as if they are predicting each other's actions successfully (e.g. in the case of inter-personal routines as shown by Cohen & Bacdayan, 1994). Predictive knowledge can be formed in a wide variety of ways - through direct communication, reliance on signals, mutual adjustment to feedback on joint outcomes - all of which constitute information processing activities.

To illustrate epistemic interdependence and predictive knowledge, consider again the unspecialized pin factory in which A and B have to produce 100 pins each, but will only get paid if both agents finish their orders; here, the tasks are independent, but the agents are interdependent to the extent that they face broad incentives. Now, regardless of whether A and B produce the pins at the same time or sequentially, as long as B does not learn A's output before A finishes her day's work, the scheduling is effectively simultaneous and the agents have to act based on their estimates of the other agent's productivity. Thus there is epistemic interdependence between them and they need to make their decisions on whether to produce their own 100 pins based on their predictive knowledge about the other agent's likelihood of finishing their 100 pins. This need to predict the other agent's output is rooted in their aim to increase their individual rewards. Predictive knowledge in this case can be formed by information processing activities, such as periodic communication regarding each other's progress (in the case of simultaneous actions), or by mutual observations, or on the basis of past experience.

Applied to the consulting firm example above, if team B does not observe the outcome of team A's restructuring efforts before it engages in the design of the new logo, team B will need to engage in information processing, anticipating what level of effort team A is most likely to put in, while A needs to anticipate B's efforts. Note that this example also points to the relative ease of generating the necessary predictive knowledge: if both teams are employed by McKinsey & Co., their information processing requirements may be relatively lower compared to a collaboration between team A from McKinsey and team B from Boston Consulting Group.

Thus, epistemic interdependence helps to precisely identify the circumstances when information processing is necessary between agents in order to form predictive knowledge. This construct is theoretically necessary because neither task nor agent interdependence suffice to explain when information processing is necessary between agents. The first proposition therefore helps to sharply distinguish epistemic interdependence between agents from interdependence between tasks.

Proposition 1: In a dyad, epistemic interdependence between agents will exist if 1) at least one agent faces broad incentives ***and*** *2) the same agent is scheduled to act before knowing the action of the other.*

Proposition 1 follows automatically from the definition of epistemic interdependence. In a dyad, there is by definition epistemic interdependence if one agent's optimal action depends on a prediction of the action of another. This situation holds when both the conditions in Proposition 1 are met. In contrast consider the case when either condition is not met. If condition 2 holds but neither agent faces broad incentives, then the rewards to each agent's actions are independent of the other's actions; if condition 1 holds but neither agent acts before knowing (or inferring) the actions of the other, then no prediction is necessary. In this case, there may still be interdependence between agents in the sense that the value of one agent's actions depends on the other's action, but there is no epistemic interdependence, and no particular implications for information processing. Thus both conditions are independently necessary and jointly sufficient to create epistemic interdependence and the need for information processing between agents. Proposition 1 also highlights that neither the broad incentives created by reward interdependence (e.g. Kelley & Thibaut, 1978), nor the need for simultaneous actions (i.e. each agent acts before the other's actions are known) generated by bi-directional workflows (e.g. Thompson, 1967) are individually sufficient to create epistemic interdependence and the need for information processing between agents.

It also follows from Proposition 1 that the patterns of task interdependence and epistemic interdependence between agents are identical only in some special cases - more generally the two cannot be assumed to be isomorphic. Trivially, they will be identical if there is no interdependence between tasks or agents, or if task interdependence and epistemic interdependence are both symmetric. However isomorphism is not guaranteed in cases of asymmetry. Suppose that in a dyad of agents A and B performing tasks 1 and 2, only task 2 is dependent on task 1 but not vice versa, i.e. the output of task 1 (which has independent value) is a necessary input to task 2. For isomorphism to hold, B must then be epistemically interdependent with A but not vice versa. This implies that (i) B must face broad incentives and be scheduled to act before knowing A's actions, and (ii) A must either face narrow incentives, or be scheduled to act after knowing B's action or both (Proposition 1).

2.4 Interdependence, Information Processing, and Organization Design

Having established the need for the epistemic interdependence construct and defined it, I use it to revisit the basic theoretical links between interdependence, information processing and the design of organizations. Influential contributions by Galbraith and Tushman defined the mapping from increasing levels of interdependence, the resulting task uncertainty and the need for information processing activities (Galbraith, 1973; Tushman & Nadler, 1978). In particular Galbraith elaborated on the concept of task uncertainty as the "difference between the information required to perform a task and the information already possessed" (1973: 5), while Tushman and Nadler's work linked the complexity of tasks as well as the variability of the environment within which the tasks were performed to the extent of task uncertainty - and therefore to the extent of information processing required.

Consistent with these prior approaches, I argue that an organization designer has two basic approaches to ensuring successful coordination among the agents in the system he is designing - he can act either to modify epistemic interdependence between agents, or enable the formation of predictive knowledge between them through information processing (or both).

2.4.1 How Epistemic Interdependence Can Be Modified

Organization designers (those individuals explicitly tasked with the goal of improving the performance of the organization) can manipulate epistemic interdependence between agents by varying scheduling and incentive breadth. A designer may be able to convert a simultaneous action schedule into a sequential action schedule, through the use of buffers and inventories (Malone & Crowston, 1994). Further, through superior measurement systems (Zenger & Hesterly, 1997), or the specification of interfaces and design rules (Baldwin & Clark, 2000) a broad measurement situation can be transformed into a narrow measurement situation.

Beginning from a situation of broad incentives and simultaneous action, these changes can lead to lower levels of epistemic interdependence (see Proposition 1).

Even if the designer could not measure actions or outputs narrowly or sequence actions, she can choose to allocate those tasks that would generate high epistemic interdependence between different agents, as clusters of tasks to individual agents. This allows the designer to create lower levels of epistemic interdependence, possibly at the cost of raising the task and cognitive burden of individual agents (Baldwin & Clark, 2000).

These variations in the ability to adjust epistemic interdependence due to variations in task allocation, scheduling and incentive breadth partly reflect differences in architectural knowledge (Henderson & Clark, 1990; von Hippel, 1990; Baldwin & Clark, 2000) across organization designers. Colfer and Baldwin define architectural knowledge as "knowledge about the components of a complex system and how they are related" (2010: 2), a definition that builds on Henderson and Clark's (1990) notion of "knowledge about the ways in which the components are integrated and linked together into a coherent whole" (1990: 2). Limited architectural knowledge implies limited comprehension of the task structure - the designer's beliefs can be more coarse-grained than reality (the designer only sees more aggregate clusters of tasks than exist in reality), incomplete (the designer fails to perceive the existence of certain tasks in the task structure) or simply wrong (the designer sees a spurious set of tasks). In turn this limits the ability of the designer to allocate, schedule, and reward task performance in a manner that minimizes epistemic interdependence. I formalize this potential consequence of architectural knowledge as follows:

> *Proposition 2: The greater the architectural knowledge of the organization designer, the lower the epistemic interdependence between agents can be.*

Since an ability to effectively replace broad with narrow incentives is also a result of architectural knowledge, Proposition 2 holds for interdependence between agents in general, and not only for epistemic interdependence, so that linkages between the pattern of task and agent interdependence in general are likely to be weaker when the designer's architectural knowledge is great. In particular, this proposition explains why (epistemic) interdependence between agents may be adjustable for an architecturally knowledgeable designer, even when interdependence between tasks is not. For instance Levinthal and Warglien (1999) discuss how the designer could transform a complex task-interdependence-landscape into a less-rugged one by imposing a smoother agent-interdependence-landscape.

However, as outlined in Perrow's (1984) work on complex systems as well as Turner's (1976) exposition of organizational and individual failure, architectural knowledge may by no means be common or complete. 'Normal' accidents occur precisely because the designer or the agents do not possess sufficient architectural or predictive knowledge to conceive of all possible contingencies. Similarly, reducing epistemic interdependence does not assume that the remaining necessary predictive knowledge is widespread or perfect. This is why Proposition 2 only states that architectural knowledge can be used to lower epistemic interdependence if it exists.

2.4.2 How Predictive Knowledge Can Be Formed

A basic tenet of the classical information processing theory of organization design is that modes of organizing differ in their information processing capacities (Galbraith, 1973; Thompson, 1967; Tushman & Nadler, 1978). Consistent with this, I believe it is useful to think of formal organizational structure as a set of prescribed arrangements that shape the efficiency with which information processing activities by agents help to meet predictive knowledge requirements (or equivalently, how effective a given amount of information processing activity is in generating predictive knowledge). Choices about organizational structure influence who interacts with whom, as well as the knowledge and skills of the interacting individuals - and therefore enable the formation of predictive knowledge.

To illustrate, consider two fundamental features of any organizational structure - grouping and linking arrangements (March & Simon, 1958; Chandler, 1962; Mintzberg, 1979; Nadler & Tushman, 1997). Grouping or departmentalization is a primary means by which the efficiency of intra-group interactions can be enhanced at the expense of the efficiency of inter-group interactions. The efficiency of predictive knowledge formation through information processing in a group can be enhanced by reducing the size and heterogeneity of the group, because communication and coordination quality declines with group size and heterogeneity (Camerer & Knez, 1996; Heath & Staudenmayer, 2000). When groups are collocated, the interaction media is effectively quite rich (Daft & Lengel, 1986). Partitioning an organization into sub-groups (units, divisions, departments) is thus a means to enhance the efficiency of information processing activity, and enables the more rapid formation of predictive knowledge within those groups.

However, precisely because the efficiency of intra-group information processing declines with group size, not all interdependent agents can be accommodated within the same group. This means that inevitably some arrangements will be needed to manage predictive knowledge requirements across groups. Scholars have proposed that linking mechanisms such as liaison roles, committees, task forces and integrators fulfill this function (Mintzberg, 1979; Nadler & Tushman, 1997). Decisions about grouping units together within common organizational boundaries are different from, and precede in order and importance, non-discrete decisions about the use of "linking" mechanisms between organizational units (Thompson, 1967; Galbraith, 1977; Nadler & Tushman, 1997) - as Nadler and Tushman put it, "The grouping decision made at the top of the organization dictate the basic framework within which all other organizational design decisions [including linking decisions] are made. (...) In short, grouping decisions determine what the organization will be able to do well and deemphasize other work." (1997: 73)"

Thus, the organizational structure shapes the formation of predictive knowledge by prioritizing certain interactions among agents at the expense of others, which is why differences in formal structure matter. I formalize this as follows:

> *Proposition 3: Formal organizational structures prioritize the formation of predictive knowledge among some agents by emphasizing information processing interactions between them, over interactions with other agents.*

2.4.3 Organization Design as the Pursuit of Integration

To make explicit the central normative claim of the information processing literature, the goal of an organization designer may be viewed as enhancing gains from coordination despite the information processing constraints of individuals and the differentiation that results from specialization (March & Simon, 1958; Lawrence & Lorsch, 1967; Galbraith, 1973; Tushman & Nadler, 1978). Equivalently, we may say that for a given allocation of tasks to agents, the designer's goal is to enhance the degree of integration in the organization, defined by Lawrence and Lorsch as "the quality of the state of collaboration that exists among departments that are required to achieve unity of effort by the demands of the environment." (1967: 11). I translate this term in the context of this theory as the joint probability that all agents in an organization have the necessary predictive knowledge. I argue that a greater probability of coordination failures is equivalent to a lower degree of integration. To keep the exposition simple and retain focus on information processing, I make the assumption here that the agents have aligned incentives – in other words integration between agents would be achieved in the absence of coordination failures.

In the case of two agents A and B in which each is epistemically interdependent with the other, the degree of integration is the multiplication of the probabilities that A has predictive knowledge about B (p_{AB}), and B has predictive knowledge about A (p_{BA}). One approach to increasing integration consists of reducing epistemic interdependence between the agents, so that only one or neither agent needs predictive knowledge about the other. This is equivalent to setting p_{AB} and/or p_{BA} equal to 1. Integration will then depend on only one probability or none, so that reducing epistemic interdependence effectively increases the degree of integration (because probabilities are less than 1). This suggests that an organization designer with superior architectural knowledge could improve overall integration by reducing the epistemic interdependence among agents (Proposition 2). A second approach to enhancing integration lies in specifying a pattern of interactions among the agents through an organizational structure (see Proposition 3) that will improve predictive knowledge (i.e. increase the probabilities p_{AB} and p_{BA}). Thus, *Proposition 4: For a given allocation of tasks, the degree of integration in an organization may be improved either by a) reducing epistemic interdependence among its agents, or b) selecting an organizational structure to enhance information processing interactions among its epistemically interdependent agents (or both).*

Integration in an organization can therefore be enhanced either by reducing epistemic interdependence, or by ensuring the formation of predictive knowledge through information processing.

2.5 Implications for the Effects of History on Organization Design

I am now in a position to consider the impact that history has on organization design decisions. In the context of the epistemic interdependence theory, a system with 'history' translates into a system in which (1) agents have formed some predictive knowledge through previous interactions[3]; and (2) the designer holds some architectural knowledge about the task at hand. In order to examine the possible effects that an established structure may have on the process of choosing a new organization design as well as the content of that new design, let us consider these choices by comparing a system with a 'blank canvas' with one that has 'history'.

To facilitate this comparison, I introduce some notation.[4] Define $\boldsymbol{T^R}$ (an *n X n binary matrix*) as the ***task structure***, the most fine-grained means-end decomposition of a goal into its constituent *n* tasks and the dependency relationships between these. The *true, underlying* task structure is unknown to the boundedly rational agents (Simon, 1945) who need to work with imperfect representations thereof. This matrix represents the designer's beliefs about the finest possible task division into (clusters of) smaller tasks. A "1" in a cell ($r_{ij} = 1$) denotes that column task is dependent on row task; each task is dependent on itself ($r_{ii} = 1$). Let $\boldsymbol{T^A_t}$ be the ***allocated task structure*** at time t (an *m X m binary matrix*). This captures the tasks or task clusters allocated to each of the *m*

[3] High levels of employee turnover would weaken this effect.

[4] The notation introduced here builds on the technical appendix outlined in Puranam, Raveendran & Knudsen (2012).

agents in the system. As such, it captures the designer's beliefs about an appropriate task allocation, given the task division represented by T^R. A "1" in a cell ($a_{ijt} = 1$) denotes that column agent's allocated tasks are dependent on row agent's allocated tasks; each agent's task cluster is dependent on itself ($a_{iit} = 1$).

Define $\boldsymbol{E_t}$ (an *m X m binary matrix*) as the ***epistemic structure*** which captures the pattern of epistemic interdependence between agents at time t. A "1" in a cell ($e_{ijt} = 1$) denotes that column agent requires predictive knowledge about row agent; each agent requires predictive knowledge about him/herself ($e_{iit} = 1$). Finally, let $\boldsymbol{I_t}$ be the ***information structure*** at time t (an *m X m matrix*), the elements of which represent the probability p_{ijt} that agent j has predictive knowledge about agent i at time t (p_{iit} captures the probability that the agent has the knowledge necessary to undertake his or her own task).

Note that we can also vary the true, underlying task structure matrix $\boldsymbol{T^R}$ as a function of the technological properties of the task. Figure 2.1 depicts two task structures matrices with different levels of complexity. Given that the designer has to make sense of the true, underlying task structure, the more complex it is, the more discrepancies his predicted (imperfect) representation of the task structure matrix will show. For the example presented in the following sub-sections, I take the task structure as depicted in Figure 2.1, panel (a) as the true underlying one and compare the effects of history on the resulting design decisions with that of a blank canvas system, which is depicted in Figure 2.2. The effects described below will be weakened for the less complex task structure matrix shown in Figure 2.1, panel (b).

Figure 2.1 - Two Task Structure Matrices with Different Levels of Complexity

panel (a)

$$\begin{bmatrix} 1 & 1 & 1 & 0 & 0 & . & . \\ 1 & 1 & 1 & 0 & 0 & & \\ 1 & 1 & 1 & 0 & 1 & & \\ 0 & 1 & 0 & 1 & 1 & & \\ 0 & 1 & 1 & 0 & 1 & & \\ . & & & & & . & \\ . & & & & & & 1 \end{bmatrix}$$

true $\boldsymbol{T^R}$ $\quad$ *nXn*

panel (b)

$$\begin{bmatrix} 1 & 1 & 0 & 0 & 0 & . & . \\ 1 & 1 & 0 & 0 & 0 & & \\ 0 & 0 & 1 & 0 & 1 & & \\ 0 & 0 & 0 & 1 & 1 & & \\ 0 & 0 & 1 & 1 & 1 & & \\ . & & & & & . & \\ . & & & & & & 1 \end{bmatrix}$$

true $\boldsymbol{T^R}$ $\quad$ *nXn*

2.5.1 History and Architectural Knowledge

The first choice regarding any organization design is how to divide up the overall task into sub-tasks (without task division there is no interdependence between sub-tasks and hence no need for integration of efforts). This choice of task division is influenced by the designer's level of understanding of the task structure, and is summarized in $\boldsymbol{T^R}$. The more architectural knowledge the designer has, the better she will be at identifying the decomposability of the task and the resulting interdependencies between the resulting sub-tasks. The blank canvas condition depicted in Figure 2.2 highlights the effects of a designer with very little or no architectural knowledge on the task structure as shown in panel (a). Note that the blank canvas condition of this matrix is likely to contain many type I and type II errors, i.e. assumed interdependencies between agents that are not present in the underlying structure, and ignored interdependencies that are present in the underlying task structure, which will - overall - result in an organizational structure that generates performance which diverges from expected performance (Lee & Puranam, 2012). On the other hand, a more experienced designer is likely to be able to extract a more accurate task division from the underlying true task structure as shown in panel (b), which provides a more advantageous starting point for the subsequent choices of task allocation and organization structure.[5]

Based on her (imprecise) representation of the task structure, the designer chooses an organization structure in view to reduce costly information processing by allocating interdependent tasks or task clusters to agents in the same unit while minimizing interdependence between agents across units. These structural choices are reflected in the resulting allocated task structures (panels (c) and (d)) and epistemic structures (panels (e) and (f)). While the allocated task structures are influenced by the designer's understanding of the underlying task structure, the epistemic structure highlights to what extent her architectural knowledge allows her to apply narrow incentives and sequencing of tasks to reduce the epistemic interdependence between the

[5] Note that architectural knowledge can be acquired through experience in a focal system over time (i.e. history), or experience in other systems where the designer faced similar tasks. Thus, even the blank slate condition could be improved from the outset by hiring a more experienced designer. For clarity of exposition, I focus on the two extreme cases of *no architectural & no predictive knowledge* and *some architectural & some predictive knowledge*.

agents. The relative lack of architectural knowledge is visible in the relatively higher number of "1"s in the blank slate conditions across these matrices (panels (c) and (e), respectively).

Figure 2.2 - History vs. Blank Canvas Condition

blank canvas

panel (a)

$$\begin{bmatrix} 1 & 1 & 1 & 0 & 1 & . & . \\ 0 & 1 & 0 & 1 & 1 & & \\ 1 & 1 & 1 & 1 & 1 & & \\ 0 & 0 & 0 & 1 & 1 & & \\ 1 & 1 & 1 & 1 & 1 & & \\ . & & & & & . & \\ . & & & & & & 1 \end{bmatrix}$$

T^R nXn

history condition

panel (b)

$$\begin{bmatrix} 1 & 1 & 1 & 0 & 1 & . & . \\ 1 & 1 & 1 & 0 & 1 & & \\ 1 & 1 & 1 & 0 & 1 & & \\ 0 & 0 & 0 & 1 & 1 & & \\ 0 & 0 & 0 & 1 & 1 & & \\ . & & & & & . & \\ . & & & & & & 1 \end{bmatrix}$$

T^R nXn

panel (c)

$$\begin{bmatrix} 1 & 1 & 0 & 1 & . & . \\ 1 & 1 & 0 & 1 & & \\ 0 & 1 & 1 & 1 & & \\ 1 & 1 & 0 & 1 & & \\ . & & & & . & \\ . & & & & & 1 \end{bmatrix}$$

$T^A{}_t$ mXm

panel (d)

$$\begin{bmatrix} 1 & 1 & 0 & 1 & . & . \\ 1 & 1 & 0 & 0 & & \\ 0 & 1 & 1 & 1 & & \\ 0 & 0 & 0 & 1 & & \\ . & & & & . & \\ . & & & & & 1 \end{bmatrix}$$

$T^A{}_t$ mXm

panel (e)

$$\begin{bmatrix} 1 & 1 & 1 & 0 & . & . \\ 1 & 1 & 1 & 0 & & \\ 0 & 0 & 1 & 1 & & \\ 1 & 1 & 0 & 1 & & \\ . & & & & . & \\ . & & & & & 1 \end{bmatrix}$$

E_t mXm

panel (f)

$$\begin{bmatrix} 1 & 0 & 1 & 1 & . & . \\ 0 & 1 & 0 & 1 & & \\ 0 & 1 & 1 & 0 & & \\ 1 & 0 & 0 & 1 & & \\ . & & & & . & \\ . & & & & & 1 \end{bmatrix}$$

E_t mXm

panel (g)

$$\begin{bmatrix} 1 & 0 & 0 & 0 & . & . \\ 0 & 1 & 0 & 0 & & \\ 0 & 0 & 1 & 0 & & \\ 0 & 0 & 0 & 1 & & \\ . & & & & . & \\ . & & & & & 1 \end{bmatrix}$$

I_t mXm

panel (h)

$$\begin{bmatrix} 1 & 0.2 & 0.8 & 0.9 & . & . \\ 0.4 & 1 & 0.2 & 0.7 & & \\ 0.1 & 0.6 & 1 & 0.3 & & \\ 0.9 & 0.2 & 0.1 & 1 & & \\ . & & & & . & \\ . & & & & & 1 \end{bmatrix}$$

I_t mXm

2.5.2 History and Predictive Knowledge

To this point, I have considered the designer's decision making process when choosing a new design, keeping the agents' level of predictive knowledge constant at zero (as depicted in the information structure for the blank canvas condition in Figure 2.2 panel (g)). While *history* has some impact on the designer's choices with respect to her architectural knowledge, it is the established interaction patterns between the agents (i.e. whether or not they hold predictive knowledge of each other) that creates deeper implications for the process and content of choosing a new design.

Let us consider the scenario in which the designer is given the task to reorganize the system. In the blank canvas condition, she would base her decisions on the information structure presented in panel (g). Hence, given that none of the agents holds any predictive knowledge of any other agent (but themselves), the designer's choices will be purely driven by her architectural knowledge and her beliefs about which structure would minimize costly information processing. Hence, the choices of task division and task allocation are driven purely by the technological properties of the task as perceived by the designer.

> *Proposition 5: In the absence of predictive knowledge, the designer's choices regarding task division are predominantly driven by her perception of the technological properties of the task.*

Contrast this scenario with a designer who faces the task to reorganize the system in light of the information structure depicted in panel (h), i.e. in a system where the agents have a level of predictive knowledge of each other above zero. While the task division is still determined by the designer's architectural knowledge and the technological properties of the task, the process of task allocation and choice of organizational structure will now be highly influenced by the existing patterns of interaction among the agents.

> *Proposition 6: The presence of predictive knowledge between agents impacts the designer's task allocation decision by reducing the need for minimizing allocated task interdependence across agents.*

Given that the presence of predictive knowledge effectively substitutes for organizational structure or efforts to reduce epistemic interdependence through narrow incentives and sequencing of tasks, a system that is re-designed may show different organizational structures and allocated task structures compared to a system that is designed from a blank canvas. Thus, two designers attempting to address identical organizational and environmental challenges through the adoption of an effective structure will choose quite distinct new designs (i.e. different *content*) if one faces the task to newly design a system while the other faces a re-design challenge.

> *Proposition 7: The designer's choice of structure when re-designing the organization is affected by the predictive knowledge that the previously established structure generated among the agents.*

Finally, any change in structure (whether as new design or re-design) will require a period of implementation before the agents in the system collaborate according to the mandated new structures. The presence of any predictive knowledge will facilitate that implementation, given that the agents can initiate their collaborative efforts from an established relationships. In this context, existing levels of predictive knowledge imply that the agents can reach the desired degree of collaboration (reflected in the level of predictive knowledge) relatively faster, compared to a system where all agents start with zero predictive knowledge. Hence,

> *Proposition 8: The presence of predictive knowledge effectively increases the implementation speed of the new design.*

2.6 Conclusion

In this chapter, I have developed theory that highlights the importance of considering the role of history in organization design choices. Building on the epistemic interdependence theory which I developed jointly with Thorbjørn Knudsen and Phanish Puranam, I highlight that a more careful distinction between task interdependence and agent interdependence, as well as the consideration of other design choices significantly affects the degree of information processing required, and the choice of organization design. The theoretical insights gained from this theory shed light on the central question in this dissertation: How does the established structure affect (a) the process of choosing a new design, and (b) the content of the new design? In particular, I have outlined why existing patterns of interactions between agents may influence the way the designer allocates different task clusters to agents (the *process*), as well as his choices regarding the type of organizational structures (the *content*).

In the following chapters I test some of the propositions developed in this chapter empirically. In particular, in chapter 3, I test how cognitive and social factors influence the task division and allocation decisions of groups as well as individual designers, over and above the well established influence of the technological properties of the task. In chapter 4, I examine the effects of prior structure on the content of new structures as well as the implementation speed of the new design.

CHAPTER 3

The Effects of History on the Process of the Division of Labor

This chapter is based on joint work with Phanish Puranam and Massimo Warglien. Massimo Warglien's role was mainly advisory regarding the design of the experimental paradigm. I conducted all laboratory sessions, coded all the data, and conducted the analyses by myself. The discussion of results and the review of the literature were done jointly.

3.1 Introduction

Since Adam Smith (1776), it is generally accepted that the division of labor is a fundamental phenomenon underlying economic life. However, it is such an omnipresent feature in our societies that we have developed some blind spots about it. The consequences of the particular form of division of labor associated with industrial production in market-based economies - such as specialization (Smith, 1776), the impact on social solidarity and individual motivation (Durkheim, 1893), and the bargaining power of workers vis-à-vis the providers of capital (Marx, 1906) - have been extensively discussed. However, surprisingly little attention has been devoted to the basic process of the division of labor - a process whereby complex objectives are divided into contributory tasks (task division) which are allocated across individuals (task allocation). A version of this process must necessarily be a part of all organizations whether pre- or post-industrial, whether connected or not to a market, or engaging in any exchange at all, as an organization by definition must aggregate individual efforts into organizational objectives (Babbage, 1833; March & Simon, 1958: 2).[1]

[1] In particular, the process of achieving task division may be uniquely important in human organizations. Division of labor also occurs in biological systems, but the key questions there pertain to why some systems evolve towards differentiated allocation of tasks given a task division and an initial undifferentiated task allocation (Rueffler, Hermisson, & Wagner, 2012).

The limited prior attention to the process by which a division of labor emerges may simply have been the consequence of pervasive functionalist assumptions. For instance, the influential position of Ludwig von Mises was that if a particular division of labor has efficiency advantages (gains from trade, for instance), its emergence could be taken for granted (von Mises, 1949). This may even have been justified to some extent in an industrial context dominated by highly repetitive activity on a shop floor, such as that celebrated in Smith (1776), where opportunities for learning through repetition could have helped uncover the efficient division of labor.

However, the degree of repeatability of tasks that organizations confront today varies significantly (e.g. it is lower in project-based work than on a shop floor), and for every existing pattern of division of labor, there must have been a point in time at which the process by which it first emerged unfolded. Put simply, organizations often confront novel tasks, and when they do, a process of division of labor must arise. It has also been noted that even if a division of labor is an efficient equilibrium, it may be just one of several equilibria in a coordination game in which other less efficient solutions are possible (Skyrms, 2004). If so, it is valuable to understand what social and psychological factors beyond the technological properties of the task influence the process through which an equilibrium - a division of labor – emerges (Schelling, 1960; Skyrms, 2004).

Scholars studying the related but distinct problem of the impact of technology on organizations have reached similar conclusions about the need to move away from the stronger forms of technological determinism (see Leonardi and Barley, 2010 for a recent overview).[2] Historically, the notion of a correspondence between technology and organization has been an influential one in organization theory (e.g. Woodward, 1958; Thompson, 1967; Galbraith, 1973; Tushman & Nadler, 1978; Henderson & Clark, 1990; von Hippel, 1990; Sanchez & Mahoney, 1996; Baldwin & Clark, 2000). However, a number of field studies indicate that the process by which individuals in an organization adopt (e.g. Fulk, 1993), interpret (e.g. Barley, 1988), and use (e.g. Poole & DeSanctis, 1990; Orlikowski & Yates, 1994) new technologies cannot be explained purely with reference to the properties of the technology itself. Pre-existing social structures (e.g. Barley, 1986) as well as individual ways of thinking (Barley, 1988) can play significant

[2] The problems are distinct because technological changes are neither necessary nor sufficient for changes in division of labor to arise.

roles. Yet, as is increasingly recognized in this literature, the path forward lies in eschewing the extremes of either social constructivism or technological determinism, to understand precisely the mechanisms through which the constraints and affordances that a technology provides shape how individuals organize around it (Zammuto et al., 2007: 752; Leonardi & Barley, 2010: 3; also see Puranam, Raveendran & Knudsen, 2012).

In this spirit, I argue that in any situation when a group confronts a novel task, multiple divisions of labor are typically possible. Technological properties will undoubtedly influence the relative benefits of the different ways to divide labor (Smith, 1776; Simon, 1962; Leijonhufvud, 1986; 1995), but may not solely determine the choice between them. As outlined in Chapter 2 (propositions 5 and 6), individual and social factors may also systematically influence which division of labor emerges.

Proposition 5 suggests that in the absence of predictive knowledge, the designer's choices regarding task division and task allocation are predominantly driven by his perception of the technological properties of the task. In order to test the impact of the technological properties of the task on the process of task division, I manipulate a critical technological task property - its *decomposability* - the extent to which the task can be divided into clusters of tasks that can be worked on independently (Simon, 1962). I further examine whether the designer's perception of the task structure has a fundamentally different effect on his decisions regarding task division and task allocation as a function of experience with the task. I focus here on the well-established cognitive tendency to *perceive* object- rather than activity-based partitions more easily in an individual's task environment.

Furthermore, proposition 6 suggests that the presence of predictive knowledge between agents impacts the designer's task allocation decision by reducing the need for minimizing allocated task interdependence across agents. I therefore test to what extent the agents' established social structures (as a proxy for predictive knowledge) impact on the designer's choices regarding task allocation and task division in a system with history compared to a blank canvas condition.

Studying the causal antecedents of division of labor in the field is challenging because it is difficult to observe and manipulate the process under controlled conditions. To overcome this challenge, I conduct experiments, in the tradition of prior work that has sought to examine important organizational issues through controlled experiments in the behavioral laboratory (e.g. Guetzkow & Simon, 1955; Cyert & March, 1963; Burton & Obel, 1984a; Malhotra & Murnighan, 2002). In particular, I examine how groups of four subjects organize to assemble two mechanical toy models. These differ on a key technological property, in that one of these is strongly decomposable - can be divided into objects that can be worked on quite independently - and the other is not. I also compare the divisions of labor agreed upon by groups of four individuals, with those planned by individual participants in a second experiment, to assess differences across a self-organizing group with some established patterns of social interaction, and one with centralized decision-making without any social structure.

The data are unusually rich, in that in addition to observing the division of labor that emerges, I also develop detailed longitudinal data (coded from video recordings) both on how the groups decide on a division of labor as well as execute within it; in addition, I also record what aspects of the problem capture the attention of participants as they engage in choosing the division of labor (by tracking their eye movement while they study the instructions).

3.2 Theory

3.2.1 Division of Labor as Task Division and Task Allocation

To aid analysis, I conceptualize the process of dividing labor as involving the search for solutions to two related but distinct sub-problems, namely task division and task allocation. *Task division* involves the decomposition of an overall goal into contributory tasks, and their subsequent clustering (also see von Hippel, 1990). A task may be thought of as a production technology - it is a transformation of inputs into outputs in a finite (non-zero) time period. *Task allocation* refers to the assignment of the clusters of tasks to individuals. It may occur either simultaneously or after task division, or may indeed influence task division.

Applying the same notation introduced in chapter 2, there will typically be many different ways to cluster the tasks in T^R, and these clusters of tasks may be allocated in different ways among the agents in the organization. T^A captures the interdependencies between the clusters of tasks allocated to the agents. The noteworthy difference is that whereas T^R is an n X n matrix where n is the number of tasks, T^A is an m X m matrix, where m is the number of agents in the organization. Since T^A embodies both a decomposition of the overall goal into clusters of tasks as well as an allocation of these task clusters among the agents, it is a concise abstract representation of a division of labor. Thus to consider the original example provided by Adam Smith, pin making could be divided into "eighteen distinct operations, which, in some manufactories are all performed by distinct hands, though in others, the same man will sometimes perform two or three of them" (1776 [1999]: 5). These would correspond to two different T^A of dimensions n=m=18 vs. n=18 and m<18 respectively, for the same underlying T^R, in which the tasks corresponded to the operations involved in pin making.[3]

We can now ask about the process that generates a T^A given a T^R - the central question in this chapter. At a very basic level, some division of labor would appear unavoidable to the extent that one individual cannot carry out all the tasks of the organization in the (perceived) T^R. While there are obviously many ways in which n tasks can be clustered and allocated across m individuals, there are two broad categories into which these alternatives fall. The tasks can be clustered either in terms of distinctive intermediate objects they generate (an 'object' based task division) or into clusters of similar tasks (an 'activity' based task division).[4] Intermediate objects may exist and have some value independent of each other; activity-based task clusters typically are without value in isolation. The value need not be restricted to the price in a market; it could reflect the ease with which a system can be rebuilt or reconfigured given the existence of intermediate objects (Simon, 1962). This well-known distinction has also been referred to as horizontal vs. vertical division of labor (Leijonhufvud, 1986) or heterogeneous vs. serial division of labor (Marx, 1906). It also relates closely to the notion of divisional vs. functional organizational designs (Chandler, 1962).

An example may clarify this distinction between activity-based and object-based task division further: say a group of people is given the raw materials and goal of building a chair. They can either choose to let one person prepare the legs, another to work on the backrest, and a third to work on the seat (an object-based task division); or

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[3] Technological change, or the adoption of a new technology may or may not lead to the need for a new division of labor; for instance technologies that support individual task execution (e.g. the replacement of slide rules with calculators) may leave the division of labor materially unchanged; conversely, a new division of labor may arise without any significant change in technology (e.g. through a reorganization, or a business process reengineering exercise).

[4] In the special case where each intermediate object requires a unique activity, the two kinds of task division are identical.

they can split the task into cutting the wood, sanding it, and applying the varnish (an activity-based task division).

3.2.2 Technological Determinants of the Division of Labor

In Smith's (1776) canonical account, three benefits of the division of labor were described - the improved productivity of the worker, the saving in time lost in switching tasks, and the development of new methods of working arising from specialization. Mintzberg noted that at the root of all three benefits cited by Smith is repetition (1979: 70) - in particular, repetition of a task cluster of narrow cognitive scope. For a given scale of production, the potential for repetition is typically higher in an activity-based (rather than an object-based) task division, because the same tasks potentially underlie multiple objects. Thus activity-based task division can enable skill building (Simon, 1962: 102). Obviously, an increase in scale further enhances the gains from skill building (Smith, 1776; Stigler, 1951).

Relatedly, activity-based task divisions also enable matching of individual agents' specialist skills to their assigned task clusters. In an extensive series of experiments, Argote, Moreland and colleagues (Liang, Moreland, & Argote, 1995; Moreland, Argote, & Krishnan, 1996; Moreland, 1999; Moreland & Myaskovsky, 2000) showed that joint assembly activities generated 'transactive memory' – knowledge of who is skilled at and knows what in a group - which is beneficial when the group approaches similar problems repeatedly. *Skill (to task) matching* is clearly a central feature of formal organizations that grow by recruitment, but in fact has been observed in division of labor patterns in non-human societies as well, where no authoritative task allocation can occur (Sendova-Franks & Franks, 1999; Anderson & Franks, 2001). Note that skill building and skill matching are jointly referred to as 'gains from specialization', but they are analytically distinguishable. Common to both though is the fact that an *activity-based* task division (equivalent to vertical or serial division of labor, Leijonhufvud, 1986) allows them to be realized more easily than an object-based task division. This was the essence of the pin factory as described by Smith (1776).

In contrast, a task division based on intermediate *objects* also offers some advantages. Clustering interdependent tasks together and assigning each cluster to a different agent can minimize the need for coordination between agents. This object-based task division (equivalent to heterogeneous or horizontal division of labor, Leijonhufvud, 1986) creates advantages through *parallelism*: first, it reduces the need for coordination across agents while enabling a focus on production (note that the agent in this sentence could easily be a 'super-agent' comprising multiple individual agents - such as an organizational unit or even a family). Given that coordination is a distinct task from production, a cognitive diseconomy of scope effectively exists for agents who must do both (e.g., due to cognitive overload). Object-based task division thus allows agents to work independently of others and with greater effectiveness at their own cluster of tasks. Second, it allows agents to make progress on several sub-tasks in parallel (Terwiesch, Loch, & DeMeyer, 2002) - this is particularly important under time constraints, which are probably ubiquitous. Third, if objects are easier to measure than activities, such a task division may also lower measurement costs (Barzel, 1982), and therefore enhance *accountability* enabling the use of sharp incentives that link rewards to outputs (Zenger & Hesterly, 1997). Marx (1906: 375) describes watch manufacturing, as an illustration of object-based task division, in which distinct intermediate objects could be worked on more or less independently, and in parallel, prior to final assembly.

Simon's account (incidentally also featuring a parable about two watchmakers- 1962 [1996]: 189) pointed to decomposability - the extent to which a task structure can be divided into clusters of tasks that can be worked on independently - as the key technological property that defined the attractiveness of object-based task division. Perfect decomposability in Nature may be rare; however, partial decomposability is not (Simon, 1962[1996]: 197). It is precisely the property of partial decomposability that sets up a tension between the choice of task division by activity or by object.

To see this, consider a case where an object-based task division is attempted for a task structure with n tasks, and let us say "x" tasks have dependencies across modules – relate to more than one object-based task cluster. Partial decomposability exists because $n>x>0$. If x is small (i.e. the task structure is "strongly decomposable"), then the gains from parallelism will be relatively larger compared to the gains from specialization through repetition; but if x is large (the task structure is "weakly decomposable"), the opposite is true.

Thus, partial decomposability allows a choice between object- and activity-based task divisions, which would then ideally be made on a comparison of the gains from parallelism and accountability from the former versus the gains from specialization in the latter. If a task structure is highly decomposable (low values of x), then the gains from parallelism (from applying an object-based task division) are relatively larger compared to the gains from specialization (from applying an activity-based task division), and vice versa. Relatedly, if m itself is large, and multiple agents are available to take them on, the gains from parallelism are enhanced.[5] Finally, if the scale (i.e. repeatability) is large, then the gains from specialization are correspondingly large.

3.2.3 Cognitive Influences on the Division of Labor

In a world of bounded rationality and partial decomposability, it may not be *ex ante* obvious whether the gains from specialization outweigh the gains from parallelism. Organizations of various sizes constantly struggle with the choice between organizing by function (activity) versus division (object) (Chandler, 1962; Gulati & Puranam, 2009). Indeed the true extent of decomposability itself may be unknown (Ethiraj & Levinthal, 2004a). Since human organizations are constituted of individuals with finite cognitive capacities as well as tendencies towards pro-social behavior (Simon, 1945; Simon, Smithburg, & Thompson, 1950) it would be surprising if cognitive factors did *not* play a role in the emergence of division of labor, quite distinct from the technological properties such as decomposability that made certain divisions of labor efficient. To be clear, I do not dispute that technological properties will influence the relative benefits of the different ways to divide labor (Smith, 1776; Simon, 1962; Leijonhufvud, 1986, 1995; Baldwin & Clark, 2000), but argue that they may not solely determine the choice between them; individuals' perception of the task should also systematically influence which division of labor emerges.

The psychology of how individual minds partition the world stresses two fundamental categories - namely, "natural" (first-order) partitions based on objects and their components, and "relational" (second-order) partitions (such as actions and processes) based on relations between first-order partitions (Gentner, 1982; Gentner & Boroditsky, 2001). Natural partitions refer to those categories that are characterized by a given set of intrinsic features, such as stand-alone objects; according to Gentner (1981)

[5] In Simon's account of the watchmakers Tempus and Hora, the difference in m played no role as neither of the watchmakers had apprentices.

these “concepts are often lexicalized as concrete or proper nouns, such as *dog, collie*, or *Lassie*.” (1981:161)[6] On the other hand, relational partitions are characterized by satisfying a specified relational structure, such as an activity relating one natural category to another; these are generally “lexicalized as predicates, usually verbs (e.g., *push, float*, or *move*) or prepositions (e.g., *across* or *near*).” (Gentner, 1981: 161). I see here a close correspondence to the distinction between object-based and activity-based task divisions in the division of labor. Objects are stand-alone and can be “concretized” as nouns, and activities of course are thought of naturally as verbs.

A significant body of evidence suggests that natural partitions are easier to generate and recall than the relational ones, especially on the ground of pure perceptual experience (e.g. Genter, 1981, 1982; Biederman, 1987; Gentner & Boroditsky, 2001; Kloos & Sloutsky, 2004). Thus, I would expect a strong tendency towards object-based task divisions rather than activity-based task divisions, for any given task structure. In the example of the group building the chair, I would expect that the group will be more likely to opt for a task division into legs, seat, and backrest, rather than wood cutting, sanding, and varnishing. I therefore propose that this ‘cognitive constraint’ should shape the emergence of a division of labor as follows:

> *Hypothesis 1a: Object-based task divisions should be perceived more easily than activity-based task divisions by those engaged in the process of division of labor.*

Further, the effects of this cognitive constraint should depend on the degree of decomposability of the task. If the task structure is strongly decomposable, separable intermediate objects are more readily available for the individuals to identify and partition by. Thus activity-based task clusters may receive relatively little or no attention in strongly decomposable tasks. However, if the task structure is only weakly decomposable, intermediate objects are either very small or hard to isolate, and task division processes are then more likely to uncover activity-based task clusters. Therefore, the less decomposable the task, the more likely it is that activity-based task clusters will be identified.

[6] Emphases in the original text

Hypothesis 1b: Activity-based task divisions should be perceived more easily in weakly decomposable task structures than in strongly decomposable task structures, by those engaged in the process of division of labor.

3.2.4 The Effect of Social Interaction Patterns and Joint Experience on the Division of Labor

Proposition 6 suggests that the presence of predictive knowledge between agents impacts the designer's task allocation decision by reducing the need for minimizing allocated task interdependence across agents. Hence, if the group has worked together before, their own (and an independent designer's) choices regarding task allocation will take the established interaction patterns between them into account. This proposition is further supported by the general tendency highlighted by different streams of research for groups to maintain their patterns of social interaction once established. The tendencies towards stability of interaction patterns within organizational aggregates at various levels of analysis have been extensively discussed. Investigating the formation of routines in a laboratory experiment, Cohen and Bacdayan (1994) highlight how dyads of participants tend to maintain their routinized responses once established. Egidi and Narduzzo (1997) show that this may even lead to inefficient path-dependency. Feldman and Pentland (2003; 2005) distinguish between different components of routines, some of which maintain stability while others instill flexibility –and they argue that the stability of routinized processes rests at the group-level (rather than the individual-level). At the organizational level, Henderson and Clark (1990) note that attempts to maintain a firm's strong-hold in a particular market leads to strong inertial forces, preventing necessary organizational changes and therefore preventing architectural innovation; while Hannan and Freeman (1977) point to the pressures toward reliability and accountability to explain organizational inertia.

Hence, a groups' established interaction patterns may have direct implications for task allocation (e.g. ensuring all group members are involved, and continue to work with whom they were working with before), and may indirectly affect task division as well (e.g. partitioning and clustering tasks so as to allow task allocation as above). I refer to this as the "history effect" on the division of labor:

> *Hypothesis 2a: Those engaged in the process of division of labor will attempt to preserve the established social interaction pattern.*

I also expect that, whether this tendency translates into the actual division of labor, depends on the degree of decomposability of the task structures and the order in which these are encountered. Specifically, strongly decomposable task structures should offer more degrees of freedom for preserving the current pattern of social interactions. This is because such tasks, by definition, can be divided into a greater number of freestanding objects that can be worked on independently (or not, as a matter of choice). Thus task allocation faces fewer constraints than in the case of weakly decomposable tasks, which do not offer this choice to the same extent. On the other hand, strongly decomposable tasks may generate weaker interaction structures because of parallelism compared to weakly decomposable structures, where by definitions, interdependencies between individuals are likely to be higher.

Hence, if the groups' social interaction patterns have been established by working on a weakly decomposable task, I expect the social interaction patterns to be maintained if the subsequent task is a strongly decomposable one (given the greater number of available freestanding objects). On the other hand, if the strongly decomposable task is encountered first, then a weaker social interaction pattern may be formed to begin with, and confronting the weakly decomposable task will 'break' it more easily. Therefore, I expect that:

> *Hypothesis 2b: Social interaction patterns are more likely to be preserved if they were established by working on weakly decomposable task structures followed by strongly decomposable task structures than in the reverse order, by those engaged in the process of division of labor.*

3.3 Experiment 1

In order to test the hypotheses, I conducted two laboratory experiments. In experiment 1, groups of four participants were asked to plan and execute the assembly of Meccano models. Meccano is a toy that consists of differently shaped metal parts (such as bars and disks), which can be fitted together with screws and nuts to build helicopters, cranes, cars etc. This toy comes in various levels of difficulty; I chose the ‘Meccano 20’ box, which contains a small battery-powered motor, and the models in the instruction booklet are about 20 steps in length.[7] The participants were told that the group would receive a monetary reward if they finished the task within the given time period, and that penalties would be applied to that reward if they failed to finish, and for every mistake made. In addition, participants received a fixed amount for their participation.

I manipulated the decomposability of the experimental task by choosing two different Meccano models for assembly: one of the models was weakly decomposable (WD) in the sense that it could be decomposed into a very limited number of minor freestanding objects, while the other was strongly decomposable (SD), as it could be decomposed into a number of significant, freestanding objects that could be worked on independently of each other except at the stage of final assembly. Each group planned and executed the assembly of both tasks (one at a time). The relative decomposability of the tasks is highlighted in Figure 3.1; the numbers in this figure refer to the different steps in the Meccano instructions, lines represent the sequence needed to connect them. In order to choose the WD and SD tasks for the experiment I created workflow diagrams like the ones shown in Figure 3.1 for each of the 20 models provided in the instruction booklet and selected the most and least decomposable ones. Both models had near identical numbers of total steps in the assembly instructions (20 vs. 21). Figure 3.2 shows a typical ‘step’ from the Meccano 20 box instructions.

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[7] I use Meccano rather than Lego as it gives me a greater level of control of decomposability. Each Meccano box comes with an instruction booklet for how to assemble the *same* pieces into very *different* objects. I make use of this feature in the operationalization of technological properties of the task (see below).

Figure 3.1 - Workflow Diagrams to Highlight Model Decomposability

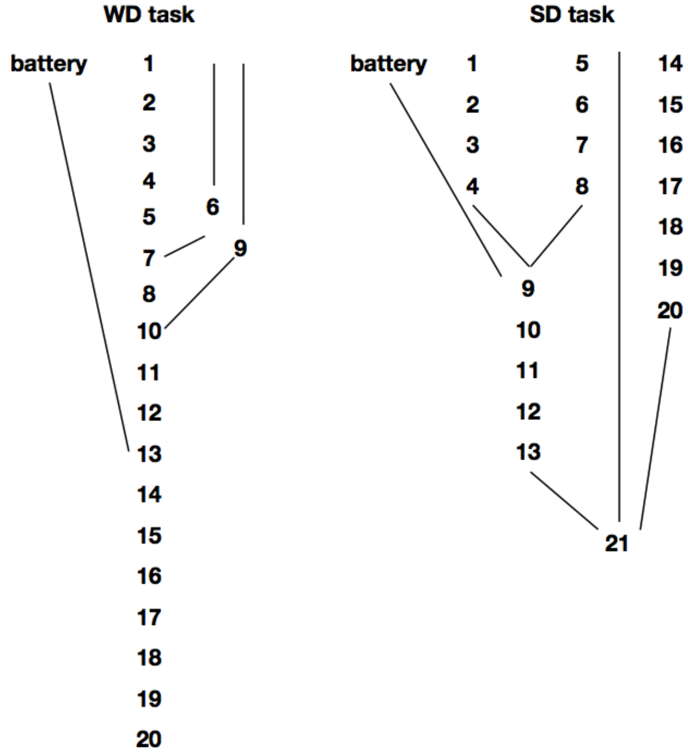
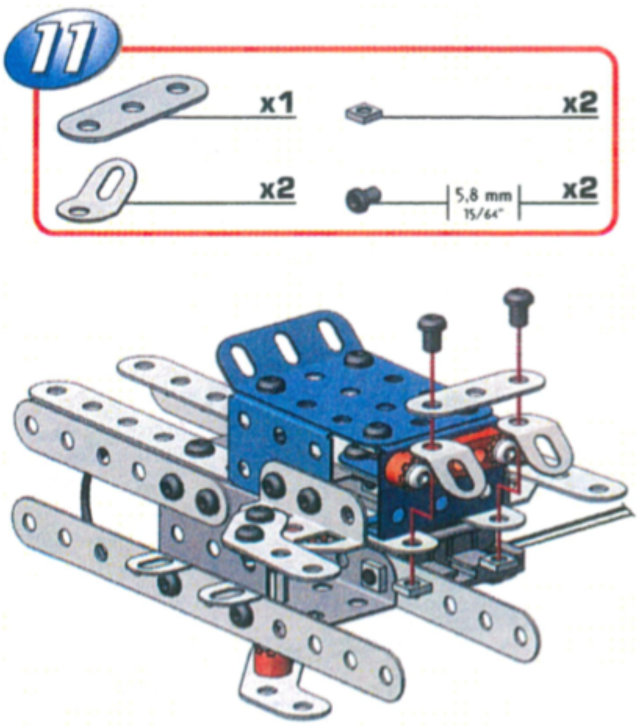


Figure 3.2 - Example of an Instruction Step from the WD Task[8]



[8] Image courtesy of Meccano Toys Ltd.

All participants were in effect provided with the same true underlying task structure T^R for each task as they received the same instructions, which show a fine-grained decomposition into steps and their necessary sequence to build the model. However, there is no prescription for the groups' allocated task structure T^A, the clusters of tasks they divide the task into, and how they distribute these task clusters among themselves.

The task clusters that participants decompose the task building problem into can be described as object-based or activity-based. *Object-based task clusters* refer to sequences of steps that can be worked on independently to produce an intermediate object. Such objects represent tangible intermediate outputs, which are eventually assembled into the model. For instance in the SD model in Figure 3.1, there are 5 objects - the sequence of steps ending in numbers 4, 8, 13, 20 and the battery.

The set of *activity-based task clusters* needed for assembly is the same across models (which one would expect given the objectives of the designers of Meccano, to allow users to assemble different models with similar skills). Based on pilot studies, I observed that the lexicon of operations that occurred in the assembly of both models constituted i. Reading instructions ii. Picking parts (finding the necessary pieces for each step), iii. Holding parts, and iv. Fixing parts together (using a toy Allen key and wrench).[9] These clusters of activities are necessary in both models. Participants seemed to display significant variation in skill at these operations, because of differences in manual dexterity, ease at reading technical specifications etc., and these activities were difficult enough to enable potential improvement through practice.

Note that both models involve the same four activities (and the same physical parts), and each of the activities is necessary *within* each object as well. Thus to the extent that coordination of an activity across objects may be necessary (for instance, the same individual and set of tools could potentially be used for Picking and Fixing across objects, giving rise to improved skill and efficiency in the use of tools), there are some interdependencies across objects in both models. However, the larger number of steps within each object in the SD model means that the benefits of parallelism are more significant in that model - participants can potentially work for longer, independently

[9] Both Fixing and Picking are explicitly represented in the instruction booklet: for each step there is a small box which lists the type and number of different pieces necessary for that step; a diagram then illustrates how those pieces are fitted together or fitted onto already existing parts of the model (see Figure 3.2 for an example).

and in parallel on their respective object without having to coordinate with others engaged in working on other objects. The two models I chose thus make salient the trade-off in task division between parallelism (easier to achieve in the SD model) and specialization (possible in both models). Yet it is not obvious from the instructions, which gains are of greater magnitude. Given the need to complete model assembly within the allocated time, it is plausible that this can be aided either by generating specialized skills at the four basic activities, or by working in parallel on different objects, but there is no basis for the participants to easily determine which is preferable (and indeed neither may be preferable across both models).

For each model, the group went through two phases: the planning phase – a five-minute period to plan the assembly in which each participant had an identical copy of the instructions – and the execution phase – a 45 minute period in which the complete Meccano set and two sets of tools were used to build the model as a group. For each group, I coded detailed task division and task allocation data for the planning phase.

I capture the object- and activity-based task clusters identified by the groups by carefully coding the different task divisions suggested by the participants throughout the five-minute planning phase of each session. For example, if the first participant highlighted that the battery could be assembled separately, I counted that as one object-based task cluster ('battery' vs. 'rest of the model'). I coded the entire conversation across the five minutes and recorded each addition (or alternative) task division suggested by the different participants, and to what extent those entailed object-based or activity-based task clusters, or both. [10] The coding process is highlighted in a simplified example in Figure 3.3. At the end of the planning phase, every group had decided on a task division.[11]

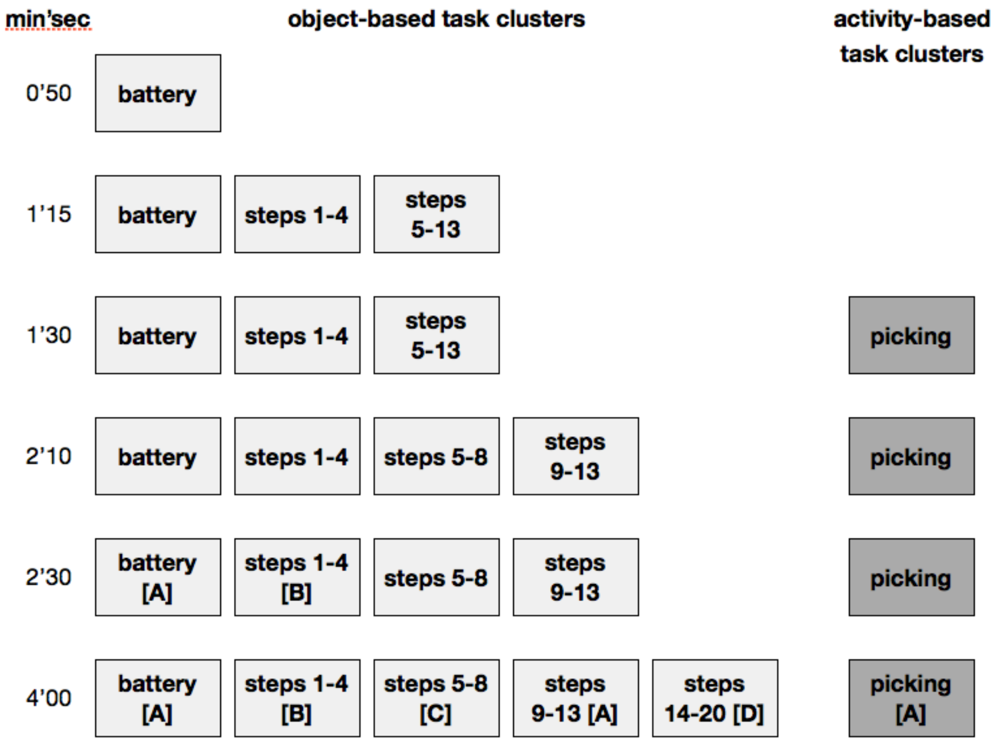
Task clusters identified during the planning phase were chosen or allocated to 'sub-groups' of different sizes. I labelled any configuration of participants that was allocated to work together as a 'sub-group'; thus the size of a sub-group could range from one (an individual) to four (all four participants working closely together). Task

[10] Everything in the planning phase was coded independently by another coder, with discrepancies settled through discussion.

[11] Note that none of the groups seemed to feel that the time allotted for the initial discussion (five-minutes) was inadequate: indeed 32% finished their discussions up to 120 seconds early and 25% asked to receive the pieces ahead of time to start assembly.

allocation occurred either through self-selection or assignment through others. The task allocations are captured by the participants' assigned identifier (A-D), and are added and updated throughout the planning phase.

Figure 3.3 - Coding Example: Initial Task Division and Allocation of a SD task[12]



For the execution phase (45 minutes) I coded who worked with whom on what step, and which participant performed which activity on the different steps for how long (in seconds). I updated the interaction structure when I observed changes in collocation and consistent joint handling of parts and coordination of activities on objects. Note that for this coding I had access not only to video but also the audio of the participants' discussions. I therefore base my analyses on very detailed data on the social patterns of interaction, as well as each individual's activities and productivity. I define a dominant

[12] Figure 3.3 provides a stylized example for the task division and task allocation during the five-minute discussion for a single group. Every row represents a new piece of information that one of the group members highlights. Object-based task clusters are represented in white, while activity-based task clusters are represented in gray. Task allocation to participants A, B, C, and D is represented by square brackets.

sub-group as the configuration of mutual interaction in which participants spent the greatest amount of time during the session.[13]

3.3.1 Procedures

Written instructions regarding the procedure of the study as well as the incentive structure were handed out and read out aloud (original instructions are provided in Appendix A). I also reiterated the main points of the procedure, and participants were encouraged to ask any questions they might have had. I explained that they would work in groups of four to assemble a toy model, and that I would provide them with the detailed instructions, the tools, and all necessary parts to put the model together correctly. They were given 5 minutes to plan the assembly of the model, followed by up to 45 minutes to plan and execute the assembly.

The groups were evaluated on the basis of (1) the time needed to complete the model, and (2) the accuracy of their model – i.e. the absence of deviations between their assembled model and that shown in the instructions. The group received £40 if they finished building the model within the time limit, else £20. I also made clear that I would deduct two pounds for every inaccuracy and for every missing step. The group was told that they would receive the final reward at the end of the session and that they would then be free to decide how to split the money among them.

I then distributed one set of the Meccano instructions to each participant for their first assigned model. They were told that they would have five minutes to plan and discuss the assembly of the model. After five minutes they received a box with all the parts that come in a standard Meccano 20 set – the parts were not separated into different types. I also added a second set of the tools (a small Allen key and wrench) to the box. A clock was available for the participants to keep track of time. At the end of the 45 minutes of assembly, I evaluated their model according to progress and accuracy, and awarded £20 or £40 minus any penalties for inaccuracies and missing steps. The participants were then asked to split the money among themselves, followed by a brief questionnaire to capture demographic information. I then announced that the second session would follow the same format as the first, while the Meccano model would be

[13] The mutual interaction among members of the same sub-group is characterized by the pattern of consultation on interpreting the instructions as well as assistance in putting or holding parts into place. In contrast, interactions across sub-groups (if any) are limited to questions about missing parts or inquiries about the time remaining.

different, and repeated the same procedure as described above. At the end of the second session I debriefed the participants and engaged in an informal discussion to answer any questions about the experiment and the purpose of the study. Both sessions were video recorded with the permission of the participants.

Participants. Sixty-four engineering undergraduate students from a globally reputed science and technology university participated in this study. Participants were randomly assigned to groups of four and to experimental conditions: eight groups received the SD model first, followed by the WD model; the other eight groups received the models in the reverse order. 56% of the groups had at least one female participant; 25% were composed of two male and two female students, while 31% contained one female student.

Testing for the Cognitive Constraint. If the participants are significantly affected by the cognitive constraint, which makes them see object-based task clusters (i.e. first-order partitions) more easily than activity-based task clusters (second-order partitions) when engaging in task division, we should expect that the groups identify more object-based than activity-based task clusters during the planning phase. I test hypothesis 1a at the aggregate level across groups and sessions, as well as across groups within session 1 (ruling out any experience effects), and within group across sessions (holding group-specific idiosyncrasies constant). I test Hypothesis 1b by comparing the number of activity- and object-based task clusters identified across SD and WD models (on aggregate and by session).

Testing for the History Effect. If the participants are significantly affected by the history effect, which makes them preserve social interaction patterns (Hypothesis 2a), we should expect that the dominant social structure from the execution phase in session 1 is carried over into the beginning of the planning phase of session 2 as the proposed task allocation. Given the constraints imposed by the WD task on the number of available, free-standing objects that can be allocated to different participants (and worked on in parallel), we should expect that the social structure successfully survives to the end of the planning phase to a greater extent in groups assembling the models in the order 1WD-2SD, but to a lesser extent in those groups assembling the models in the reverse order (1SD-2WD) (Hypothesis 2b).

3.3.2 Results

Figure 3.4 summarizes the results for experiment 1. I report the session- and model-specific mean values across the eight groups for each of the treatments (standard errors are reported in brackets). All differences are tested for statistical significance using the Wilcoxon rank-sum test (also known as the Mann-Whitney two-sample statistic), unless stated otherwise. The Wilcoxon rank-sum test tests the hypothesis that two independent samples are from populations with the same distribution and is appropriate for small samples. All results are equally robust when the Fisher exact test, or a non-parametric k-sample test on the equality of medians is used.

Evidence for the Cognitive Constraint. In the planning phase, the groups systematically identified a greater number of object-based than activity-based task clusters (this holds throughout the planning phase as well as for the final, agreed-upon task division for the groups, reported here): Aggregating across session and models, groups identified an average of 3.81 object-based and 0.56 activity-based clusters (paired ttest $p<0.001$), a result that holds equally strongly when comparing the type of task clusters identified by session (Session 1: object-based = 3.25, activity-based = 0.56, paired ttest $p<0.001$; Session 2 object-based = 4.38, activity-based = 0.56, paired ttest $p<0.001$). Thus, hypothesis 1a is supported. Note that all groups agree to divide the assembly task predominantly by object, regardless of its degree of decomposability (WD object=3.3125, activity=1.0, paired ttest p=0.0003; SD object=4.3125, activity=0.125, p=0.000, across sessions).

Hypothesis 1b predicted that the decomposability of the task should influence how the cognitive constraint operates. Specifically, it should make the discovery of activity-based task clusters relatively easier in WD than SD tasks. I find that in the planning phase, the groups indeed identified a greater number of activity-based task clusters in the WD model than in the SD model, regardless of session (SD=0.125, WD=1, Wilcoxon p=0.0004), even though in principle the same number of activity-based task clusters is feasible in both models (namely four- Reading, Picking, Holding and Fixing). The results also hold when comparing the number of activity-based task clusters identified in the WD and SD models by session (see Figure 3.4, session 1 Wilcoxon p=0.0852; session 2 Wilcoxon p=0.001). Thus, hypothesis 1b is also supported.

Figure 3.4 – Experiment 1: Summary of Results

		Experiment 1 - Group	
		SD	**WD**
Session 1 - Planning Phase	**number of object-based task clusters**	4.125 (0.227)	2.375 (0.263)
	number of activity-based task clusters	0.25 (0.164)	0.875 (0.295)
Session 1 - Execution Phase	**number of specialists**	0.25 (0.164)	0.875 (0.227)
	error-adjusted rewards	29.375 (3.746)	4.25 (1.578)
	group completed the task	0.75 (0.164)	0 (0.0)
	average number of steps completed after 10 mins	4.625 (0.420)	1.5 (0.189)
	average number of steps completed after 25 mins	12.375 (0.498)	5.125 (0.398)

		SD	**WD**
Session 2 - Planning Phase	**number of object-based task clusters**	4.5 (0.378)	4.25 (0.701)
	number of activity-based task clusters	0 (0.0)	1.125 (0.227)
Session 2 - Execution Phase	**number of specialists**	0 (0.0)	0.75 (0.25)
	error-adjusted rewards	35 (3.273)	16 (3.464)
	group completed the task	0.875 (0125)	0.125 (0.125)
	average number of steps completed after 10 mins	7.25 (0.366)	3.125 (0.350)
	average number of steps completed after 25 mins	13.875 (0.581)	7.75 (0.453)

Evidence for the History Effect. Hypothesis 2a predicts that groups will carry over their previous session's dominant social structure into the beginning of the planning phase of the next session. Throughout the 45-minute assembly, I coded who worked with whom for how long on which steps. From those data I could identify the dominant social structure for each group and compare that to the task allocation suggestions at the beginning (t=0) and the end (t=5) of the planning phase from session

2. Remarkably, I found that the discussions in every single group (regardless of task type in session 2) initially focused on maintaining the existing sub-group structure, i.e. the initial attempts of task division and task allocation were done taking the existing social structure as fixed; these results are reported in Figure 3.5. Thus, hypothesis 2a is supported.

Figure 3.5 – Experiment 1: Dominant Social Structures

Experiment 1 - Group		**SD1-WD2**	**WD1-SD2**
		SD1	**WD1**
Session 1 - Execution Phase	**average time spent in dominant social structure**	1696.5 (237.713)	1899.375 (230.898)
		WD2	**SD2**
Session 2 - Planning Phase	**attempt to maintain dominant social structure at t=0**	100%	100%
	success at maintaining dominant social structure by t=5	12.50%	100%

Hypothesis 2b predicted that the decomposability of the task should make the preservation of the social patterns of interaction easier in session 2 when the groups established their social interaction patterns by working on a WD task and faced the SD task in session 2. The data support this asymmetry in the preservation of the social interaction patterns: in the groups that worked on the two models in the sequence of WD1-SD2, dominant sub-groups were replicated 100% of the time, while in the reverse sequence (SD1-WD2), only 12.5% of groups retained those dominant sub-groups into session 2 (WD-SD=1, SD-WD=0.125, Wilcoxon p=0.0006). It appears that this result is not driven primarily by the relative stability of the interaction patterns for the WD and SD task in session 1; the average time spent in the most stable sub-group configuration in SD1 was not statistically different from the average time spent in WD1 (SD1 = 1696.5; WD1 = 1899.375; Wilcoxon p=0.6735). Thus it appears that the greater degree of freedom offered in the SD task is the key factor.

3.3.3 Additional Post-Hoc Analysis

An additional implication of H1b is that specialization is more likely to emerge in WD tasks than in SD tasks. To test this intuition, I defined a participant within a group to be a specialist in an activity k in session t if he or she spent more than 50% of the total time spent on that activity k by the group in session t.[14] The extent of specialization in the group in a session was defined as the sum of the number of specialists in that group in that session. I found that in general, more specialization emerged in the WD task than in the SD task (significant by session (session 1 Wilcoxon p=0.0451, session 2 p=0.0098 as well as on aggregate: SD=0.125, WD=0.8125, Wilcoxon p=0.0013); even though both models allow for the same number of activity-based task clusters to be identified.

I also examined if the cognitive constraint had any noticeable performance implications. I compared the error-adjusted rewards (i.e. the performance-based reward the groups receive at the end of their assembly time) based on whether the groups identified any activity-based task clusters by the end of the planning phase. I would expect that a group that starts the WD task with an object-based task division should fare worse than a group that starts the WD task with at least some activity-based task clusters. Out of the 16 groups, four groups started the WD task without any activity-based task clusters. On average, those groups received a total of 4.50 currency units, while the groups with some activity-based task clusters from the start received an average of 12.00 currency units; the difference is marginally significant (p=0.0765).

In the SD task, I saw no significant performance differences between groups that did or did not identify activity based task clusters. This may be because in the SD model, the gains from parallelism are just overwhelmingly large; it is also the easier model to assemble in a group under time pressure, as group performance was relatively high in the SD task, and less so in the WD task (task completed: SD=0.8125, WD=0.0625). This is true even if measured as the extent of completion at different time intervals (5, 10, 15, 20, and 25 minutes, Table 3.4 includes the numbers for t=10 and t=25).

I also conducted additional analyses on the impact of the social interaction patterns on the division of labor. With respect to the task division, I found that the

[14] The result stated holds for a lower threshold of 30% as well.

groups were equally careful in sessions 1 and 2 to find at least four task clusters (either of object or activity) so that none of the group members would remain idle (average number of task clusters is 4.375, not significantly different from the number of participants in each group – 4 in a paired t-test). This was particularly evident in the WD task where the initial conclusions in the groups' discussions left them short of four task clusters. This may be seen as an instantiation of the humorous adage referred to as "Parkinson's Law".[15]

However, with respect to the task allocation for the WD task in session 2, the groups broke up their group structure in order to accommodate the relative lack of decomposability. Interestingly, the stability of sub-group structures across sessions in the WD1-SD2 sequence may have led to a less efficient task allocation for the SD task – while four object-based task clusters were identified by the groups (average of 4.5 object-based clusters in SD2), the average number of sub-groups used for SD2 was 2.75 (significantly different from 4, paired t-test t=0.0053). Thus, groups *identified* four separable object-based task clusters for the SD task, and noticed that those could be worked on in parallel, but then proceeded to allocate those to the existing *sub-groups* rather than the four *individuals*.

I also found that the distribution of rewards at the end of each session was always equal. Regardless of individual performance during the sessions (in terms of competence or effort), every group chose to split the rewarded money evenly across the members. Even though as an observer I could identify a number of 'less competent' group members as well as a few who spent a large proportion of their time on 'watching others' or 'doing nothing' (on average 15.0% of time in the WD task (min=1.25, max=26.4 minutes) and 7.4% in the SD task (min=1.1, max=18.8 minutes), none of those were at the receiving end of negative remarks, actions, or consequences in terms of reward split. Thus, the participants seemed more inclined to split equally than to argue for their (subjectively) fair share, an approach that may further signal their desire to preserve the social structure. It is also possible that this result is at least partly driven by a form of partition dependence (Langer & Fox, 2005).

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[15] This law, articulated by Cyril Northcote Parkinson as "Work expands so as to fill the time available for its completion" can be extended in this context to the number of individuals required to complete a given task. (http://en.wikipedia.org/wiki/Parkinson's_law)

3.3.4 Discussion

The findings from Experiment 1 provide evidence for systematic ways in which the decision-makers' perception of the task and 'history' among the subjects play a role in the process of the division of labor. I find that object-based task clusters emerge more often than activity-based task clusters (H1a). This tendency is moderated by the decomposability of the task, to the extent that the WD model makes activity-based task clusters more salient, due to the relative lack of independent object-based task clusters (H1b). In additional analyses I see that specialists are more likely to emerge in the WD task, even though the same set of activities underlies both tasks.

The evidence from Experiment 1 also suggests a tendency for existing interaction structures to be preserved, particularly when going from a strongly to a weakly decomposable task (H2a & b). Thus the general tendency to preserve interaction patterns is constrained by the technological properties of the task - and the tendency is more likely to prevail if the SD task is encountered later, given the greater degrees of freedom it offers in terms of task allocation. Thus, history - the existing social interaction pattern - can shape the emergence of the division of labor, but within the limits imposed by technological properties.

While Experiment 1 offers encouraging evidence for the theoretical arguments developed above, it also raises a few questions. First, it is not clear if the evidence for the cognitive constraint really reflects a property of how people think when engaged in task division, or of how groups agree on task division; perhaps objects are just easier to articulate and coordinate on as a basis for task division. (Note that it is implausible that the results are simply explained by participants anticipating greater gains from parallelism in the SD model, and greater gains from specialization in the WD model; this is because participants still identify more objects than activities in the WD task, and in fact do not identify all four activities in the WD task.)

Second, it is possible that the evidence for the two factors is confounded in this study; perhaps participants prefer object-based task division and the parallelism it entails in order to keep all group members simultaneously occupied. Further, the observed tendency of the participants to construct a division of labor that kept all group members occupied (they found roughly four task clusters of either activities or objects) may be a consequence of the tasks I selected (i.e. they could be broken up into four tasks on average), rather than reflecting a “Parkinson’s Law”-like effect. To shed further light on these issues, I conducted a second experiment using the same set of tasks.

3.4 EXPERIMENT 2

In experiment 2 I gave the same two Meccano models to individual participants and studied the planning phase only. In addition to their verbalized choices of task division and task allocation, I observed the non-verbalized behavior of the individuals by tracking their eye movements while they studied the instructions. The use of eye tracking to study attention patterns in individuals is well established in a variety of fields (see Duchowski (2002) for an overview). This method allows me to use the individual’s gaze as a proxy for his or her attention. Thus, I can draw inferences about the relative prevalence of information on the medium presented (here the instruction pages) as perceived by the individuals (e.g. Wedel & Pieters, 2000; Rayner et al., 2001), and hence measure the cognitive constraint more directly.

The task for these individual designers consisted in deciding how many group members to recruit for the assembly, and choosing a task division and allocation for those recruits. While the individual participants (designers) were paid a fixed fee independent of their choices, the reward for their (fictitious) recruits was identical to that in experiment 1. Note that experiment 2 differs from experiment 1 in two important ways: (1) it allows for a more precise measurement of the effects of the cognitive constraint; (2a) it removes any effects of prior social interactions on the task by implementing a centralized decision-making structure as opposed to a self-organizing group and (2b) it precludes the accumulation of joint group experience prior to choosing a division of labor for the second model. At the same time the task sequencing for participants (WD-SD and SD-WD) was the same as in Experiment 1.

3.4.1 Procedure

In experiment 2 I used the same Meccano model instructions as in experiment 1, to be studied by a single ‘designer’ to make decisions about the task division and task allocation. While these single participants did not engage in the actual execution phase, they were initiated into the experiment by explaining that a group of subjects were to assemble two Meccano models in sequence on their directions. I described the same rules and reward structure as in experiment 1 and asked the designers to study the instructions to make their decision.

Each designer (of the 16 individuals drafted from the same subject pool but distinct from the group members in experiment 1) was shown the instructions for the two models on a computer screen while I tracked their eye movements, using a Tobii T60 (built-in desktop) eye tracker; the sequence of the models was reversed for half of them. I asked the participants to state how many individuals they would select to assemble the model in 45 minutes (allowing up to four members). They were then asked to verbalize how they would divide and allocate the task among those group members. While I told the designers that the group members they recruited would receive the same monetary reward as in experiment 1, the subjects in experiment 2 were paid £10 independent of their choices.

Testing for the Cognitive Constraint. The eye tracking data allows me to observe a non-verbalized aspect of the participants' process of the division of labor. The eye tracker accurately records which part of the screen the participant focuses on and for how long. I was able to measure the fixation time (seconds spent) on object-based versus activity-based visual information as well as the ratio of time spent looking at activity- to object-based task clusters to capture the relative difference across the SD and WD models. We should expect that participants spend more time focusing on object-based than activity-based task clusters, and that this ratio is greater for the SD model than for the WD model (H1a and H1b).

Unlike the participants in experiment 1, the individual designers in experiment 2 were not exposed to any social interaction or group experience before they made their choices of task division and task allocation in session 2; therefore no direct test of H2a or H2b is attempted in this experiment.

3.4.2 Results

Evidence for the Cognitive Constraint. Table 3.6 summarizes the results for experiment 2. Overall, the individual designers identified more object- (2.91) than activity-based (0.78) task clusters (paired ttest $p<0.0001$), although this tendency was weaker for session 2 than session 1 (Session 1: object-based = 3, activity-based = 0.625, paired ttest $p<0.001$; Session 2 object-based = 2.813, activity-based = 0.938, paired ttest p=0.0197). These results are in line with the results from Experiment 1 and support H1a. Further, the number of activity-based task clusters identified was higher in the WD model than in the SD model among the individual designers in this experiment (SD=0.375, WD=1.19; Wilcoxon p=0.0073; SD1=0.25, WD1=1, Wilcoxon p=0.0372; SD2=0.5, WD2=1.375, Wilcoxon p=0.0751), providing strong support for H1b.

Table 3.6 - Experiment 2: Summary of Results

Experiment 2 - Individual Designer

		SD	WD
Session 1 - Verbalized Choices	**number of object-based task clusters**	3.875 (0.295)	2.125 (0.441)
	number of activity-based task clusters	0.25 (0.164)	1.00 (0.267)
	number of group members	2.625 (0.263)	2.375 (0.263)
	ratio of activity/object task-clusters identified	0.042 (0.042)	0.625 (0.246)
Session 1 – Eye tracking Data	**ratio of fixation on activity/object**	0.315 (0.036)	0.491 (0.037)

		SD	WD
Session 2 - Verbalized Choices	**number of object-based task clusters**	4.375 (0.532)	1.25 (0.590)
	number of activity-based task clusters	0.5 (0.189)	1.375 (0.375)
	number of group members	2.75 (0.25)	1.75 (0.25)
	ratio of activity/object task-clusters identified	0.333 (0.122)	0.563 (0.175)
Session 2 – Eye tracking Data	**ratio of fixation on activity/object**	0.394 (0.021)	0.390 (0.065)

The eye tracking data revealed that, in general, individuals displayed greater fixation times on the pictorial representations of the object-based than on the activity-based instructions, regardless of the model (object=125.96; activity=48.78, Wilcoxon p=0.0000). This is despite the fact that the activity-based instructions are represented saliently in a separate box for each step of assembly in both models (as shown in Figure 3.2). This supports H1a. Partially consistent with H1b, I also found that the ratio of fixation time on activity-based to object-based instructions was greater for the WD model than for the SD model in session 1 (SD1=0.32, WD1=0.49; Wilcoxon p=0.0025); however this difference disappeared for the second session (SD2=0.39; WD2=0.39).

3.4.3 Additional post-hoc analysis

While I have removed the effect of social interaction in experiment 2, I may still be able to confirm indirectly whether the Parkinson's Law result highlighted in Experiment 1 is due to the experimental setup or a 'real' result. Recall that I found in Experiment 1 that the groups were equally careful in sessions 1 and 2 to find at least four task clusters (either of objects or activities) so that none of the group members would remain idle (average number of task clusters was 4.375, not significantly different from the number of participants in each group – 4 in a paired t-test). In experiment 2 I found that the designers consistently chose less than four members for their groups (average group size=2.88, different from 4, one-sample ttest p<0.0000), confirming the fundamental impact that the fixed group size in Experiment 1 had on the groups' task division process. The individuals also chose systematically less members for the WD task than for the SD task, regardless of session (SD=3.3125, WD=2.4375, Wilcoxon p=0.0028), reflecting fewer opportunities for parallel work in the WD task.

3.4.4 Discussion

The results of Experiment 2 strengthen my confidence in the existence of the cognitive constraint – individuals do indeed show a greater propensity to perceive object-based task clusters rather than activity-based task clusters when engaging in task division. These findings are in line with the choices made by the groups in experiment 1. This tendency towards object-based task division seems to be reflected in their non-verbal behavior (what they pay attention to) as much as in their verbalized choices and is manifested at the individual- as well as group-levels; and it occurs in the absence of any history or social effects. Thus, even though object-based task division may be preferred by individuals based on motivational reasons (Hackman & Oldham, 1976) or for ease of monitoring (Zenger & Hesterly, 1997), I show in experiment 2 that the cognitive constraint has at least an important additional impact on the participants' choice.

In contrast to the findings for the groups in experiment 1, familiarity with the task appears to weaken the individual designers' tendency to choose object-based task clusters, as well as their tendency to focus more on activity-based task clusters in the WD model (eye fixation). It appears that this 'experience' effect is suppressed in groups; I speculate that the preference for object-based task clusters gets weakened with any experience (in groups and individuals, with or without hands-on experience), but it may be that the greater ease of naming and describing objects rather than activities counteracts the experience effect in groups (Reagans, Miron-Spektor, & Argote, 2012).

There was no social or history effect by design in Experiment 2. However, I could indirectly assess whether the task division observed in Experiment 1 had a social component by contrasting it with that in Experiment 2, where there is none. The results suggest that this is indeed the case; participants in experiment 2 systematically recruited less than four group members for the same tasks as those in experiment 1. Hence the tendency towards preserving the existing social interaction structure appears to influence not only task allocation but also task division.

3.5 Conclusion

The process of the division of labor is an integral part of organization design. In this chapter I examine this process in great detail by studying the decisions of task division and task allocation in the behavioral laboratory. I test to what extent the subjects' cognitive constraints as well as the established social interaction patterns between them (history) affect their choices regarding task division and allocation. The results suggest that this process of division of labor is significantly affected by the individuals' tendency to perceive object-based task division more easily than activity-based task division.

In addition, my results suggest that history has an important impact: the process of division of labor when a pre-existing group takes on a task is not the same as that when a group is formed around a task. In the former case, the tendency to preserve the existing group structure - its boundaries and internal interaction patterns - may preclude certain divisions of labor and make others more likely. This tendency may confront and succumb to objective technological constraints in weakly decomposable task environments, but if the technological properties offer many degrees of freedom in organizing the work, then the preservation tendency may prevail. Specifically, the more decomposable task in the experiments allowed the existing interaction structure to prevail, but the less decomposable task did not. An organization designer who is blind to the existing social structure (as in experiment 2) may offer a means by which groups can avoid their past exercising undue influence on their division of labor.

CHAPTER 4

The Effects of History on Corporate Reorganizations

4.1 Introduction

Corporate reorganizations are a common occurrence and indeed have been a focus of inquiry since the inception of academic analysis of corporate strategy (Chandler, 1962). While the focus in this domain has largely been on which organization design and environmental factors trigger a given reorganization as an independent event (Burns & Stalker, 1961; Lawrence & Lorsch, 1967; Thompson; 1967; Galbraith, 1973), several scholars have pointed to a pattern only observable when examining successive reorganizations. These scholars have highlighted that firms show a tendency in their reorganization decisions to revert back to the organizational structure they had previously abandoned - and to do so repeatedly, creating a reversal pattern over time. For example, Mintzberg noted that "the swings between centralization and decentralization at the top of large American corporations have resembled the movements of women's hemlines" (1979: 294); while Carnall points to the repeated choice between centralization and decentralization as one of the main design dilemmas firms face (Carnall, 1990: 18). This pattern of reversal has also been commented upon repeatedly in later work (Eccles & Nohria, 1992; Cummings, 1995; Nickerson & Zenger, 2002).

A reorganization is the CEO's conscious decision to change the organizational units the employees are grouped into, be that around a set of products, geographic regions, users, or functions (or a combination of these). Since there are realistic limits to effective integration of efforts within a unit as unit size increases due to bounded rationality (Simon, 1945) and opportunism (Williamson, 1975), the partitioning of the organization into sub-units is inevitable (Lawrence & Lorsch, 1967). The key issue then becomes which among several possible groupings is most useful at a given point in time, recognizing that any choice implies emphasizing some interactions (within units), while deemphasizing others (across units) (Nadler & Tushman, 1997). As such, a reorganization is one of the tools at the CEO's disposal to address important organizational challenges, a tool which allows him or her[1] to change the employees' focus around particular problems that need to be addressed, or new market opportunities that should be realized (Nadler & Tushman, 1997). Reorganizations have been studied extensively as a realignment tool in the context of organization design (Chandler, 1962; Lawrence & Lorsch, 1967; Thompson, 1967; Galbraith, 1973). We have learnt about several important triggers of reorganizations such as changes in strategy, leadership, environmental conditions, age, and corporate scope (Chandler, 1962; Kimberly & Miles, 1980; Egelhoff, 1982; Fligstein, 1985; Karim & Mitchell, 2000; Agarwal & Helfat, 2009), and scholars have also noted tendencies for firms to conform to the examples set by competitors (Fligstein, 1985; Haveman, 1993). While these factors explain why an individual reorganization may occur, they cannot account for the reversal pattern over time, unless we make the highly implausible assumption that these external factors themselves show cyclicality.

To date, we have accumulated some anecdotal evidence for this reversal pattern, and a theoretical explanation for its occurrence has been proposed. In particular, Nickerson and Zenger (2002) suggested that the repeated reversal between centralization and decentralization is the CEO's attempt to overcome the limitations of organizational structure by preventing excessive alignment between how the employees get work done (the informal organization), and what the reporting structure directs them to do (the corporate structure). While this is an important first step, the dichotomy applied to the structural choice set (between centralization and decentralization) and other simplifying assumptions, which underlie much of the anecdotal and theoretical work on this topic, limit our understanding of this phenomenon. In particular, if the set of feasible corporate structures is limited to two, a reversal appears to be the only possible outcome of any reorganization decision; and if we do not account for the differences that different structures impose on the employees' behavior, we will gain only limited insights into what drives these decisions.

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[1] Throughout the rest of the chapter I will assume that the particular CEO under discussion is female and hence avoid saying "him or her" for economy of expression.

In this chapter, I highlight that a more careful consideration of the different types of structure an organization may adopt is necessary to make a clear distinction between reorganizations in general and reversals in particular. I argue that reorganization and reversal decisions may be driven by different mechanisms. While changes in *external factors* create pressures to realign the internal structure to the new external conditions thus leading to *reorganizations* (e.g. Lawrence & Lorsch, 1967; Thompson, 1967; Galbraith, 1973), the CEO may choose to ***revert*** back toward the type of structure previously abandoned because of recurrent problems created by the *organizational structure* itself (Cyert & March, 1963; Nickerson & Zenger, 2002). In doing so, I highlight the effect of prior structures on the choice and timing of subsequent re-design choices.

I focus on the strategic role reorganizations can play as a tool to focus the employees' attention around the most pressing challenge or issue the CEO identifies at a given point in time in order to explain the reversal decision. While the organization structure is a powerful focusing device, it has strong limitations in that it can focus the employees around a limited set of issues only, and the deficiencies of any organization structure become apparent over time (Nadler & Tushman, 1997). Hence, the CEO may make a conscious decision to revert towards the previously abandoned type of structure in order to alleviate the shortcomings of the current organization design – even in the absence of any external triggers for structural change. These insights allow me to develop theory that highlights why the ***rate*** at which reversals occur is driven by the current type of structure held by the organization. To date, the rate of reversal has been assumed to be constant, i.e. independent of the structure held by the organization. I probe deeper into the mechanism that drives the reversal and highlight that we should expect an ***asymmetric*** rate of reversal as a function of the current structure held by the organization. Given that the type of structure adopted significantly impacts the employees' collaboration behavior, we should expect that the speed of achieving the desired level of collaboration is also significantly (and differentially) affected by who the structure groups together.

Empirically, I show that the reversal pattern does indeed occur systematically in the industry under study, thus providing a first large-sample test of this phenomenon. However, it is conceivable that all reorganization decisions are driven by changes in the contingencies; the anecdotal evidence on the reversal patterns could be explained by a regression to the mean effect, i.e. as an occasional chance event. In order to strengthen the empirical test, I adopt this regression to the mean explanation as a more sophisticated Null Hypothesis against which to test the reversal hypotheses. Furthermore, I test the macro-effects of the theory developed in this chapter and show empirically that the type of structure does indeed drive asymmetry in the rate of reversal. In order to test the theory effectively, I develop a way of operationalizing organizational structure as a continuous measure, which will allow me to better capture reality. To test the theory developed, I use a unique dataset on the global cellphone manufacturing industry that contains all corporate-level reorganizations for the vast majority of firms from the inception of the industry in 1983 through 2008.

4.2 Theory

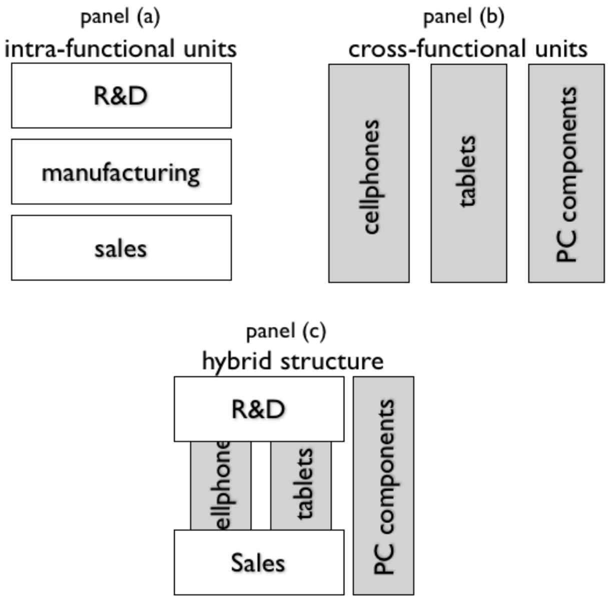
4.2.1 Corporate Reorganization: A Shift in Structural Emphasis

According to the anecdotal evidence, the reversal pattern consists of a pendulum-like back-and-forth between centralization and decentralization. If we consider Mintzberg's quote from the introduction, he highlights how large corporations appear to repeatedly cycle between these two structures. Similarly, Nickerson and Zenger (2002) present anecdotal evidence describing how HP, Ford, and KPGM showed repeated shifts between centralizing their corporate structure followed by decentralizations. This degree of simplification in the terminology is misleading for two reasons; if taken literally it implies (1) that the CEO effectively pulls the last organization chart out of her drawer and re-implements what she abandoned the last time around; and (2) that the CEO has no choice but to decentralize the firm if it is currently centralized and vice versa (which makes the reversal pattern tautological). Thus, while the construct of centralization is useful in describing certain aspects of an organizational structure (e.g. Zannetos, 1965), applying it to the corporate structure as a whole leads to a misrepresentation of the phenomenon of reversal.

In today's business world we are accustomed to seeing corporate structures that are either organized around (at least) two dimensions in a matrix structure (e.g. user-focused and product-focused units (Galbraith, 1971; 2008)) or to follow a different kind of hybrid structure that consists of a number of company-wide functional units (such as a corporate R&D unit) and a number of product-focused and geography-focused units (or any other combination of the four basic grouping dimensions outlined by Gulick (1937), by product, user, geography, or function). While small organizations may function well without much formal structure, larger organizations require the grouping of employees into organizational units in order to facilitate coordination and cooperation *within* the units, while also putting in place linking mechanisms to connect individuals *across* organizational units (Lawrence & Lorsch, 1967; March & Simon, 1958; Nadler & Tushman, 1997). Given the multiplicity of grouping dimensions applied to hybrid structures, the interpretation of what constitutes a centralized structure is rather difficult to ascertain. Furthermore, attempting to force these complex structures into one of the two extremes of centralization and decentralization would disregard important variation.

I therefore adopt an alternative conceptualization of corporate structure, which allows me to compare these rather complex hybrid structures on a continuum of possible structural choices. Rather than attempting to judge the corporate structure as a whole, I shift the focus to the corporate-level units (i.e. the units that report directly to the CEO) and ascertain the grouping logic for each of those units separately. At the most fundamental level, an organizational unit can either be focused on a particular value-chain activity such as R&D, manufacturing, or sales (Porter, 1985), or on a particular output such as a product category or user group (including geographic regions) (Nadler & Tushman, 1997). Thus, an activity-based unit pools all the employees across different product- and user-groups into one unit in order to focus them around their functional specialization (e.g. into one R&D unit for PC components, tablets, and cellphones) – I will refer to such units as having an ***intra-functional focus***. On the other hand, an output-based unit pools all the employees across different functional specializations into one unit in order to focus them around a particular product category (e.g. into one cellphone unit, combining R&D, manufacturing, and sales for that product group) – I will refer to such units as having a ***cross-functional focus***. These two grouping logics are illustrated in Figure 4.1, panel (a) and (b), respectively.

Figure 4.1 - Types of Structure



Once each of the corporate-level units are categorized according to their basic grouping logic, we can aggregate them to get an idea of the ***structural emphasis*** of the corporate structure.[2] A simple example may highlight the advantages of this approach. Panel (c) in Figure 4.1 depicts an organizational structure that is organized by products and functions. However, even for this relatively simple hybrid structure it is not clear to what extent this is a centralized or decentralized structure. On the other hand, it is easy to categorize each of these corporate units according to their basic grouping logic, which results in two intra-functional (R&D, Sales) and three cross-functional units (cellphones, tablets, PC components) – thus, the structural emphasis of this particular organization leans ***towards*** more cross-functional focus. The purpose of this categorization is not to put a label on the type of structure, but rather to serve as a starting point against which to judge subsequent structural choices.[3]

Adopting this conceptualization has two important implications: (1) a CEO may show reversal in the structural emphasis of the choices he makes in subsequent

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[2] This terminology is just one possible categorization. Just like the centralization/decentralization category, it strips away some interesting variation, and makes a number of simplifying assumptions. In particular, it assumes that the corporate units (regardless of type) are of roughly the same size.

[3] In the extreme, the categories of centralization and decentralization map onto this new conceptualization: If all corporate-level units are intra-functional (Figure 1(a)), the structure can be interpreted as a centralized organization (equivalent to Chandler's (1962) functional form in which the authority rests with headquarters); on the other hand, if all corporate-level units are cross-functional (Figure 1(b)), the structure can be interpreted as a decentralized organization (equivalent to Chandler's (1962) divisional or M-form in which the authority rests with the business units).

reorganizations without ever touching the exact same previous structures again. Hence, we are talking about a relative reversal towards a particular focus of the overall structure as opposed to a reversal to the exact same structure previously abandoned; and (2) even under the prevalence of such hybrid structures as depicted in Figure 4.1(c), the CEO will almost always have a choice to change the corporate structure in one direction or another, that is to say, to shift the structural emphasis of the organization towards more intra-functional or more cross-functional focus, regardless of its current focus. Thus, the reversal towards the previously abandoned focus becomes an actual choice as opposed to the inevitable consequence of the decision to reorganize.

The existing theory on why reversals persist over time posits that the CEO engages in reversals in order to maintain the desirable level of alignment or misalignment between what the reporting structure directs the employees to do (organizational structure) and how they get work done (the informal organization) (Nickerson & Zenger, 2002; Gulati & Puranam, 2009). The informal organization refers to the emergent patterns of interactions which is influenced by the organizational structure but not imposed from the top; rather it is generated by the repetitive activities of the employees' job descriptions (Mintzberg, 1979) and the formation of informal ties between employees due to frequency of contact and homophily (Smith-Doerr & Powell, 2005). Under the assumptions that the organizational structure can only take on discrete configurations (e.g. centralization and decentralization), and that the 'ideal' organizational configuration would lie in between those discrete options, a systematic reversal in successive reorganizations would effectively ensure that such mid-way solution was obtained - albeit temporarily - given the slow adjustment of the informal organization to changes in the formal structure (Nickerson & Zenger, 2002). Thus, CEOs 'oscillate' between centralization and decentralization in order to prevent excessive alignment. As such, the desire to maintain misalignment is interpreted as both, the reason for reversal as well as the trigger of the next reorganization.

Much of the focus of the existing theory on the reversal pattern rests on the conditions under which a misalignment between the formal and informal organization may be more or less desirable (Nickerson & Zenger, 2002; Gulati & Puranam, 2009). In contrast, the goals of this chapter are twofold. In a first step, I aim to disentangle the mechanisms underlying the reversal pattern on the one hand and the reorganization decisions on the other; while the established theory on the reversal pattern assumes away external triggers of change and proposes that the desired level of alignment will induce the CEO to revert back to the other extreme, the complexity of actual structures and the variety of external pressures to reorganize present the CEO with a real choice of when to reorganize, and whether to increase or decrease the current structural emphasis at any point in time. Thus, on the back of the development of a workable definition of the reversal itself as a relative shift in the structural emphasis, the starting point of this chapter is the theoretical distinction behind the drivers for reorganizations in general and reversals in particular with an empirical validation of the reversal pattern – newly defined - across firms and over time. In a second step, I aim to deepen our insights into the mechanism that drives this reversal pattern (i.e. the choice to shift structural emphasis away from the current one), by developing theory that speaks to the expected rate of reversals; I highlight that we should expect an asymmetric rate of reversal as a function of the current structure held by the organization.

4.2.2 Why do Reversals Occur and Persist over Time?

In order to understand why a reversal pattern may occur and persist over time we need to answer two related but distinct questions, namely (1) what triggers the decision to reorganize (not all reorganizations need to be reversals)? And (2) what leads to the decision of reversal (as opposed to another type of structure)?

The literature on organization design has established a host of external triggers of reorganizations, such as changes in strategy, leadership, environmental conditions, age, competitors' structure, and corporate scope (Chandler, 1962; Kimberly & Miles, 1980; Egelhoff, 1982; Fligstein, 1985; Haveman, 1993; Karim & Mitchell, 2000; Agarwal & Helfat, 2009). These triggers suggest that a reorganization will occur in order to fix the misfit between the organizational structure that resulted from changes in the firm's environment (broadly defined[4]); however, this fit argument does not consider the current corporate structure as a factor in the choice of the newly adopted one. Nevertheless, changes in strategy, competitors, or the firm's market conditions may trigger the decision to change the corporate structure without necessarily generating a

[4] External to the structure, not necessarily to the corporation as a whole

reversal pattern over time. Thus, reorganizations in general are interpreted as a realignment tool of the internal structure to changes in the external environment.

The established theory on the reversal pattern adds a possible internal trigger for reorganizations to this list, namely the CEO's choice to prevent excessive alignment. Thus, the CEO will initiate a new reorganization once she observes that the employees' behavior has adapted to the corporate structure. However, given the simplifying assumptions made about the structural choice set, the decision to choose to revert or not for a given reorganization is left unexplored. Thus, the question remains under what conditions the CEO would freely decide to revert the structural emphasis of corporate structures adopted over subsequent reorganizations. Building on prior research in this and related areas, I posit that two simple observations about organizational structure and reorganizations are necessary and jointly sufficient to explain a tendency of reversal in structural emphases as a logical progression of successive reorganizations in the absence of external triggers, namely structural limitations and adjustment lag.

Structural Limitations - The purpose of any corporate structure is to focus the employees' attention around a certain challenge or goal that the CEO deems most relevant to accomplish (Simon, 1945; March & Simon, 1958; Chandler, 1962); this may be to increase market share in a particular segment, to generate higher profits, or to outbid competitors. While the corporate structure is but one lever at the CEO's disposal, it is arguably the most powerful one, in that it shapes the employees' daily interactions, by influencing who they sit close to and hence, who they interact with the most (Allen, 1977), who they report to, and what actions they get paid for etc. (Nadler & Tushman, 1997). This is not to say that other aspects (such as recruitment, selection etc.) are unimportant, but rather that the corporate structure can make those other aspects either more effective or ruin their usefulness. Given the importance of reorganizations as a strategic tool, it should come as no surprise that we see frequent reorganizations. However, with all its power in influencing employees' attention, the organizational structure has some important limitations. Most notably, it is limited in the number of goals or challenges it can effectively address at a time (Lawrence & Lorsch, 1967).

While we can *conceive* of very complex matrix structures that expect the simultaneous focus on several geographic regions, user-groups, and global product lines to maximize profit and market responsiveness in each of those areas (Galbraith, 1971), we already know that these structures are difficult to implement (Davis & Lawrence, 1977; Galbraith, 2008). What makes their effective implementation challenging is the demands they put on the employees; with limited resources (e.g. time, cognitive capacity, budget) and important social factors influencing choices (e.g. power, career aspirations, favors), employees work more effectively if they report to one or two supervisors rather than several with competing goals (e.g. Joyce, 1986; for a comprehensive review of the advantages and disadvantages of matrix structures see Ford & Randolph, 1992). The limitation of organizational structure becomes even more apparent when we try to create a structure that focuses the employees around market responsiveness on the one hand, while emphasizing cost cutting and efficiency on the other. These goals are fundamentally opposing, and so the organizational structure alone cannot successfully focus the employees' attention and behavior to achieve both these goals simultaneously (Porter, 1985; Tushman & O'Reilly, 1996; Gulati, 2011).

Two fundamental issues lie at the core of this structural limitation. First, employees have limited resources (e.g. time, cognitive capacity, budget), and spreading these too thinly will result in subpar performance on all their goals (Joyce, 1986). Secondly, and more importantly in this context, competing organizational goals cannot successfully be addressed simultaneously through an organizational structure. As we move along the continuum of structural emphasis from intra- to cross-functional focus, a choice between (a) an improvement in organizational efficiency by cutting cost and streamlining operations, and (b) an increase in market responsiveness and speed of development of new offerings by focusing attention around certain geographic or product markets (Porter, 1985; March, 1991) seems inevitable. This also implies that there is an inherent tradeoff in the structural emphasis regarding the problems it solves and the problems it creates. Therefore, solving problems that pertain to one of these dimensions through the corporate structure comes at the expense of solving the other and vice versa.

Adjustment Lag - The announcement of a reorganization is only the first step of addressing the goal or challenge the CEO has in mind. It is only through the implementation of the required changes that the goals and challenges may be solved. But what does it mean for a reorganization to be implemented? Apart from the logistics of moving employees into their new units and drawing up the organization chart with all its implications (e.g. establishing new reporting and remuneration paths, disseminating information about the changes), it is the employees' behavior in solving their tasks and who they approach to collaborate on their work that needs to adjust to the changes in the corporate structure in order for the reorganization to show its desired effect. The purpose of grouping employees into the same unit is to facilitate the communication and coordination of their activities by aligning their incentives around the same organizational sub-goals (at the unit-level), and by providing the necessary room for effective collaboration (Lawrence & Lorsch, 1967; Nadler & Tushman, 1997). The time lag and even limitations of this behavioral adjustment have been widely studied, and its effects have been pointed out to be both detrimental (Miller & Friesen, 1984; Lamont, Williams, & Hoffman, 1994) as well as potentially beneficial for the firm (Nickerson & Zenger, 2002; Gulati & Puranam, 2009).

The CEO will be induced to reorganize when she perceives the current structure to be inadequate in solving the most severe problems the organization faces (Simon, 1945; Cyert & March, 1963). Thus, the decision to reorganize (irrespective of the reversal decision) may well be driven by external factors alone and – as such - maintains theoretical independence from the current structural emphasis. However, the structural limitations can be interpreted as the source of a particular kind of problem where the structural choice in its solution already contains the seed for creating the next problem - thus, solving one problem (through structure) actively creates the next one. Given the adjustment lag, these problems do not surface instantaneously, but come to the CEO's attention after an adjustment period. Thus, given the structural limitations and adjustment lags following reorganizations, the CEO will implement reversals specifically in order to balance the problems and solutions that structures with a relative focus on intra- versus cross-functional emphasis provide. Note that these observations do not require the CEO to actively aim for a misalignment between the formal and informal organization (Nickerson & Zenger, 2002), but merely to consider the additional problems and challenges generated by the structural limitations as issues equivalent in importance to those problems generated by a misfit between the internal structure and its environment. Thus, the misalignment argument forms a special case of this more general explanation of reversals.

In a world of stable environments, lack of growth and strategic changes, each reorganization would show a shift away from the current structural emphasis, i.e. an organization with relatively more intra-functional units would be expected to shift toward more cross-functional focus in the next reorganization, and back toward more intra-functional focus during the subsequent change. This neat succession of reversals would be due to the fact that the only mechanism driving any need for structural change would be the structural limitations outlined above and the relatively slower adjustment of employees' behavior to changes in the organizational structure. However, reality is rarely this neat. Thus, while we would expect the reversal pattern to show a pendulum-like shift between more intra-functional and more cross-functional focus as the CEO tends to the problems created by each of those structures, external changes and the CEO's reorganization decisions triggered by those changes (as opposed to the internally generated issues) will make this pattern less pronounced. Nevertheless, as long as the rate of the external changes is not systematically higher than the rate at which the internal challenges are generated, we should still expect to see a reversal tendency. I therefore hypothesize that

> *Hypothesis 1a - The greater the intra-functional focus in the current structure, the lower the probability of a shift toward more intra-functional focus in the next structure.*

> *Hypothesis 1b - The greater the intra-functional focus in the current structure, the greater the probability of a shift toward more cross-functional focus in the next structure.*[5]

Regression to the Mean - If we disregarded the observations about the structural limitations and adjustment lag, and only considered external triggers to drive the CEO's reorganization decisions we could still account for the anecdotal evidence regarding the reversal patterns by making the following arguments: Under the assumptions that (1) any given reorganization is triggered by the well-established

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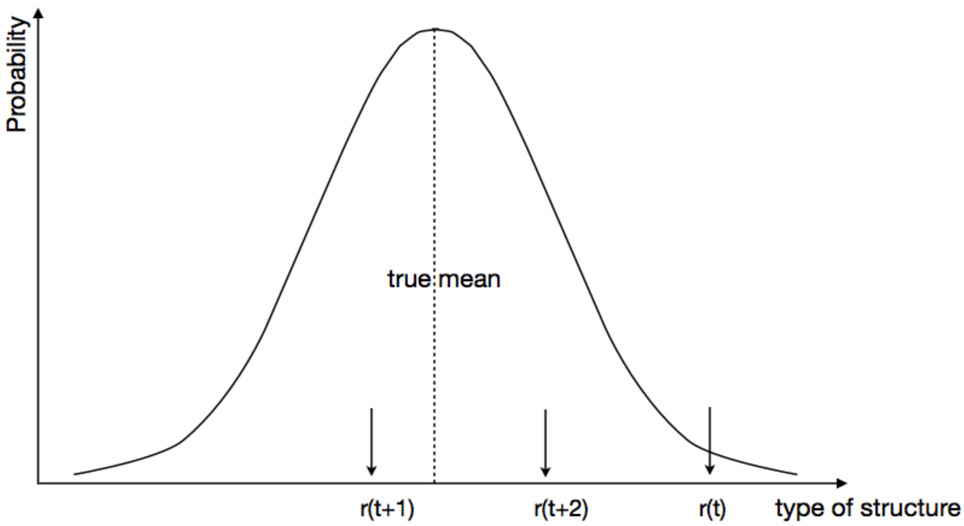
[5] H1a & b are expressed in terms of the intra-functional units only in order to explore the reversal both ways, keeping the independent variable (the intra-functional focus) constant. The hypotheses and empirical test for the cross-functional integration are the exact mirror image of these.

external factors outlined above (e.g. changes in leadership, strategy, environmental factors), and (2) the choice of new structure is made independently of the firm's current structure, we can think of successive reorganizations as independent draws of new structures from a given distribution, with an unknown mean (which may or may not change over time). If the choice of structure in reorganization r_t is relatively far to the right of the true underlying mean of structures in the distribution, the next choice of structure r_{t+1} is likely to be closer to the mean - namely to the left of r_t, as shown in Figure 4.2. A reversal pattern will emerge if the subsequent choice of new structure r_{t+2} falls between the first two choices.

Figure 4.2 - Reversal by Chance based on Regression to the Mean



Surely, such a pattern will only occur occasionally, however, its occurrence is not inconceivable and could well account for the anecdotal evidence on which the theories and accounts of the reversal of reorganizations rests to date. The important difference to the choice explanation is that we have no reason to believe that this reversal pattern will go on indefinitely, or even beyond the single instance of reversal - as time t tends to infinity, the choice of structure approaches the true mean. The timing of the next reorganization is driven by changes in external factors. Therefore, in the absence of further external change, there is no reason to change the underlying structure again. Note that the theoretical distinction between this chance explanation and the reversal mechanism outlined above is simple - in the former, reversals will stop after a brief back-and-forth, while the latter would predict indefinite chains of reversals. Given the plausibility of this alternative explanation, I will take this as the Null Hypothesis against which to test the systematic reversal tendency. Thus, support for Hypotheses 1a and 1b showing that reversals occur systematically across firms and over time would lend support to the reversal mechanism over the regression to the mean based argument.

4.2.3 The Current Structural Emphasis Determines the Rate of Reversals

While the external triggers of reorganizations are well established in the literature, our understanding of the reversal pattern as a subset of successive reorganizations is rather sparse. Up to this point, I have proposed that the reversals in structural emphases are the CEO's conscious attempts to deal with the internal, recurrent problems created by the structural limitations and adjustment lag. Thus, we have enhanced our insight into the reversal tendency by distinguishing between the purpose for reorganizations and reversals. To further enhance our understanding of this phenomenon it is worth probing into the mechanism underlying the reversal pattern in greater detail. The existing theory proposes that the reversals are intended to maintain a certain level of misalignment between the corporate structure and the informal organization to overcome the shortcomings of the corporate structure. It is the adjustment lag that makes the level of misalignment feasible. However, the existing theory focuses on the conditions under which a misalignment between the formal and informal organization may be more or less desirable and assumes that the readjustment occurs at a constant rate (Nickerson & Zenger, 2002).

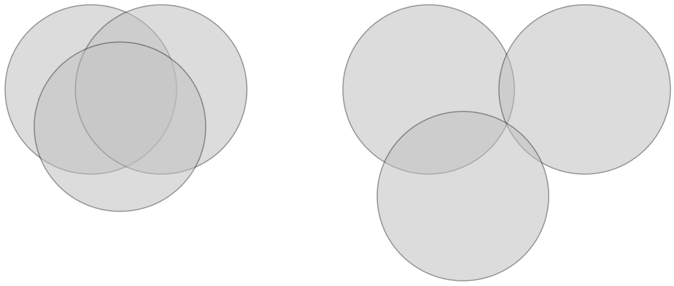
In order to gain deeper insights into the mechanism that drives this reversal pattern I probe into the factors that influence the rate of the adjustment lag itself. Recall that the purpose of any reorganization is to focus the employees' attention around a particular set of goals or challenges the CEO deems most important to address at the time. Furthermore, the CEO will only see the effect of the reorganization after some time has passed during which the employees adjust their way of 'getting things done' to the new corporate structure (e.g. Miller & Friesen, 1984). This adjustment process starts with the grouping of a set of employees into a new unit, based on which their incentives are now aligned (Nadler & Tushman, 1997). They are requested to coordinate their tasks among the employees within the new unit, which was created to facilitate communication and collaboration in the first place (Lawrence & Lorsch, 1967). Once the group of employees has found a way to collaborate effectively within the new unit (rather than with their colleagues from their old unit now grouped into a different unit), the way they 'get things done' has adjusted to the changes in structure.

If we assume that employees are homogeneous, i.e. all employees are equipped with the same specializations, backgrounds, and expertise, the rate at which this adjustment process will show visible effects will be the same, whether we increase the number of cross-functional or intra-functional units. However, several scholars have investigated the extent to which employees of different organizational functions (such as scientists in an R&D unit or sales people in the global sales office) show differences in the way they approach their tasks and make sense of their environment (Joyce, 1986; Dougherty, 1992; Cronin & Weingart, 2007). In an insightful qualitative study, Dougherty (1992) describes how the different 'knowledge funds' which employees from different areas of expertise possess create very different 'thought worlds' through which these individuals perceive the world, leading to differences in what they define as problems and what tasks they priorities.

If we take these fundamental differences in the way problems are perceived and how tasks are approached as given, we can draw important inferences for the relative adjustment speed of the employees' behavior to different types of changes. For example, if an employee of type A is grouped together with other employees of the same type (say, a group of engineers), they are more likely to belong to the same thought world (Dougherty, 1992) and face less representational gaps (Cronin & Weingart, 2007), captured by the extent to which the Venn diagrams in panel (a) of Figure 4.3 overlap. However, if the same employee is grouped together with other employees of types A, B, and C (say, a group of engineers, sales mangers, and procurement managers), the extent to which they share a common knowledge base will be dramatically lower (panel (b), Figure 4.3).

To make this intuitive point more formally, we can represent an organization with two corporate level units in a task structure matrix, which captures the interdependence between the employees (see Figure 4.4); in these matrices the employees are represented by numbers one through eight, and the 'x' inside the matrix represent interdependence between them. Let us say employees E1 through E4 are engineers, and employees S1 through S4 are sales managers, and the organization produces two products, P1 and P2. The two grouping logics are by output (P1, P2) or

Figure 4.3 - Overlap of Knowledge by Types of Employees[6]



activity (R&D, sales). If we group the employees around activities, the organizational structure imposes a collocation of all engineers into one R&D unit, and all sales managers into a separate Sales unit (regardless on which product they work on), this is depicted in Figure 4.4, panel (a). In contrast, Figure 4.4 (b) shows a grouping of employees by output – engineers and sales managers working on product 1 are grouped into one unit, and similarly for product 2. When contrasting the task structure matrices across these two structures, the important points to notice are that (1) while agent interdependence within each of the units (regardless of the grouping logic) remains the same (number of 'x' inside and across each of the units is eight in both examples), (2) the employees' 'neighbors' in an activity-based unit are mostly people of relatively similar knowledge funds, and in an output-based unit they are mostly people with very different knowledge funds. Thus, the increased ease in achieving effective collaboration is not due to a lower level of interdependence in units that group employees based on activities (into intra-functional units), but rather due to their common background and possibly homophily, which facilitates effective collaboration.[7]

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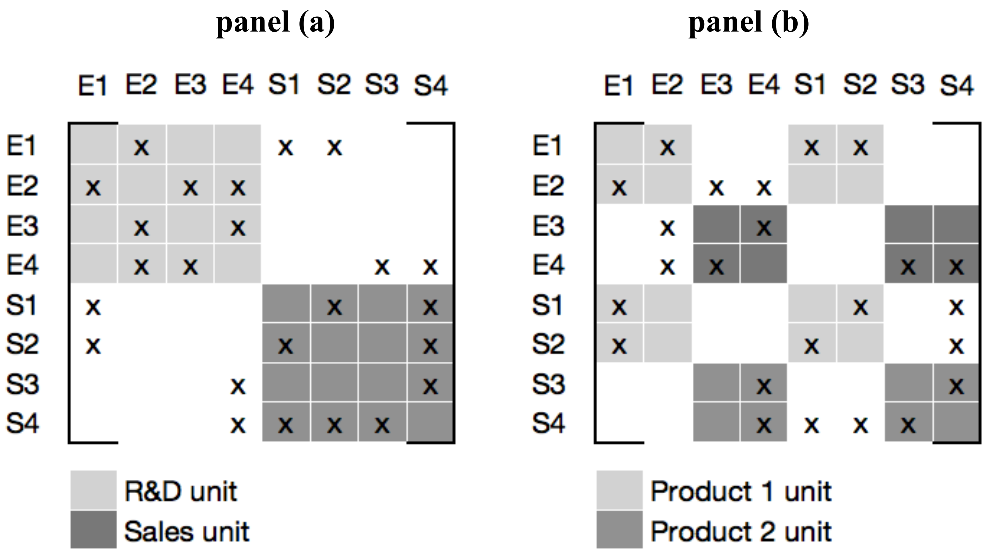
6 Figure 4.3 represents the relative overlap of different employees with the other employees in their business unit. Panel (a) depicts the overlap in "knowledge funds" for a group of three very similar employees; panel (b) represents the overlap in "knowledge funds" for a group of three very different employees.

7 The focus of this paper rests on the corporate level, i.e. the layer directly reporting to the CEO. Naturally, additional intra- and cross-functional units will be nested inside those first-level units. This implies that a cross-functional corporate unit contains intra-functional units at lower hierarchical level and vice versa. However, the argument I am making here is one of relative ease of achieving collaboration, keeping the level of analysis constant.

It follows that the speed with which employees adjust to working effectively with their colleagues in the new organizational unit they are grouped into after a reorganization is influenced by the grouping logic – if they are grouped based on activities, they should achieve effective collaboration relatively more quickly than if they are grouped together based on outputs. Thus, the adjustment lag should be relatively smaller if the current structure has a strong intra-functional focus, and relatively larger if it has a strong cross-functional focus.[8]

Figure 4.4 - Task Structure Matrices by Activity and Output[9]



This implies that the reversal rate is non-random and should show an asymmetry – if the current structure has a strong intra-functional focus the next reversal

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[8] This assumes that a structure that has a strong focus on intra-functional units groups a greater proportion of employees based on an activity-based grouping logic. If the number of employees in the corporation stays the same, this assumption is not implausible. However, even if intra-functional units were systematically larger (or smaller) than cross-functional units, the relationship would still hold as this hypothesis looks at an absolute focus on one dimension and the likelihood of switching away from it (as opposed to a relative shift as in H1).

[9] Figure 4.4 represents the task interdependence between employees of different types (engineers E1-E4 and sales managers S1-S4) in two different organizational structures, working on two different products, P1 and P2. Say E1, E2, S1, and S2 work on P1 and E3, E4, S3, and S4 work on P2. Panel (a) represents a grouping into intra-functional units based on activities – all engineers (regardless of their product) are grouped into one unit, while all sales managers are grouped into a separate unit. Panel (b) represents a grouping into cross-functional units based on outputs – all employees working on Product 1 are grouped into one unit, while all employees working on Product 2 are grouped into a separate unit. While the number of 'x's are constant within and between units across the two structures, the employees in panel (a) are grouped together with more colleagues that are highly similar to them, than the employees in panel (b).

should occur relatively sooner, while it should occur relatively later if the current structure has a strong cross-functional focus.

> *Hypothesis 2 - The time to the next reversal is longer if the current structure has a predominantly cross-functional focus, than the time to the next reversal if the current structure has a predominantly intra-functional focus.*

Can this prediction be accounted for by the regression to the mean explanation? Recall that the regression to the mean explanation predicts that the driver of reorganizations is the occurrence of some external event that throws the organization's structure into misalignment with its environment. Therefore, the timing of a reorganization is purely driven by the rate of change of the different external factors (which are beyond the ability of the CEO or the researcher to predict). The reversal pattern would be generated by regression to the mean of successive draws from the distribution of possible structures, sometimes generating an apparent reversal pattern. Again, I take the chance explanation as the Null Hypothesis for H2, which predicts no relationship between the rate of reorganizations and the type of the current structure. Support for H2 would therefore show that the reversal mechanism has relatively greater predictive strength than the regression to the mean explanation in explaining the reversal pattern.

4.3 Methods

4.3.1 Sample Selection

I test the hypotheses on a sub-segment of the Information and Communication Technology industry, namely on the global cellphone manufacturing industry. This industry is well defined, with a relatively small number of firms contributing to more than 99% of the global market. In addition, it is a relatively young industry (with the launch of the first commercial cellphone in 1983) allowing for data collection from the birth of the industry, which prevents survival bias in the sample selection. The segment shows a relatively high number of corporate-level reorganizations, which is an important sampling criterion for this study, given that I need to observe at least 2 reorganizations per firm (on average) over the observation period in order to test for possible reversal tendencies.

Figure 4.5 - Overview of the Data

Firms	entry	number of reorganizations	exit
Motorola	1983	8	
Siemens	1985	4	2005
Nokia	1986	5	
Ericsson	1987	9	2001*
Mitsubishi Electric	1987	1	2007
Benefon	1988	3	
Kyocera	1991	0	
Panasonic	1991	2	
Samsung Electronics	1991	5	
Sharp	1991	3	
NEC	1992	9	
Safran, Sagem	1992	4	2008
Toshiba	1993	5	
Sanyo	1994	6	2008
HTC	1997	0	
Huawei	1997	1	
LG Electronics	1997	7	
PantechCuritel	1997	2	
Sony Electronics	1997	6	2001*
Acer Peripherals	1998	3	2001
BenQ	1998	3	
Ningbo Bird	1998	0	
TCL Communication Technology	1999	2	
Amoi	2000	2	
FIC	2001	0	
Haier	2001	2	
Palm	2001	5	
Sendo	2001	0	2005
Sony Ericsson	2001	0	
Handspring	2002	2	2003
RIM	2002	0	
Asustek	2003	2	2008
UTStarcom	2004	2	2008
Apple	2007	0	

* Ericsson and Sony Electronics were coded as having exited the industry as separate entities. Sony Electronics was founded as a separate entity with its own operations based on London, separated from both parent companies' headquarters.

The sample for this study contains 102 corporate-level reorganizations by 34 firms over 25 years, from 1983 through 2008. The sample selection started with Gartner's listing of firms with highest market share in 2008, further supplemented by searches on Hoover's, GSM's website (a standard setting body), and the web to capture all major cellphone manufacturers. In addition to tracking the 21 firms identified in 2008 back to their founding (or their entry into the cellphone telephony market), I conducted this same search for each year from 2008 to 1983. The final sample contains the firms that hold a combined global market share of over 99% in 2008 and all previous years, a total of 34 firms. The final percentage point is comprised of small firms (many of which reside in China) that specialize in replicating other firm's phones for local sales. The reason for the exclusion of those firms is lack of viable data. Hence, the results of this study should not be interpreted as indicative of the Chinese cellphone manufacturing segment. Figure 4.5 lists all firms included in the sample, with the years of founding, entry into the cellphone manufacturing segment, the number of reorganizations included in the sample, and (where applicable) their year of exit from the industry.

Reorganization-Level Data - Reorganization-level data was manually collected from trade press and newspaper articles, accessed through Factiva. These data sources were supplemented by annual reports, companies' websites, press releases, and analyst reports. Using these different data sources, I triangulated (1) the announcement date of the corporate-level reorganization, (2) the name and description of the units the structure was comprised of before the reorganization, and (3) the name and description of the units of the new structure post-reorganization. I then used those descriptions to code the old and new business units according to Gulick's (1937) four categories of customer, product, geography, and function (see also Fligstein, 1985; Williams & Mitchell, 2004). Please refer to Appendix B for a coding example.

I categorized each corporate-level unit as grouping its employees according to a cross-functional (such as product lines or customer segments) or intra-functional focus (such as R&D or sales units).[10] By collecting data on the old and new business units surrounding each reorganization announcements, I ensured continuity in the timeline, i.e. that I would not miss any changes in the corporate structure. For larger firms, I

[10] The more detailed categorization into product-, user-, geographic-, and functional-units is used for robustness checks.

collected data on the subsidiary that contained the cellphone manufacturing activities - for example, for Samsung Co. I focused on reorganizations of Samsung Electronics. A second coder who was not informed about the purpose of the study also completed the reorganization coding. For a sub-sample of firms the second coder also did the data collection to ensure that information was not left unseen. In both cases (data collection and data coding) the two coders did not encounter disagreement, highlighting the straightforward nature of categorizing corporate units into one of the four categories used.

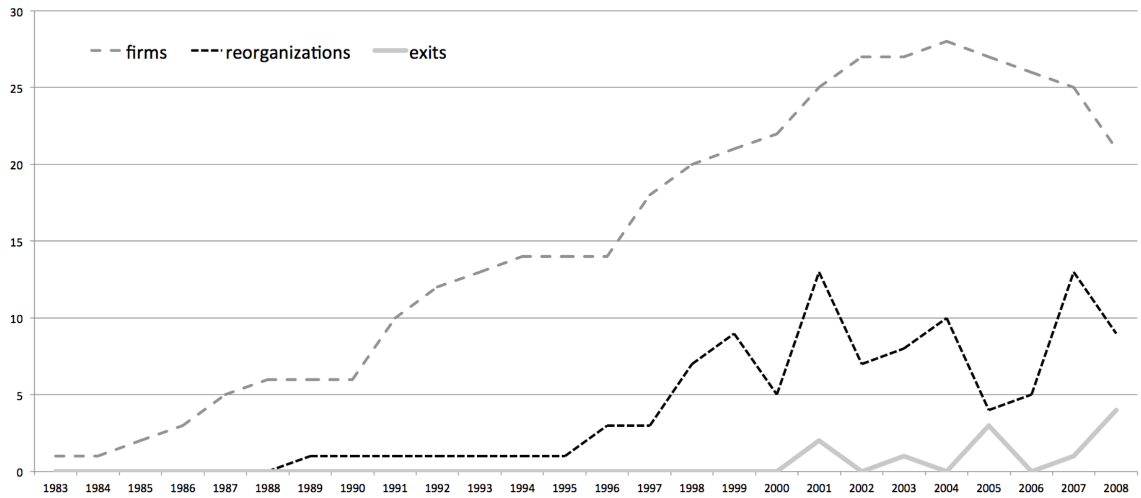
I verified the data collected for a sub-sample of firms via interviews with mid- to high-level managers (one or two per firm). I conducted 13 semi-structured interviews lasting about one hour each; each interview was recorded and transcribed by the author immediately afterwards. The data collected where verified as correct in all cases, while further detail on the process of change in the organizations was collected as background information. In the informal discussions following the interviews, the reversal pattern resonated highly with many of my interviewees.

Firm-Level Data - Performance measures and employee numbers were obtained from Compustat and Datastream, complemented by data from annual reports. I collected information on year of founding (age), year of entry into the cellphone market, country of origin, and degree of diversification (of the relevant subsidiary where applicable) from annual reports. Wherever data from annual reports was used, I ensured that the figures (if variable) were attributed to the correct chronicle year.

Industry-Level Data - The number of reorganizations and entrants into the global cellphone manufacturing markets were computed using the reorganization-level data. In addition, I capture the major technological disruptions in the industry. I focus on three 'game-changing' events, namely the switch from analog to digital standard in the core technology in cellphones in 1989; the introduction of the first smart phone (by Nokia) in 1996; and the announcement of a new generation of smart phones (by Apple) in 2007.

Figure 4.6 shows all reorganizations in the segment from the inception of the industry (1983) to the end of data collection (through December 2008). The figure includes the total number of active firms as well as the number of exits from the industry. Note that a considerable number of reorganizations coincided with the year of the dot-com crash (2001) and the iPhone announcement/sub-prime crisis (2007), and a reduction in the number of firms coincides with the economic downturn in 2008. Clearly, external events matter in the overall pattern of reorganizations. The question I address in this chapter is whether internal factors also play an important enough role to influence these reorganization decisions and their direction.

Figure 4.6 - Summary of the Industry



4.3.2 Research Design

The aim of this chapter is to explore the temporal pattern of successive reorganizations. In particular, I want to (1) estimate whether a greater structural emphasis on one dimension is more likely to be followed by reversals than others; and (2) explore whether organizations maintain one particular type of structural emphasis for a longer period of time than the other. The observations for most of the firms in the sample are right-censored, i.e. even though some of the firms may not have reorganized their structure on or before December 31, 2008 (the end of my observation period), it does not imply that they did not reorganize after that date. This creates problems when attempting to estimate models that rely on accurate statistics. I therefore employ Event History Analysis (also referred to as Survival Analysis), which lends itself to these kinds of questions, and also deals effectively with censoring (Singer & Willett, 2003). (Please refer to Appendix C for a discussion of the exploratory analyses conducted to verify that the dependent variables do indeed vary with time.)

The dataset is set up to observe *repeated* reorganizations by individual firms over time; I therefore conduct a repeated events analysis, which reenters each firm into the 'at risk' population after each reorganization. While this characteristic of the dataset is crucial to be able to test the hypotheses, it precludes me from reporting life tables and other statistics that derive from those estimates. The level of detail the data were coded at allows me to conduct the analyses in continuous (rather than discrete) time, which allows for more powerful modeling approaches. The two hypotheses require different dependent and independent variables, as well as distinct model specifications. I therefore discuss the measures as well as the specifications for each hypothesis in turn. Figure 4.7 summarizes the definitions and descriptive statistics of the measures used in this study.

Figure 4.7 - Summary of Variables

Variables	Definition	Mean	Std. Dev.	Min	Max
reorganization	the announcement of a reorganization	0.76	0.429	0	1
shift toward intra-functional focus	captures whether the announced reorganization increases the corporate structure's relative focus toward more cross-functional units	0.34	0.474	0	1
shift toward cross-functional focus	captures whether the announced reorganization increases the corporate structure's relative focus toward more intra-functional units	0.42	0.496	0	1
# intra-functional units in old structure	count of the number of intra-functional units in the old structure, prior to the focal reorganization	2.15	2.297	0	13
# cross-functional units in old structure	count of the number of cross-functional units in the old structure, prior to the focal reorganization	5.09	3.438	0	16
reversal	reorganizations that switch from intra- to cross-functional or from cross- to intra-functional focus	0.43	0.5	0	1
old structure is mostly intra-functional	equal to one if the number of intra-functional units outweighs the number of cross-functional units in the old structure.	0.13	0.335	0	1

old structure is mostly cross-functional	equal to one if the number of cross-functional units outweighs the number of intra-functional units in the old structure	0.79	0.408	0	1
total number of units in old structure	total count of the number of units (regardless of type) in the old structure, prior to the focal reorganization	7.24	4.713	2	22
CEO changed prior to Reorg	equal to one if the CEO changed in the spell prior to the focal reorganization	0.32	0.468	0	1
number of competitors	total count of the number of units (regardless of type) in the old structure, prior to the focal reorganization	25.12	4.155	12	29
number of entrants	A count of the number of firms entering the sample in any given spell	3.85	5.724	0	27
age (ln)	age of the focal firm (in years) at the time of the reorganization announcement	3.59	0.839	1.39	5.06
number of employees (ln)	the number of full-time employees at the time of the reorganization announcement	10.13	2.161	4.39	13.04
number of reorgs in the industry	the sum of reorganizations in the sample within one year of the focal reorganization	8.04	3.12	0	15
degree of diversification	the extent to which the focal firm is specialized in mobile phone manufacturing (1), specialized in the ICT industry (2), or involved in a broader set of products (3)	1.95	0.802	1	3

Systematic Reversal

Hypotheses 1 a and b predict that the greater the structural emphasis on one dimension, the greater the instantaneous risk rate of a shift away from that dimension. Note that these hypotheses test the *relative* shifts *towards* more or less cross- and intra-functional focus, rather than an absolute switch to or from a given focus. This is to say that hypotheses 1 a and b test a reversal *tendency*, in line with the suggested theoretical considerations regarding the conceptualization of reversal in terms of the relative shift in structural emphasis rather than the extreme choice between centralization and decentralization. Therefore, the main relationship to be tested is whether a greater proportion of units of type A in the current structure increases the instantaneous risk rate of a reorganization towards type B. In order to test this relationship I conduct a competing risk analysis. This setup allows me to statistically compare the effect of the independent variable on the likely occurrence of a reorganization of *any kind*, with its effect on the likely occurrence of a relative shift toward more intra- and cross-functional focus, respectively. Given that the choice of which type of structure to shift toward is an integral part of the decision to reorganize, the two decisions cannot be decoupled, so that a competing risk analysis is the most appropriate setup to compare the coefficients across models (Hachen, 1988).

Dependent Variables – For the setup of the competing risk analysis we require three dependent variables, namely the instantaneous risk rate of a reorganization of any type, the instantaneous risk rate of a reorganization that shifts the structural emphasis towards more intra-functional focus, and the instantaneous risk rate of a reorganization that shifts the structural emphasis towards more cross-functional focus.

The 102 reorganization announcements of the 34 firms over the 25 years of observation provide the necessary data for the first dependent variable. The data are set up in 'spells', capturing the time between successive reorganizations for each firm. The first spell of each firm starts with the date of entry into the industry [11], and ends with the date of the first reorganization since entry. That date is associated with a reorganization event, and the independent variables and controls are coded with respect to that focal event. The subsequent spell begins with the first day after the reorganization announcement for the focal firm and ends on the announcement date of the next reorganization or the date of exit from the industry (if applicable). If the firm is still active in the cellphone industry on 31 December 2008 the last spell is 'censored' (i.e. observation ended before the next event occurrence). Thus, a firm that went through five reorganizations and is still active in the cellphone industry on 31 December 2008 will occupy six spells in the dataset, one spell for each reorganization, and one censored spell.

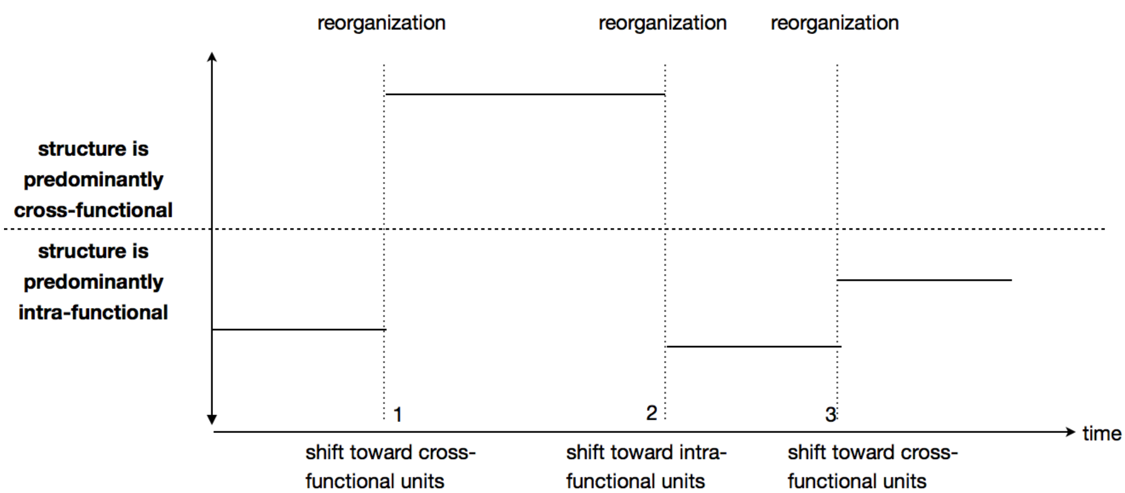
By comparing the structural emphasis of the organizational structure prior to the focal reorganization to the structural emphasis after the event for each firm, we can categorize each of the 102 reorganizations based on whether they increase the structural emphasis on intra- or cross-functional focus. If the structure at time t is comprised of five units with an intra-functional focus and five units with a cross-functional focus

[11] There is no left-censoring in these data as I start observation at the inception of the industry.

(5,5), a shift to five intra- and seven cross-functional units (5,7) will be coded as a shift toward more cross-functional focus. Similarly, a shift from (5,5) to (3,5) units would be coded as a shift toward more cross-functional focus. Rather than capturing which kind of units have been added or changed, this measure captures the *relative shift towards* more intra- or cross-functional focus.[12] Thus, in order to test Hypotheses 1 a and b, I predict the effect of a greater proportion of intra-functional units in time t on the instantaneous risk rate of (1) a reorganization of any type, (2) a shift towards more intra-functional focus, and (3) a shift towards more cross-functional focus. The theory predicts that the type of structure in time t will have no distinctive effect on a reorganization of any type to occur; however, the instantaneous risk rate of a shift towards more intra-functional focus is predicted to be negative, and the instantaneous risk rate of a shift towards more cross-functional focus is predicted to be positive, the higher the structural emphasis on intra-functional focus in time t.

Figure 4.8 shows a stylized example of the data structure for the dependent variables. It displays a *relative shift toward more intra-functional units* versus *a relative shift toward more cross-functional units*. Note that each of those instances is coded as a *reorganization* of any type.

Figure 4.8 - Dependent Variables



[12] Note that there were four reorganizations that left the structural emphasis unchanged (e.g. a shift from (3,3) to (4,4)). For these cases I went back to the raw data to gain insights into the relative importance of the new units created and coded the reorganizations accordingly. I also tested whether dropping those observations or splitting them into intra- and cross-functional reorganizations would affect the results (it did not).

Independent Variables – In order to capture the relative intra-functional focus of the structure in time t (i.e. prior to the focal reorganization), I include two variables, namely the *number of intra-functional units in time t* (a simple count of intra-functional units at the corporate level), and the *number of total units in time t*. This allows me to interpret the coefficient of the number of intra-functional units as a measure of the relative focus on intra-functional units.[13] I also run the same analyses with the *number of cross-functional units in time t* as the main independent variables (the results of those analyses are reported in Appendix E).

Control Variables - The control variables are chosen specifically with a view on controlling for commonly identified triggers of reorganizations in the contingency literature. Specifically, I control for a change in leadership, as this is commonly associated with a change in strategy (Chandler, 1962), and number of competitors and entrants to capture a change in the competitive nature of the environment. I control for size and age of the companies, and the degree of diversification, given that research in corporate strategy (Chandler, 1962) and lifecycle theory (Kimberly & Miles, 1980; Miller & Friesen, 1983; Quinn & Cameron, 1983) suggests that bigger companies are less likely to adopt a purely intra-functional structure, and that age is correlated with more complex organizational structures (such as the divisional, multi-divisional, or matrix structure). In order to see whether companies tend to copy reorganization behavior from other firms in their segment (e.g. Haveman, 1993) I control for the number of reorganizations in the industry. In the robustness checks I also control for Returns on Assets reported in the quarter prior to the focal reorganization (standardized by firm). Given that this variable is missing for a number of observations and given the small sample size, I run the main analyses without the performance measure. However, the results of the independent variables are not altered by the inclusion of this measure.

Model Specification - To test hypothesis 1, I employ the partial likelihood estimation developed by Cox (1975), which allows me to leave the baseline hazard unspecified. This model assumes proportionality in the baseline hazard functions across firms, which implies that each firm's baseline hazard function is assumed to be a constant multiple of a common baseline function. However, this assumption is

[13] An alternative way to capture this would be to include a ratio of intra-functional over total units. The results with that independent variable do not vary – but the interpretation of the separate variables is easier, especially to assess their separate impact on the event of 'any reorganization'.

theoretically unjustified given the 34 different firms in my sample. The most efficient way to address this is to use a fixed-effects partial likelihood estimation and stratify by firm (Allison, 1996). This approach effectively replaces the denominator of the partial likelihood (the sum of the contemporaneous risk scores of everyone at risk) with the sum of contemporaneous risk scores of everyone at risk in stratum s. This non-proportional Cox model is appropriate as we are not interested in the effects of different firms on the risk rate per se. Thus, I estimate the following function:

$h(t_{ij}) = h0s\ (t_j) + exp(\beta_1\ intra\text{-}functional\ units_j + \beta_2\ total\ units_j + \beta_3\ controls_j)$

for firm i in time period j; the subscript s captures the strata per firm.

Rate of Reversals

Hypothesis 2 predicts that the *absolute* structural emphasis of the structure in time t will have a systematic effect on the rate of *reversals*. More concretely, if the structure in time t groups a greater proportion of employees into intra-functional units, the *time to the next reversal* (i.e. shift away from the current focus) will be shorter relative to the time to the next reversal if the current structure groups a greater proportion of employees into cross-functional units. While the mechanism of this asymmetric adjustment rate is unobservable with the available data, the predicted macro-level effects would generate a relatively higher instantaneous risk rate of reversals if the current structure was predominantly organized into intra-functional units (as opposed to cross-functional units).

Dependent Variable – The basic setup of the dataset into spells for each event (explained for hypothesis 1) equally applies to the test of hypothesis 2. However, to test the relationship between the absolute structural emphasis in time t and the reversal rate, the set of events that comprises the dependent variable is more restricted. In particular, out of the 102 reorganizations, I constructed a subset of those events that showed a *reversal* in structural emphasis; 58 reorganizations shifted the structural emphasis from intra- to cross-functional (14 reversals) or from cross- to intra-functional (44 reversals). The dependent variable is the instantaneous risk rate of these reversals.

Independent Variable – In order to test whether an absolute focus on intra- or cross-functional focus impacts the rate of reversals I constructed a dichotomous variable that equals one if the absolute structural emphasis in time t is intra-functional and zero if it is cross-functional.

Controls - Strictly speaking the external triggers for reorganization (such as changes in demand conditions, competitors, and entrants) are not theorized to affect the reversal decision. However, to facilitate comparison across models I initially report the same set of control variables for the test of Hypothesis 2. In a second step I limit the control variables to the (more parsimonious set of) internal factors, namely performance, change in CEO, age, employees, and degree of diversification.

Model Specification – To test Hypothesis 2 I conduct two analyses. In a first step, I run a fixed-effects partial likelihood model (as described above). Recall, that the Cox model requires the baseline hazard to be proportional (albeit u,nspecified). Given the reduced event number per firm in the sub-sample used to test Hypothesis 2, I cannot use stratification to account for the violation of that assumption in these data. I therefore use the alternative approach, namely an interaction of the 'offending' variable (the firms) with time. This is equivalent to including firm dummies in a non-proportional hazard model (Singer & Willett, 2003). I estimate the following function:

$$h(t_{ij}) = h_{0s}(t_j) + exp(\beta_1\ intra\text{-}functional\ focus_j + \beta_2\ controls_j)$$

for firm i in time period j.

While Cox regression analysis has many advantages, it is less appropriate when trying to estimate the actual time to an event (Singer & Willett, 2003). This is due to the fact that the time-specific part of the partial-likelihood estimator is dropped, and only the order of events is taken into account when estimating a model using Cox regression analysis. I therefore provide a second test of Hypothesis 2 by estimating an accelerated failure time model, invoking a log-logistic distribution. This model allows me to examine the timing (or more precisely the delay) until the next reorganization explicitly, by estimating the natural logarithm of the survival time as a linear function of the covariates.

Note that this model requires the specification of the functional form of the baseline hazard underlying this transformation; examining the Cox-Snell residuals for the estimated hazard rate suggests that a log-logistic distribution would fit the data best (see Appendix D) (Allison, 1995). Thus, in a second analysis I estimate the following equation:

$h(t_{ij}) = [\lambda\gamma(\lambda t)^{\gamma-1}]/[1+(\lambda t)^{\gamma}]$

where $\gamma = 1/\sigma$ and

$\lambda = \exp(-[\beta_0 + \beta_1 \text{ type of structure}_j + \beta_2 \text{ controls}_j])$

for firm i in time period j.

4.4 Results

4.4.1 Does the Reversal Pattern Occur Systematically Over Time?

I ran a number of residual analyses to ensure that the models are properly fitted and that the results are not driven by any outliers (a summary of these are reported in Appendix D). Results for the fixed-effects partial likelihood model to test hypotheses 1 a and b are shown in Figure 4.9. To compare the effects of the different coefficients across the types of reorganizations as well as with results from previous studies that did not distinguish between reorganization-types, I conducted a competing-risk analysis, reporting the risk rate of any reorganization (regardless of type) (Models 1 to 3 in Figure 4.9), and the risk rate of a shift towards more intra-functional (Models 4 to 6) and towards more cross-functional focus (Models 7 to 9). Note that the coefficients reported are the instantaneous risk rates; thus, a positive coefficient can be interpreted as increasing the instantaneous risk rate of the focal event, while a negative coefficient decreases that risk rate.

As shown in Model 3, the instantaneous risk rate of a reorganization of any type decreased with the entry of a new competitor, and with age (logged). For example, a firm was 29% less likely to reorganize when a new firm entered. On the other hand, the higher number of competitors in the market, the higher a firm's instantaneous risk rate of any type of reorganization, in particular, a firm with one additional competitor was 11% more likely to reorganize compared to a firm with no additional competitor. Note that a change in CEO and the shape of the firm's formal structure prior to the reorganization did not predict the occurrence of a reorganization when the type of change is ignored. Thus, some of the well-established external triggers appear to drive reorganization decisions in this dataset as well. As expected, the relative emphasis on intra- or cross-functional units in the current structure does not have a significant effect on the occurrence of reorganizations.

Figure 4.9 - Systematic Reversal

Cox Non-Proportional Hazard Model	DV: any reorganization			DV: shift towards intra-functional focus			DV:shift towards cross-functional focus		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
total number of intra-functional units in the old			0.00812			-0.450***			0.895***
			(0.142)			(0.146)			(0.196)
total number of units in the old structure		0.0582	0.0549		0.169**	0.330***		0.00371	-0.426***
		(0.0381)	(0.0585)		(0.0671)	(0.0741)		(0.0582)	(0.105)
change in CEO during the spell leading to the reorg	-0.180	-0.198	-0.194	-0.102	-0.223	-0.425	-0.892*	-0.890*	-1.611***
	(0.296)	(0.295)	(0.300)	(0.480)	(0.455)	(0.514)	(0.520)	(0.539)	(0.609)
age (ln)	-6.393***	-6.904***	-6.937***	-9.189***	-11.51***	-7.794**	-8.145**	-8.165**	-14.26***
	(1.609)	(1.496)	(1.721)	(2.614)	(2.783)	(3.789)	(3.812)	(3.638)	(3.993)
employees (ln)	-0.936	-0.914	-0.914	-2.759***	-2.896***	-2.478***	0.457	0.458	1.667
	(0.748)	(0.750)	(0.758)	(1.028)	(0.881)	(0.848)	(0.947)	(0.939)	(1.285)
degree of firm diversification	-0.365	-0.353	-0.353	0.301	0.324	0.385	-0.763	-0.760	-1.538
	(0.347)	(0.343)	(0.347)	(0.410)	(0.444)	(0.441)	(0.471)	(0.475)	(0.950)
number of reorgs in the industry within 1 year	0.0453	0.0481	0.0486	0.225*	0.265**	0.233*	-0.0864	-0.0863	-0.149
	(0.0803)	(0.0798)	(0.0768)	(0.130)	(0.131)	(0.133)	(0.113)	(0.113)	(0.134)
number of entrants during the spell leading to the reorg	-0.334***	-0.339***	-0.339***	-0.433***	-0.503***	-0.530***	-0.274***	-0.274***	-0.303***
	(0.0496)	(0.0474)	(0.0482)	(0.0900)	(0.116)	(0.138)	(0.0601)	(0.0610)	(0.109)
number of competitors during the spell leading to the reorg	0.108**	0.108**	0.107***	0.0600	0.0526	0.0868	0.243***	0.243***	0.289***
	(0.0426)	(0.0433)	(0.0339)	(0.0582)	(0.0723)	(0.0654)	(0.0586)	(0.0579)	(0.0737)
strata									
number of observations	132	132	132	132	132	132	132	132	132
Log-pseudolikelihood	-76.90	-76.30	-76.30	-28.83	-26.96	-25.51	-39.02	-39.02	-31.57
Chi-square	189.0	191.3	206.9	47.45	70.50	92.37	60.80	71.57	407.3
number of clusters	34	34	34	34	34	34	34	34	34
number of failures	102	102	102	48	48	48	54	54	54
days at risk	151598	151598	151598	151598	151598	151598	151598	151598	151598
degrees of freedom	7	8	9	7	8	9	7	8	9

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

Model 6 shows the instantaneous risk rates of a reorganizations that shift the structural emphasis towards more intra-functional focus. The effect of a greater proportion of intra-functional units in the organization's structure prior to the focal reorganization is significant and negative; in particular, the hazard of a shift towards more intra-functional units decreased by 36% for every additional intra-functional unit in the structure prior to the focal reorganization. On the flip side, the risk of a shift towards more intra-functional units increased by 57% for every additional cross-functional unit in the prior structure (this model is reported in Appendix E, Model 2, $\beta=0.450$, $SE=0.146$, $p\text{-value}=0.002$). Thus, hypothesis 1a, which predicted that the lower the intra-functional focus in the current structure, the lower the propensity of a shift towards more intra-functional focus in the next structure is supported. In addition, the total number of units the organization is composed of mattered: for every additional unit in the organization prior to the shift towards more intra-functional units, the hazard of such a shift increased by 39%. Note that a change in CEO did not systematically drive the organization to adopt a more intra-functional structure. While age and entrants had the same negative effects on the hazard rate of a shift towards more intra-functional units to occur as it had on the hazard rate of any reorganization, a greater number of employees lowers a firm's hazard rate of a shift towards a more intra-functionally focused structure. This effect is in line with prior research that suggests that large firms are generally less likely to adopt highly intra-functional structures (Chandler, 1962; Quinn & Cameron, 1983).

In Model 9 I estimate the instantaneous risk rate of a reorganization to occur that shifts the focus of the structure towards more cross-functional units. The effect of a greater proportion of intra-functional units in the organization's structure prior to the focal reorganization is significant and positive; in particular, the hazard of a shift towards more cross-functional units more than doubled for every additional intra-functional unit (specifically, the hazard increased by 2.5 for every additional intra-functional unit). On the flip side, the risk of a shift towards more cross-functional units decreased by 59% for every additional cross-functional unit in the prior structure (model 3 in Appendix E, $\beta=-0.895$, $SE=0.196$, $p\text{-value}<0.001$). Thus, hypothesis 1b, which predicted that the greater the intra-functional focus in the current structure, the greater the propensity of a shift towards more cross-functional focus in the next structure is supported. In addition, for every additional unit in the organization, the hazard of a shift towards more cross-functional units decreased by 35%. Note that the effects of the number of competitors, entrants and the age of the firms were similar to the effects for the hazard rate of any reorganization; however, the hazard of a shift towards more cross-functional units was lower when the CEO had changed between the last and the focal reorganization (by 81% relative to a firm where the CEO had remained the same).

In order to confirm the prediction of the competing risk model which tests that distinguishing between different types of structural change matters statistically, I test the compound Null Hypothesis that all coefficients associated with each predictor were identical across event-types (shift towards intra-functional vs. cross-functional focus). I compared the -2LL statistic of the global model (Model 3) with the sum of -2LL statistics of the two event-specific models (Models 6 & 9). The difference is 19.22; with 9 degrees of freedom (chi-square distribution) the critical value of 18.48 at p-value=0.03 is exceeded, thus, I reject the Null Hypothesis - the difference in the type of reorganization matters indeed. In a second step we can now examine the targeted null hypothesis to test whether the set of coefficients of the independent variables is identical (or not) across event-specific models. Given that there are only two event-types, we can use the simplified Wald statistic (Singer & Willett, 2003). The coefficients for the total number of intra-functional (and cross-functional) units in the old structure are significantly different across the two event-specific models (intra-functional coefficients: observed test statistic of 30.29, exceeds the critical value of 10.83 for p=0.001; cross-functional coefficients: difference of 34.61, exceeds the critical value of 10.83 for p=0.001). Thus, the competing risk model further confirms that Hypotheses 1 a and b are supported.

4.4.2 Does the Current Structural Emphasis Determine the Rate of Reversals?

I now turn to testing hypothesis 2, which predicts that the time to the next ***reversal*** is longer if the current structure has a predominantly cross-functional focus, than the time to the next reversal if the current structure has a predominantly intra-functional focus. I ran a number of residual analyses to ensure that the models are properly fitted, and that the results are not driven by any outliers.

Results for the fixed-effects partial likelihood model are shown in Figure 4.10. Recall that the dependent variable for these models is the ***reversal*** rather than *any reorganization*. The coefficients reported are the instantaneous risk rates; thus, a positive coefficient can be interpreted as increasing the instantaneous risk rate of a reversal occurring, while a negative coefficient decreases that risk rate. To facilitate

Figure 4.10 - Rate of Reversals: Fixed-Effects Non-Proportional Hazard Model

	Dependent Variable: reversal			
	Model 1	**Model 2**	**Model 3**	**Model 4**
old structure is predominantly intra-functional		0.527*	0.612**	0.634**
		(0.276)	(0.291)	(0.309)
number of reorgs in the industry within 1 year	0.0153	0.0183		
	(0.0637)	(0.0623)		
number of entrants during the spell leading to the reorg	-0.305***	-0.310***		
	(0.0552)	(0.0556)		
number of competitors during the spell leading to the reorg	-0.0349	-0.0464		
	(0.0288)	(0.0325)		
change in CEO during the spell leading to the reorg	0.0586	0.0590	-0.0778	-0.228
	(0.258)	(0.241)	(0.264)	(0.302)
age (ln)	-0.0848	-0.138	0.0629	-0.0571
	(0.388)	(0.341)	(0.305)	(0.241)
employees (ln)	0.121	0.146	0.135	0.241*
	(0.156)	(0.134)	(0.138)	(0.132)
degree of firm diversification	0.110	0.123	0.0619	0.0802
	(0.145)	(0.150)	(0.162)	(0.208)
ROA in the quarter prior to the focal reorg (standardized)				-0.286***
				(0.102)
firm control	yes	yes	yes	yes
number of observations	132	132	134	118
Log-pseudolikelihood	-189.5	-188.3	-213.5	-191.7
Chi-square	90.87	109.7	61.44	67.80
number of clusters	34	34	34	32
number of failures	58	58	58	54
days at risk	151598	151598	152453	135261
degrees of freedom	8	9	6	7

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

comparison, models 1 and 2 estimate the instantaneous risk rate of the occurrence of reversal with the same controls as the models in Figure 4.9, even though the external factors are not predicted to drive reversal patterns. Only he number of entrants during the spell leading up to the focal reorganization appears to have a significant (negative) effect on the instantaneous risk rate of reversal; for every additional entrant, a firm is 27% less likely to show reversal. Model 3 and 4 reports the analysis with those control variables that the theory would predict to influence the reversal in particular (as opposed to reorganizations at large); thus, it includes only control variables internal to the firm. The hypothesized relationship of reversal holds across all three models. The full model (Model 4) shows that the instantaneous risk rate of a reversal is 88% higher if the current structure is predominantly intra-functional than if it is predominantly cross-functional.

To further corroborate the results, I run the same models reported in Figure 4.10 as an accelerated failure time model. The advantage of the accelerated failure time model is that it allows me to estimate the time between events explicitly. Thus, it estimates the difference in the rate at which the firms experience different kinds of events. These results are shown in Figure 4.11. The interpretation of these coefficients is quite different from the Cox regression model. Here, a positive coefficient is interpreted as a longer delay to the next reversal while a negative coefficient is interpreted as a shorter delay. In general, older and larger firms show a relatively longer delay to the next reversal. The results in model 4 further support Hypothesis 2. Namely, the coefficient for *old structure is predominantly intra-functional* is negative and significant, indicating a shorter delay until the next reorganization; relative to a firm with predominantly cross-functional focus in the current structure, a firm with predominantly intra-functional focus will initiate the next reversal sooner. Converting the coefficient to a time ratio shows that the time to the next reversal is more than twice as long if the current structure is predominantly cross-functional, compared to it being predominantly intra-functional. In addition, support of Hypothesis 2 helps comprehensively refute the regression to the mean explanation, which predicted the lack of a temporal pattern of reversals and type of structure held.

Figure 4.11 - Rate of Reversals: Accelerated Failure Time Model

	Dependent Variable: reversal			
	Model 1	Model 2	Model 3	Model 4
old structure is predominantly intra-functional		-0.213	-0.598*	-0.869**
		(0.197)	(0.352)	(0.389)
number of reorgs in the industry within 1 year	-0.0607	-0.0571		
	(0.0469)	(0.0471)		
number of entrants during the spell leading to the reorg	0.115***	0.112***		
	(0.0187)	(0.0184)		
number of competitors during the spell leading to the reorg	-0.0264	-0.0267		
	(0.0267)	(0.0267)		
change in CEO during the spell leading to the reorg	-0.0676	-0.0546	0.320	0.422
	(0.205)	(0.188)	(0.297)	(0.280)
age (ln)	2.753***	2.983***	1.344	2.189
	(0.905)	(1.002)	(1.628)	(1.699)
employees (ln)	0.461*	0.482*	0.604*	0.733**
	(0.246)	(0.254)	(0.348)	(0.352)
degree of firm diversification	-0.239	-0.243	-0.0986	0.0226
	(0.163)	(0.162)	(0.230)	(0.233)
ROA in the quarter prior to the focal reorg (standardized)				0.0883
				(0.0849)
constant	-4.723	-5.606	-2.343	-6.170
	(3.186)	(3.680)	(5.075)	(5.524)
firm dummies	yes	yes	yes	yes
number of observations	132	132	134	118
Log-pseudolikelihood	-75.50	-75.01	-98.04	-86.83
number of clusters	34	34	34	32
number of failures	58	58	58	54
days at risk	151598	151598	152453	135261
degrees of freedom	18	28	17	19

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

While we can only interpret these coefficients in relative terms, it may be interesting to get an approximation of what this difference means in real terms. We can gain an idea of the difference in reorganization speed by looking at the average time between different types of reorganizations. Note that the average time in the survival analysis dataset would be unduly influenced by the censored observations. I therefore drop those observations in order to compute the average survival time between observed reorganizations only. I find that a structure with a predominantly cross-functional focus is held for an average of 1282 days until it increases its intra-functional focus, while a structure with a predominantly intra-functional focus is held for an average 652 days until it increases its cross-functional focus. The median values are closer together, with 506 days before reversal for predominantly intra-functional structures, and 719 days before reversal for predominantly cross-functional structures.

4.4.3 Robustness Checks and Additional Analyses[14]

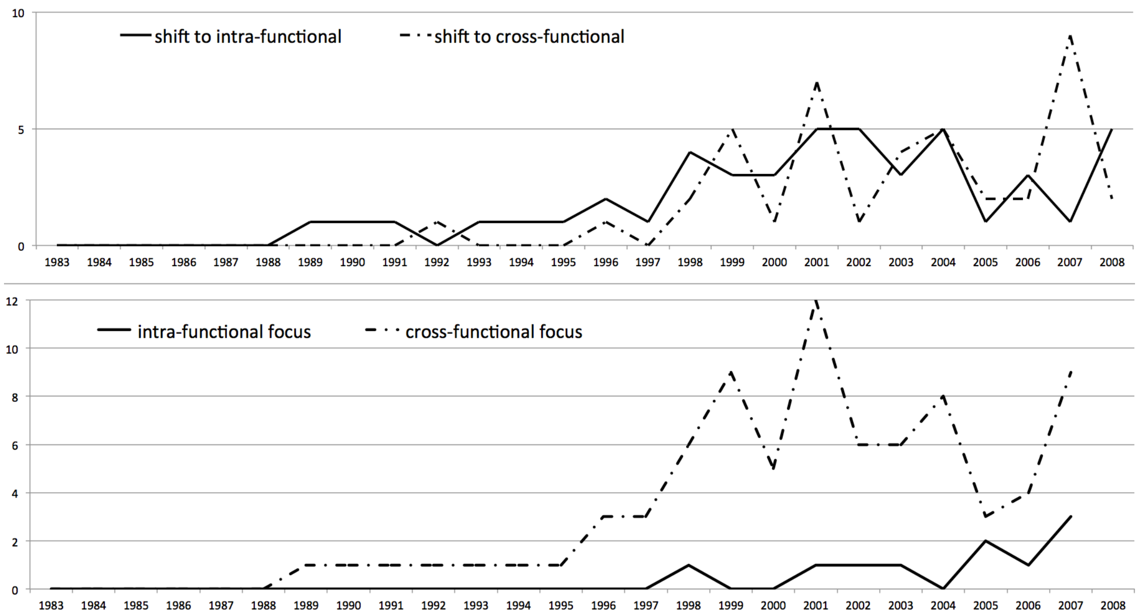
Is the reversal pattern due to cyclicality in the environment?

If the well-established drivers of reorganization showed cyclicality in their reoccurrence, we would see a reversal pattern in the firms' reorganization decisions to match that pattern. However, given that most of those drivers would affect all firms in the industry equally (controlling for performance and CEO changes), we should expect to see many of the firms reorganize 'in sync', i.e. shift their structures in similar directions over time as exogenous factors change. Figure 4.12 shows the relative shift in focus (panel a) as well as the absolute focus of the structures adopted (panel b) - as it may just be that some firms do not reorganize in response to a particular change because they are already well aligned to the new parameters. However, neither of these figures shows a consistent pattern of in-sync-alignment of the structures across the industry, where all firms abandon one type of structure simultaneously and do so repeatedly over time.[15] Therefore, the external factors alone are unlikely to drive the reversal pattern.

[14] The results were robust to a variety of models and specifications. I ran analyses using parametric and non-parametric hazard models (using time interactions for H2). I also ran a pooled cross-sectional logistic regression with firm fixed-effects, using a continuous measure of changes in the business units for each reorganization, as well as a tobit regression model with a percentage change in units as the dependent variable. The direction and significance of the main predictors were consistent with the results reported here across those alternative specifications.

[15] Changing the time scale does not generate such a pattern either.

Figure 4.12 - Types of Structures Held by all Firms



Is the reversal pattern due to the CEO's repeated adjustment attempts to environmental changes?

If we relax the inherent assumption in contingency theory (Donaldson, 2001) that the CEO can make sense of the environment as well as the complex interactions of the organization's structural elements (Ethiraj & Levinthal, 2004a), and allow for bounded rationality and satisficing on part of the CEO (Simon, 1945), a change in the environment may not translate directly into the knowledge of which structural levers to pull (Siggelkow & Levinthal, 2003). Rather, the CEO may know in what direction to push the general focus of the organization in response to the environmental change, but not by how much. Given the urgency of the decision, she may choose to adopt some structure based on an educated guess, which may require further adjustments after a brief period to align the structure properly, once additional information is available to her. Thus, we may see the occasional reversal pattern, accounting for the anecdotal evidence while maintaining the theoretical argument of 'structure follows changes in strategy' and other environmental factors. It would even be conceivable to explain a systematic reversal pattern if the CEO felt the need to adjust her decision every time an initial reorganization is triggered. This may be a reasonable scenario when the environment is particularly uncertain (e.g. Davis, Eisenhardt, & Bingham, 2009). Given the relatively turbulent environment encountered in the industry under study, support for Hypotheses 1a and 1b would therefore not allow us to draw conclusions regarding the explanatory power of this explanation. However, the timing of a reorganization in this context is driven by the rate of change of the different external factors (which are beyond the ability of the CEO or the researcher to predict). The reversal pattern would be generated by the CEO's corrective actions after an initial realignment attempt was judged sub-optimal. There is no reason to expect that the CEO improves her understanding of the environment faster or slower, depending on what structure the organization has currently adopted. Therefore, this explanation can be refuted through the support of Hypothesis 2.

There are more categories of 'cross-functional' units (i.e. by product, geography, user) than 'intra-functional' units (i.e. function) – does that imply that firms have fewer options for maintaining an intra-functional focus?

If we think of the choice of structure as a random walk on a peaked landscape, where the peaks represent structures with a predominantly intra-functional or predominantly cross-functional focus, the concern outlined above would translate into a greater number of cross-functional peaks. Let us assume that we reorganize at a constant rate; and for every reorganization we choose a new peak at random; if we only capture the switch from a predominantly intra-functional structure to a predominantly cross-functional one, we will necessarily find that cross-functional structures are followed more frequently by more cross-functional structures than intra-functional structures by intra-functional ones. Hence, the asymmetry finding would be a result of structural availability rather than driven by the asymmetry in the adjustment lag.

However, if we limited the structural choices to just two categories, functions and products (Gulick, 1937), disregarding shifts to user and geography, this structural availability argument should predict that the time to the next switch would be symmetric. On the other hand, the theory outlined above would predict that the time spent in a predominantly functional structure (before it switches to a predominantly product-based one) would be significantly shorter than the time spent in a predominantly product-based structure (before it switches to a predominantly functional one). I test this on a sub-sample, by taking all structures that are predominantly organized around product units and predict the switch to more functional focus (-0.373, SE=0.1685) and compare that coefficient to those structures that are predominantly organized around functional units and predict the switch to more product-focus (-1.513, SE=0.424). The difference is statistically significant, with p=0.02 (Wald statistic 6.245, 1df); the switch away from the current focus happens faster for structures that are currently organized by intra-functional units.[16]

Is the asymmetry in reversals driven by faster goal achievement in organizations with an intra-functional focus?

Assuming that we take the choice explanation outlined above as given, the asymmetry in the shift away from an intra-functional versus cross-functional focus may be driven by other factors. For example, what if the CEO moves away from an intra-functional focus more quickly because her aim for those structures is to cut costs, which she feels she achieves instantaneously by laying off part of the workforce? In order to account for this explanation, I control for layoffs that are associated with the reorganization. Coded from layoff announcement surrounding the announcement and/or implementation of the reorganization (with different time windows of reorganization ± 3-6 months), I include a dichotomous variable that captures whether the focal reorganization was accompanied by layoffs. Controlling for layoffs does not change the coefficients or significance of the results reported above. Layoffs are also not systematically associated with shifts to intra-functional focus (or cross-functional focus) – the variable shows no significant effect across the models.

How does firm performance affect the results?

Figure 4.13 reports the main results from Figure 4.8 with the inclusion of the performance measure. The main effects of the independent variables remain unaffected by the inclusion of this performance measure. The return on assets in the quarter prior to the focal reorganization does not affect the instantaneous risk rate of reorganizations, regardless of type. However, a one standard deviation increase in return on assets in the prior quarter increases the instantaneous risk rate of a shift toward more intra-functional focus, while it decreases the hazard of a shift toward more cross-functional focus.

[16] Note that this concern would not be applicable to the testing of Hypotheses 1 a and b, given the focus on the relative shift ***towards*** more intra- or cross-functional focus.

Figure 4.13 - Systematic Reversal with Performance

Cox Non-Proportional Hazard Model	any reorg Model 1	shift toward intra-functional focus Model 2	shift toward cross-functional focus Model 3
total number of intra-functional units in the old	-0.0102 (0.133)	-0.414*** (0.147)	0.646*** (0.222)
total number of units in the old structure	0.145** (0.0735)	0.463*** (0.174)	-0.232 (0.175)
change in CEO during the spell leading to the reorg	-0.181 (0.285)	-0.932* (0.546)	-1.059 (0.701)
ROA in the quarter prior to the focal reorg	-0.248 (0.204)	1.396** (0.552)	-0.402* (0.230)
age (ln)	-7.340*** (2.345)	-11.32* (5.937)	-11.84*** (4.484)
employees (ln)	-0.772 (0.804)	-2.693*** (0.855)	1.631* (0.874)
degree of firm diversification	0.0390 (0.505)	0.972** (0.415)	-1.179 (0.891)
number of reorgs in the industry within 1 year	0.115 (0.0909)	0.355** (0.172)	-0.104 (0.181)
number of entrants during the spell leading to the reorg	-0.364*** (0.0644)	-0.562** (0.233)	-0.313* (0.160)
number of competitors during the spell leading to the reorg	0.0989** (0.0487)	0.106 (0.0652)	0.233*** (0.0843)
strata	firm	firm	firm
number of observations	116	116	116
Log-pseudolikelihood	-62.21	-20.95	-24.82
Chi-square	103.6	112.3	62.55
number of clusters	32	32	32
number of failures	92	45	47
days at risk	134406	134406	134406
degrees of freedom	10	10	10

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01

The cellphone manufacturing industry has gone through a number of disruptive technological changes – how do those affect the results?

During the period covered by this study, the cellphone manufacturing industry went through three ‘game-changing’ events, namely the switch from analog to digital standard in the core technology in cellphones in 1989; the introduction of the first smart phone by Nokia in 1996; and the announcement of a new generation of smart phones by Apple in 2007. In order to test how those events impact the hazard of reorganizations, I include a year dummy for the affected years. None of the events (individually or on aggregate) affected the instantaneous risk rate of *any reorganization* to occur. The only noticeable effect of the change in the core technology from analog to digital (1989) was an increase in the time lag toward the next reversal (*technology 1989*: β=0.479*** SE=0.132), however the main effect stayed significant (*current focus is intra-functional*: β= -0.590* SE=0.352). The introduction of the first smartphone by Nokia in 1996 had a dampening effect on the instantaneous risk rates of reorganizations of any type and of a shift toward more intra-functional focus, while all the main effects remained unchanged. The introduction of the iPhone introduction (in 2007) reduced the effect size of a shift toward more intra-functional focus (although it stayed significant, β=-0.301* SE=0.175). The inclusion of all industry events on aggregate shows a dampening effect on reorganizations that shift focus toward more intra-functional focus (β=-2.620** SE=0.497).

How does the scope of change affect the reversal pattern?

In order to answer this question I would need to manipulate the hazard function to vary with the intensity of the change. I am not aware of an empirical way to combine the hazard function with an intensity variable. Given that this methodology is borrowed from medical research, such a question is unlikely to be of importance (i.e. what matters is the likelihood of death by a number of diseases which is run as a competing risk analysis – the quality of death is not studied in this context as far as I am aware). However, if we assume that the effect of scope is such that a greater focus on intra-functional units in the current structure magnifies the reversal effect, then the current set up (ignoring the scope effect) would not introduce a bias but reduce the chances of finding a significant effect. In the present test of this effect I am assuming that all reversals are of the same magnitude. Thus, if I get significant results for this noisier test, the results should hold when accounting for the scope of change as well.

4.5 Discussion and Conclusion

Repeated reversals between centralization and decentralization have been remarked upon repeatedly as a curious pattern of successive reorganizations (Mintzberg, 1979; Carnall, 1990; Eccles & Nohria, 1992; Cummings, 1995) and some theoretical reasoning for its occurrence has been proposed (Nickerson & Zenger, 2002; Gulati & Puranam, 2009). However, the dichotomy applied to the structural choice set and other simplifying assumptions, which underlie much of the anecdotal and theoretical work on this topic, have limited our understanding of this phenomenon to date. In this study I highlight the effect of history on corporate reorganizations. Specifically, I highlight that a careful consideration of the type of structure adopted is necessary to make a clear distinction between reorganizations in general and reversals in particular; I deepen our understanding of the mechanism underlying the reversal pattern; I show that the current type of structure held by the organization crucially impacts the rate at which reversals occur.

By developing a conceptualization of the complex structures we encounter in today's business world as a continuum between greater or lesser structural emphasis on intra- versus cross-functional focus at level of the corporate units, I have highlighted that the choice of reversal is a real one; namely, (1) a CEO may show reversal in the structural emphasis of the choices he makes in subsequent reorganizations without ever touching the exact same previous structures again; and (2) the reversal towards the previously abandoned focus becomes an actual choice as opposed to the inevitable consequence of the decision to reorganize. Hence, when considering reversal tendencies we are talking about a relative reversal ***towards*** a particular focus of the overall structure as opposed to a reversal to the exact same structure previously abandoned. On the back of the development of a workable definition of the reversal itself as a relative shift in the structural emphasis, I have proposed a theoretical distinction between the drivers for reorganizations in general and reversals in particular. By developing the established theory on reversals further, I have highlighted that reversals (as opposed to reorganizations of other types) are likely to be driven by the structural limitations and tradeoffs inherent in any organization design and have validated the theory empirically.

I have deepened our theoretical understanding of reversals by probing further into the mechanism that may drive this phenomenon. If we acknowledge that employees approach challenges and tasks with their individual ‘knowledge funds’, and given that this is highly influenced by their specialization and socialization in a particular function of the firm (Dougherty, 1992), we can derive interesting predictions regarding the rate of reversals. In particular, I highlight that the way we group employees into different kinds of units may have important efficiency implications, in that certain groupings speed up the achievement of collaboration among its employees, resulting in a speedier adjustment of the employees to the new structure. Namely, grouping employees into units around activities with colleagues of similar backgrounds through collocation and allocation of common incentives into intra-functional units will help them to achieve the necessary collaboration more quickly; while grouping employees into units consisting of individuals of very different backgrounds into cross-functional units will slow that process down. I test these theoretical arguments empirically and find support for the macro-level effects that we would expect to see if this mechanism did indeed influence the adjustment process between reversals. Namely, I find that firms move away from an intra-functional focus significantly more quickly than from a cross-functional focus.

CHAPTER 5
Conclusion

In this dissertation I focus on how history - the established interaction patterns between employees and the given structure - influences the process of choosing a new design as well as the content of that new design. Prior research on organization design has devoted a lot of attention to questions of appropriate structural forms, triggers of structural change, and obstacles to organizational renewal. However, the fundamental impact that the established organizational structure has on the effectiveness of its current design and on the content and process of structural change going forward has received relatively little attention. In this dissertation, I have developed theory that speaks to the effect of history on organization re-design choices, and I have set up two empirical studies that allow for a direct test of some of the propositions derived from that theory.

In chapter 2, I explore the organizational re-design decision theoretically. Building on the epistemic interdependence perspective which I developed jointly with Thorbjørn Knudsen and Phanish Puranam, I establish that the organization design choices of a designer are fundamentally different in a new system (in which neither the agents nor the designer have any knowledge of anyone else in the system) compared to a system with history (in which the designer and the agents have worked with each other before), which depends on both, the designer's as well as the employees' knowledge repositories. In particular, I propose that *history* affects the designer's process of task allocation, as well as his choice of new designs, and the implementation speed of new structures.

In chapter 3, I study the effect of history on the process of organization design empirically. In particular, I examine the extent to which the process of division of labor (comprised of task division and task allocation) is affected by the technological properties of the task in conjunction with individuals' perception of the task decomposability and prior experience of joint work (*history*). I find that task division is significantly affected by the individuals' perception of the task, and task allocation is altered in the presence of history. The technological property of the task has an important impact on both, the task division as well as the task allocation.

In chapter 4, I examine the impact of prior structures (*history*) on reorganization decisions at the macro-level. My empirical setting is the global cell phone manufacturing industry. I use the corporate-level reorganizations across the entire industry over 25 years to examine the impact of the established structural emphasis on subsequent re-design choices. I find that firms show a systematic tendency of reversal between different structural foci. In addition, the rate of reversals is significantly and asymmetrically affected by the organization's current structural emphasis, which speaks to the question of the effect of history on the implementation speed of new structures.

5.1 Main Findings

In chapter 2, I developed theory that speaks to the impact that history may have on the process and content of organization design decisions and outlined four specific propositions. In this section, I discuss the findings from chapters 3 and 4 which speak to each of those propositions in turn.

5.1.1 Evidence in Support of Proposition 5

> *Proposition 5: In the absence of predictive knowledge, the designer's choices regarding task division are predominantly driven by her perception of the technological properties of the task.*

In chapter 3, I examine the impact of a blank canvas condition on the designer's choice of task division and task allocation explicitly by observing the results from the first sessions in both experiments. Experiment 1 provides insights into the dynamics of a set of self-organizing 'designers', while Experiment 2 captures the scenario of an individual, centralized decision-maker on behalf of a group. The designer's perception clearly plays an important role in the choice of initial task division; namely, the tendency to observe object-based task clusters more easily than activity-based task is clearly visible in the results. Thus, even though object-based task division may be preferred by individuals based on motivational reasons (Hackman & Oldham, 1976) or for ease of monitoring (Zenger & Hesterly, 1997), I show in experiment 2 that the cognitive constraint has at least an important additional impact on the participants' choice. In addition, the technological properties of the task have a strong moderating effect on the designers' choice of task division - weakly decomposable tasks make the activity-based task clusters relatively more salient, due to the relative lack of independent object-based task clusters.

5.1.2 Evidence in Support of Proposition 6

> *Proposition 6: The presence of predictive knowledge between agents impacts the designer's task allocation decision by reducing the need for minimizing allocated task interdependence across agents.*

The results from chapter 3 clearly show that the designer's task allocation decisions are significantly influenced by the presence of prior interactions between the individuals. However, this influence is more multifaceted than predicted, especially when we contrast the effect of self-organizing designers with detached, centralized ones. The evidence from Experiment 1 suggests a tendency to preserve the established task allocation from the prior session in self-organizing teams, especially when going from a strongly to a weakly decomposable task. Thus, the presence of established interaction patterns (including predictive knowledge) shapes the process of the task allocation, but within the limits imposed by the technological properties of the task. In contrast, the centralized designer's choices regarding task allocation does not appear to be affected by the possibility of established predictive knowledge among the individuals. This may be at least partly due to the research design. The designers in experiment 2 were asked to imagine that they would organize a group, rather than actually instruct four subjects. This may have reduced the prevalence of the possible shared history in session 2 when choosing the division of labor for the second task. Future research may alter the research design by either providing (fictitious) background information on the subjects the designer may choose to assign to certain tasks (including their shared history with other potential group members), or integrating the centralized designer and his choices into a real group as reported in experiment 1. The latter approach would shed further light on the relative effectiveness of the design effort by a centralized individual vis à vis a self-organizing group.

5.1.3 Evidence in Support of Proposition 7

> *Proposition 7: The designer's choice of structure when re-designing the organization is affected by the predictive knowledge that the previously established structure generated among the agents.*

In addition to the micro-level evidence of the impact of history on the choices regarding task division and task allocation described in chapter 3, the macro-structure analyses in chapter 4 shed further light on this proposition. While the literature on reorganizations has largely focused on external drivers of structural change, chapter 4 focuses on the impact of the established structure. Arguably, all organizational structures implement certain limitations as well as beneficial effects, due to the behavioral opportunities and constraints any structure imposes on the employees. This leads to a constant trade-off between different structural foci. In order to overcome those, reversals appear to occur, where the structural advantages of one focus overcome the challenges created by the other. Over time, this trade-off leads to a reversal pattern - a tendency to shift the organization's structural emphasis on a continuum towards more intra- and cross-functional focus, respectively. The results reported in chapter 4 support these arguments empirically, and thus lend support to the proposition that history affects the content of re-design choices.

5.1.4 Evidence in Support of Proposition 8

> *Proposition 8: The presence of predictive knowledge effectively increases the implementation speed of the new design.*

The theoretical arguments developed in chapter 4 further elaborate on this proposition. In particular, hypothesis 2 suggests that the implementation speed of the new design will depend crucially on the type of structural emphasis currently in place -

predicting a reversal to occur sooner when the current structure is predominantly intra-functional. The argument is based on the fact that intra-functional units group together individuals with a relatively greater baseline of predictive knowledge which facilitates the creation of collaboration. Thus, the desired effect of overcoming the structural limitation of predominantly intra-functional structures is achieved relatively more quickly, leading to a reversal towards more cross-functional focus. The empirical results support the predicted macro-level effects of this theory. There is indeed an asymmetry in the timing of reversals, in the sense that reversals from intra-functional to cross-functional focus occur relatively sooner than reversals in the opposite direction. Nevertheless, the study reported in chapter 4 does not test this theory at the micro-level; this is left for future research.

5.2 Implications for Theory

In this dissertation, I develop theory and empirical evidence that make contributions at two different levels of analysis. By highlighting different factors that influence the process of division of labor, I contribute to our understanding of the micro-foundations of organization design. In addition, the insights derived from the large-sample study and the accompanying theory shed light on a particular macro-level issue in the organization design literature, namely the equifinality of designs.

The results from the two experiments reported in Chapter 3 generate insights into how the process of division of labor for novel tasks is affected by attributes of the individuals and groups that engage in it. While it has generally been taken for granted that the technological properties of the task drive the division of labor (rooted in the work by Smith, 1776), in these experiments I show that the individuals' perception of the task structure and the dynamics that derive from prior interaction among the individuals significantly impact that process. These findings have interesting implications for our understanding of the process of the division of labor.

The individuals' tendency to identify object-based task partitions more easily in the task environment suggests that the emergence of activity-based task division is not spontaneous. This implies that the proliferation of the division of labor by activity and the subsequent specialization in small sub-parts of the production process as described by Smith (1776) required additional ingredients to come about. In particular, it appears that a high level of repetition is a necessary condition for specialization by activity to emerge and become a viable way of dividing the work. This has concrete implications for the organization of work in 'one-shot' organizations such as project-, disaster relief-, research- or combat teams, where the gains from specialization may remain invisible unless a general template for organizing exists in that domain (e.g. Baron, Hannan, & Burton, 2001; Bechky, 2006).

By taking the division of labor as given (March & Simon, 1958; Lawrence & Lorsch, 1967; Thompson, 1967), the established literature on organization design tends to pass over an important determinant of structural effectiveness. As the experiments reported here show, the conditions under which a task is split into contributory (clusters of) sub-tasks, and the individuals involved in this process significantly shape the resulting division of work, including the interdependencies between tasks and agents. Hence, closer attention to this process may generate a wider set of structural choices by avoiding the introduction of limitations too early in the process.

The finding of a systematic reversal toward the structure previously abandoned and the role that the different types of structures play (as reported in chapter 4), has important implications for our empirical studies of reorganizations, as well as for our theory development. Empirically, it highlights an important source of variation that may explain why finding the effects of certain contingency factors in the extant literature in cross-sectional data has been challenging (e.g. see Drazin & Van de Ven, 1985; Capon, Farley, & Hoenig, 1990 for a review).

At a broader level, the finding of a systematic reversal pattern also has interesting implications for the organization design literature. When we look at a misalignment between the firm's structure and its environment, we assess which new design would be best suited for the new set of 'contingencies' (Donaldson, 2001). What the findings in this study highlight is that almost every problem of design encountered is really a problem of re-design. At a superficial level this implies that the design issue is highly influenced by the firm's current structure; at a more fundamental level it implies that two firms, A and B, which face the same exogenous shift in the environment and reorganize in response to it, may adopt very different - but equally effective - new designs. The source of this equifinality may actually lie in the different changes necessary to address this new problem, given the type of structure they were previously in, rather than in an efficiency frontier of different structural options available to address any given environmental condition (Gresov & Drazin, 1997).

At a micro-level, this insight translates into an interplay between the designer's knowledge of how to divide and allocate tasks (architectural knowledge) and the agents' knowledge of how to integrate tasks (predictive knowledge), which - in turn - is influenced by the extent to which designer and agents have shared history. Thus, different organizations may indeed tackle the same tasks with different divisions of labor, but the potential for variety is limited by the technological properties of the task and bounded rationality.

5.3 Implications for Practice

Overall, the aim of the research presented as part of this dissertation is to contribute to the renewal of interest and enquiry in this important aspect of corporate strategy. Ultimately, we need to ensure that the theory we build on is relevant and can generate significant insights for the decisions made regarding structure and design in *today's* organizations. Specifically, the findings have the following implications for practice.

Regarding the organization of work, the experiments reported in chapter 3 provide two interesting insights. First, the results suggest that the process of division of labor is quite different when a task is taken on by an established group versus a group that is newly formed around a task. In the former case, the tendency to preserve the existing group structure may preclude certain divisions of labor and make others more likely. The findings further highlight that the technological properties of the task may weaken this effect; in particular, if the task is only weakly decomposable, its constraints on task division are likely to reduce the degrees of freedom at the group's disposal regarding its choice of task allocation. Thus, while established interaction patterns between individuals certainly have several advantages in reducing the need for costly information processing and structure to facilitate it, *history* may also have a detrimental effect on the effectiveness of task allocation.

Second, while a designer who is ignorant of the established interaction patterns will certainly impose a structure that is unconstrained by these social considerations, it would also lack the beneficial aspect. In that sense, the effect of established interaction patterns is a trade-off that needs to be carefully balanced. In general, an organization that faces tasks with a wide variety of decomposability may be better off maintaining a pool of loosely connected individuals that are grouped together by an external designer in ad hoc teams, so that the ‘Parkinson’s law’ effect of task allocation can be avoided. On the other hand, if the tasks an organization face are relatively homogeneous, the established interaction patterns between its members will be highly beneficial in speeding up task division and allocation and making the division of labor more efficient.

The study presented in chapter 4 provides interesting insights regarding reorganization decisions. In particular, innovative work practices that can be implemented to facilitate cross-unit collaboration should decrease the rate at which reversals - induced by the structural limitations - would be necessary. The implementation of such linking mechanisms between units should decrease the correlation between the speed of achieving collaboration and the need for structural change. In the face of strong unit-boundary spanning technologies, a reorganization would merely encourage new links between employees but not necessarily weaken the existing ones.[1] To facilitate the establishment of such mechanisms, the theory developed here suggests that they would be taken up more enthusiastically if the current structure is highly cross-functional.

Finally, the results from the study reported in chapter 4 highlight that reversals may be *necessary* rather than merely due to the top management’s incapacity to get it right or their desire to feint progress. Providing a clearer explanation for its necessity may lighten some of the cynicism that many repeated reorganization announcements generate. As one of my interviewees from a large software development company put it,

> *The point is, to employees this [reversal] looks kind of stupid.(...) after the second time, they think, OK, in two years’ time it’s going to happen again, they are just stupid up there, they are kind of crazy, because they don’t know what they want to do.*

[1] There are certainly limits to their effectiveness, given the individuals’ bounded rationality.

References

Agarwal, R. & Helfat, C.E. 2009, Strategic Renewal of Organizations. ***Organization Science***, 20(2): 281-293.

Allen, T. J. 1977. ***Managing the Flow of Technology: Technology transfer and the dissemination of technological information within the R&D organization.*** Cambridge, MA: MIT Press.

Allison, P. D. 1996. Fixed effects partial likelihood for repeated events. ***Sociological Methods and Research***, 25: 207–222.

Allison, P. D. 1995. ***Survival Analysis Using the SAS System: A practical guide***, SAS Institute Inc., Cary, NC.

Anderson, C. & Franks, N.R. 2001 Teams in Animal Societies, ***Behavioral Ecology***, 12(5): 534-540.

Arrow, K.J. 1974. ***The Limits of Organization.*** New York: WW Norton & Company.

Babbage, C. 1833 ***On the Economy of Machinery and Manufactures***, London, UK: Charles Knight, 3rd edition.

Baldwin, C.Y. & Clark, K.B. 2000 ***Design Rules***, Cambridge, MA: The MIT Press.

Barley, S. 1986 Technology as an Occasion for Structuring: Evidence from observations of CT scanners and the social order of radiology departments, ***Administrative Science Quarterly***, 31: 78-108.

Barley, S. 1988 The social construction of a machine: Ritual, superstition, magical thinking and other pragmatic responses to running a CT scanner, In M. Lock & D. Gordon (eds.), ***Biomedicine examined***. Dordecht, The Netherlands: Kluwer.

Barnard, C. I. 1938. The Functions of the Executive. Cambridge, MA: Harvard University Press.

Barnett, W.P. & Carroll, G.R. 1995. Modeling Internal Organzational Change, ***Annual Review of Sociology***, 21: 217-236.

Baron, J.N., Hannan, M.T. & Burton, M.D. 2001 Labor pains: change in organizational models and employee turnover in young high-tech firms, ***American Journal of Sociology***, 106(4): 960-1012.

Barzel, Y. 1982 Measurement Cost and the Organization of Markets, ***Journal of Law and Economics***, 25(1): 27-48.

Bechky, B.A. 2006 Gaffers, gofers, and grips: Role-based coordination in temporary organizations, ***Organization Science***, 17: 3–21.

Biederman, I. 1987 Recognition-by-Components: A theory of human image understanding, Psychology Review, 94(2): 115-147.Brown, S. L., Eisenhardt, K.M. 1997. The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. ***Administrative Science Quarterly***, 42(1): 1–34.

Burns, T. & Stalker, G.M. 1961. ***The Management Innovation***, Tavistock, London.

Burton, R.M. & Obel, B. 1984a. A computer simulation test of the M-form hypothesis, ***Administrative Science Quarterly***, 25(3): 457-466.

Burton, R.M., & Obel, B. 1984b. ***Designing Efficient Organizations: Modelling and Experimentation***, Amsterdam: North-Holland, Elsevier Science Ltd.

Cafferata, G.L. 1982. The Building of Democratic Organizations: An embryological metaphor, ***Administrative Science Quarterly***, 27: 280-303.

Camerer, C. 2003. ***Behavioural Game Theory: Experiments in Strategic Interaction***. Princeton: Princeton University Press.

Camerer, C. & Knez, M. 1996. Coordination, Organizational Boundaries and Fads in Business Practices. ***Industrial and Corporate Change,*** 5(1): 89-112.

Capon, N., Farley, J. U., & Hoenig, S. 1990. Determinants of financial performance: A meta- analysis. ***Management Science***, 36: 1143–1143

Carnall, C. A. 1990. ***Managing Change in Organizations***. Prentice Hall, London, U.K.

Chandler AD. 1962. ***Strategy and Structure: Chapters in the history of industrial enterprise***. Cambridge, MA: MIT Press.

Child, J. & Kieser, A. 1981. Development of Organizations Over Time. in ***Handbook of Organizational Design***, ed. W. Starbuck & P. Nystrom, I: 29-64, New York: Oxford.

Clark, H. 1996. ***Using Language***. Cambridge, UK: Cambridge University Press.

Cohen, M.D. & Bacdayan, P. 1994. Organizational Routines Are Stored as Procedural Memory: Evidence From a Laboratory Study, ***Organization Science***, 5(4): 554-568.

Colfer, L. & Baldwin, C.Y. 2010. ***The Mirroring Hypothesis: Theory, Evidence and Exceptions***. Working Paper No. 10-058, Harvard Business School, Cambridge, MA.

Cox, D.R. 1975. Partial Likelihood. ***Biometrika***, 62: 269-276.

Cronin MA, Weingart LR. 2007. Note - Representation Gaps, Information Processing, and Conflict in Functionally Diverse Teams. ***Academy of Management Review***, 32(3): 761-773.

Cummings, S. 1995. Centralization and decentralization: The never-ending story of separation and betrayal. ***Scandinavian Journal of Management*** 11(2): 103-117.

Cyert, R. M., J. G. March. 1963. ***A Behavioral Theory of the Firm***. Prentice-Hall, Englewood Cliffs, NJ.

Daft, R.L., & Lengel, R.H. 1984. Information Richness: A New Approach to Manager Information Processing and Organization Design in ***Research in Organizational Behavior,*** B. Staw and L. L. Cummings (Eds.), JAI Press, Greenwich, Connecticut.

Daft, R.L., & Lengel, R.H. 1986. Organizational Information Requirements, Media Richness and Structural Design. ***Management Science***, 32(5): 554-572.

Davis, J.P., Eisenhardt, K.M., Bingham, C.B. 2009. Optimal Structure, Market Dynamism, and the Strategy of Simple Rules. ***Administrative Science Quarterly***, 54:413-452.

Davis, S.M. & Lawrence, P.R., 1977. ***Matrix***, Reading, MA: Addison-Wesley.

Delacroix, J. & Swaminathan, A. 1991. Cosmetic, Speculative and Adaptive Change in the Wine Industry: A longitudinal study, ***Administrative Science Quarterly***, 36: 631-661.

Donaldson, L. 2001. ***The Contingency Theory of Organizations***. Thousand Oaks, CA: Sage

Dougherty D. 1992. Interpretive Barriers to Successful Product Innovation in Large Firms. ***Organization Science***, 3(2): 179-202.

Drazin, R. & Van de Ven, A.H. 1985. Alternative Forms of Fit in Contingency Theory. ***Administrative Science Quarterly***, 30(4):514-539.

Duchowski, A.T. 2002. A Breadth-First Survey of Eye-Tracking Applications, ***Behavior Research Methods, Instruments, and Computers***, 34(4): 455-470.

Dunbar, R.L.M. & Starbuck, W.H. 2006. Learning to design organizations and learning from designing them. ***Organization Science*** 17(2): 171-178.

Durkheim, E. 1893. ***The Division of Labor in Society***. New York: Free Press.

Eccles, R. G., Nohria, N. 1992. ***Beyond the Hype: Rediscovering the Essence of Management.*** HBS Press, Cambridge, MA.

Edmondson, A, Dillon, J., Roloff, K.S. 2007. Three Perspectives on Team Learning Outcome Improvement, Task Mastery, and Group Process. ***Academy of Management Annals***, 1: 269-314.

Egelhoff, W.G. 1982. Strategy and Structure in Multinational Corporations: An information-processing approach. ***Administrative Science Quarterly***, 27: 435-458.

Egidi, M. & Narduzzo, A. 1997. The emergence of path-dependent behaviors in cooperative contexts, ***International Journal of Industrial Organization***, 15(6): 677-709.

Emerson, R.M. 1962. Power-Dependence Relations. ***American Sociological Review***, 27(1): 31-41.

Eppinger, S.D. 1991. Model-based Approaches to Managing Concurrent Engineering, ***Journal of Engineering Design***, 2: 283-290.

Ethiraj, S. K., & Levinthal, D. A. 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, S.K. & Levinthal, D.A. 2004b. Modularity and Innovation in Complex Systems. ***Management Science,*** 50(2): 159-173.

Feldman, M.S. & Pentland, B.T. 2003. Reconceptualizing Organizational Routines as a Source of Flexibility and Change, ***Administrative Science Quarterly***, 48: 94–118.

Fligstein,N. 1985. The Spread of the Multidivisional Form Among Large Firms, 1919-1979. ***American Sociological Review***, 50: 377-391.

Ford RC & Randolph WA. 1992. Cross-functional structures: A review and integration of matrix organization and project management. ***Journal of Management***, 18: 267–294.

Fulk, J. 1993 Social construction of communication technology, ***Academy of Management Journal***, 36(5): 921–951.

Galbraith, J.R. 1971. Matrix Organization Designs: How to combine functional and project forms, ***Business Horizons***, 29-40.

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

Galbraith, J.R. 1977. ***Organizational Design.*** Reading, MA: Addison-Wesley.

Galbraith JR. 2008. ***Designing Matrix Organizations That Actually Work***, Jossey Bass.

Gentner, D. 1981. Some interesting differences between nouns and verbs, ***Cognition and Brain Theory***, 4: 161-178.

Gentner, D. 1982. Why nouns are learned before verbs: Linguistic relativity versus natural partitioning, In S. Kuczaj (ed.), ***Language Development: Vol. 2. Language, thought and culture***: 199-241. London, UK: Cambridge University Press.

Gentner, D. & Boroditsky, L. 2001. Individuation, relativity and early word learning, In M. Bowerman and S. Levinson (eds.), ***Language Acquisition and Conceptual Development***: 215-256. Cambridge, UK: Cambridge University Press.

Grant, R.M. 1996. Toward a knowledge based theory of the firm. ***Strategic Management Journal,***, 17: 109-122.

Gresov, C., & Drazin, R. 1997. Equifinality: Functional equivalence in organization design. ***Academy of Management Review***, 22: 403–428

Guetzkow, H & Simon, H. A. 1955. The Impact of Certain Communication Nets upon Organization and Performance in Task-Oriented Groups, ***Management Science***, 1(3-4): 233-250.

Gulati, R. 2011. ***Reorganize for Resilience***, Cambridge, MA: Harvard Business School Press.

Gulati R, Puranam P. 2009. Renewal through Reorganization: The Value of Inconsistencies between Formal and Informal Organization. ***Organization Science,*** 20(2):422-440

Gulati, R. & Singh, H. 1998. The Architecture of Cooperation: Managing coordination costs and appropriation concerns in Strategic Alliances. ***Administrative Science Quarterly,*** 43(4): 781-814.

Gulick, L. 1937. Notes on the theory of organization. ***Papers on the Science of***

Administration. L.U.L. Gulick, ed. Institute of Public Administration, Columbia University, New York, 3–45.

Hachen, D.S. 1988. The Cometing Risks Model: A Method for Analyzing Processes with Multiple Types of Events, ***Sociological Methods & Research***, 17(1): 21-54.

Hackman, J.R. & G.R. Oldham, 1976. Motivation through the Design of Work: Test of a Theory, ***Organizational Behavior and Human Performance***, 16: 250-279.

Hall, R. H. 1991. ***Organizations*** (5th ed.). Englewood Cliffs: Prentice-Hill.

Hannan, M.T. & J. Freeman, 1977. The population ecology of organizations, ***American Journal of Sociology***, 82: 929–964.

Hannan, M.T. & J. Freeman, 1984. Structural Inertia and Organizational Change, ***American Sociological Review***, 49: 149-164.

Hannan, M.T., Pólos, L. & Carroll, G.R. 2003. Cascading Organizational Change, ***Organization Science***, 14(5): 463-482.

Haveman, H.A., 1993. Follow the Leader: Mimetic Isomorphism and Entry Into New Markets. ***Administrative Science Quarterly***: 38, 593-627.

Heath, C., & Staudenmayer, N. 2000. Coordination Neglect: How Lay theories of organizing complicate coordination in organizations. ***Research in Organizational Behavior,***, 22(53-191.).

Henderson R.M. & Clark K.B.1990. Architectural Innovation: The reconfiguration of existing product technologies and the failure of established firms. ***Administrative Science Quarterly***, 35: 9–30.

Holmstrom, B., & Roberts, J. 1998. The Boundaries of the Firm Revisited. ***Journal of Economic Perspectives***, 12(4): 73.

Ibarra, H. 1992. ***Structural Alignments, Individual Strategies, and Managerial Action: Elements Toward a Network Theory of Getting Things Done***. Boston: Harvard Business School Press.

Ibarra, H. 1993. Network Centrality, Power, and Innovation Involvement: Determinants of Technical and Administrative Roles. ***Academy of Management Journal***, 36(3): 471-501.

Joyce, W.F. 1986. Matrix Organization: A social experiment, ***Academy of Management Journal,*** 29(3): 536-561.

Karim, S. & Mitchell, W. 2000. Path-dependent and Path-Breaking Change:

Reconfiguring business resources following acquisitions in the U.S. medical sector, 1978-1995." ***Strategic Management Journal***, 21(10-11): 1061-1082.

Kelley, H.H., & Thibaut, J.W. 1978. ***Interpersonal Relations: A Theory of Interdependence***. New York: John Wiley & Son.

Kimberly. JR, Miles, RH, & Associates (Eds.). 1980. The organizational life cycle. San Francisco: Jossey-Bass.

Kloos, H. & V. Sloutsky, 2004. Are Natural Kinds Psychologically Distinct from Nominal Kinds? Evidence from learning and development, in ***Proceedings of the meeting of the Cognitive Science Society***, Chicago, IL.

Kretschmer, T., & Puranam, P. 2008. Integration through Incentives in Differentiated Organizations. ***Organization Science.***, 19(6): 860-875.

Lamont, B. T., Williams, R.J., Hoffman, JJ. 1994. Performance during "M-form" reorganization and recovery time: The effects of prior strategy and Implementation Speed. ***Academy of Management Journal***. 37(1) 153–166.

Lawrence PR, Lorsch J. W. 1967. ***Organization and Environment: Managing Differentiation and Integration***. Boston: Harvard Graduate School of Business Administration.

Lee, E. & Puranam, P. 2012. The Implementation Imperative: Why effective implementation may be useful even with bad strategy, ***London Business School, Working Paper.***

Leijonhufvud, A. 1986. Capitalism and the Factory System, in R.N. Langlois (ed.) ***Economic as a Process: Essays in the New Institutional Economics***: 203-223. New York: Cambridge University Press.

Leijonhufvud, A. 1995. The Individual the Market and the Industrial Division of Labor, In C. Mongardini (Ed.) ***L'Individuo e il Mercato***: 61-78. Roma: Bulzoni Editore.

Leonardi, P.M. & S.R. Barley, 2010. "What's under Construction Here? ***Academy of Management Annals***, 4(1): 1-51.

Levinthal, D. A. 1997. Adaptation on Rugged Landscapes. ***Management Science,*** 43(7): 934.

Levinthal, D.A. & Warglien, M. 1999. Landscape Design: Designing for Local Action in Complex Worlds. ***Organization Science***, 10: 342-357.

Liang, D.W., R.L. Moreland, & L. Argote, 1995. Group versus individual training and group performance: The mediating role of transactive memory, ***Personality and Social Psychology Bulletin***, 21 (4): 384–393.

Lippitt, G.L. & Schmidt, W.H. 1967. Crises in a Developing Organization, ***Harvard Business Review,*** 45: 102-112.

Malhotra, D. & J.K. Murnighan, 2002. The effects of formal and informal contracts on interpersonal trust, ***Administrative Science Quarterly***, 47: 534–559.

Malone, T.W. & Crowston, K. 1994. The Interdisciplinary Study of Coordination. ***ACM Computing Survey,*** 26(1)

March, J. G. 1991. Exploration and exploitation in organizational learning. ***Organization Science***, 2: 71-87.

March JG, Simon HA. 1958. ***Organizations***. Cambridge, MA: Wiley.

Marx, K. 1906 ***Capital***, New York: Modern Library.

McCann, J.E. & Ferry, D.L. 1979. An Approach for Assessing and Managing Inter-Unit Interdependence. ***Academy of Management Review,*** 4(1): 113-119.

Milgrom, P. & J. Roberts, 1990. The economics of modern manufacturing: Technology, strategy, and organization, ***American Economic Review***, 80(3): 511-28.

Milgrom, P. & Roberts, J. 1995. Complementarities and Fit Strategy, Structure, and Organizational Change in Manufacturing. ***Journal of Accounting and Economics,*** 19(2-30): 179-208.

Miller, D., & Friesen. P. H. 1983. Successful and unsuccessful phases of the corporate life cycle. ***Organizational Studies***, 4: 339-357.

Miller, D., Greenwood, R., Prakash, R. 2009. What happened to organization theory? ***Journal of Management Inquiry***, 18 (4): 273-279.

Miner, A.S., Amburgey, T.L., & Stearns, T.M. 1990. Interorganizational Linkages and Population Dynamics: Buggering and transformational shields, ***Administrative Science Quarterly***, 35: 689-713.

Mintzberg H. 1979. ***The Structuring of Organizations***. Englewood Cliffs, NJ: Prentice Hall.

Mohr, L.B. 1971. Organizational Technology and Organizational Structure. ***Administrative Science Quarterly,*** 16(4): 444-459.

Moreland, R.L. 1999. Transactive memory: Learning who knows what in work groups and organizations, In L. Thompson, D. Messick, and J. Levine (eds.), ***Shared***

cognition in organizations: The management of knowledge: 3–31. Mahwah, NJ: Erlbaum

Moreland, R.L., L. Argote, & R. Krishnan, 1996. Socially Shared Cognition at Work: Transactive memory and group performance, In J.L. Nye, and A.M. Brower (eds.), ***What's Social about Social Cognition? Research on socially shared cognition in small groups***: 57-84. Thousand Oaks, CA: Sage

Moreland R.L & L. Myaskovsky, 2000. Exploring the Performance Benefits of Group Training: Transactive Memory or Improved Communication? ***Organizational Behavior and Human Decision Processes***, 82(1): 117–133.

Nadler DA, Tushman ML. 1997. ***Competing by Design: The Power of Organizational Structure***. Oxford University Press.

Nickerson JA, Zenger TR 2002. Being Efficiently Fickle: A Dynamic Theory of Organizational Choice. ***Organization Science*** 13(5): 547-566.

Orlikowski, W.J. & J. Yates, 1994. Genre repertoire: The structuring of communicative practices in organizations, ***Administrative Science Quarterly***, 39: 541–574.

Pentland, B.T. & Feldman, M.S. 2005. Organizational Routines as a Unit of Analysis, ***Industrial and Corporate Change***, 14(5): 793-815.

Perrow, C. 1984. ***Normal Accidents: Living with high-risk technologies***. New York: Basic Books.

Pfeffer, J. & Salancik, G.R. 1978. ***The External Control of Organizations: A Resource Dependence Perspective***. New York: Harper & Row.

Poole, M.S. & G. DeSanctis, 1990. Understanding the use of group decision support systems: The theory of adaptive structuration, In J. Fulk and C. Steinfield (eds.), ***Organizations and communication technology****:* 173–193. Newbury Park, CA: Sage.

Porter, M. E. 1985. ***Competitive Advantage***. Free Press, New York.

Puranam, P., M. Raveendran, & T. Knudsen, 2012. Organization Design: The Epistemic Interdependence Perspective, ***Academy of Management Review***, 37(3): 419-440.

Puranam, P., Singh, H., & Chaudhuri, S. 2009. Integrating acquired capabilities: When structural integration is (Un)Necessary. ***Organization Science.***, 20(2): 313-328.

Quinn, R. E.. & Cameron, K. S. 1983. Organizational life cycles and shifting criteria of effectiveness; Some preliminary evidence. ***Management Science,*** 29: 33-51.

Rayner, K., C.M. Rotello, A.J. Stewart, J. Keir, & S.A. Duffy, 2001. Integrating text and pictorial information: Eye movements when looking at print advertisements, ***Journal of Experimental Psychology: Applied***, 7: 219-226.

Reagans, R., E. Miron-Spektor, L. Argote, 2012. Two Wonders of Experience: How Specialization and Coordination Influence Team Performance, ***Working Paper***, presented at the Organization Science Winter Conference 2011.

Roethlisberger, F. J., & Dickson, W. J. 1939. ***Management and the Worker.*** Cambridge: Harvard University Press.

Rueffler C., J. Hermisson, & G.P. Wagner, 2012. Evolution of Functional Specialization and Division of Labor, ***Proceedings of the National Academy of Science of the USA***, 109: E326–E335.

Sanchez, R. & J. Mahoney, 1996. Modularity, flexibility, and knowledge management in product and organization design, ***Strategic Management Journal***, 17: 63-76.

Schelling, T. 1960. ***The Strategy of Conflict***. Cambridge, MA: Harvard University Press.

Sendova-Franks, A.B. & N.R. Franks, 1999. Self-assembly, Self-Organization and Division of Labor, ***Philosophical Transactions of the Royal Society: Biological Sciences***, 354: 1395-1405.

Shrader, C. B., Lincoln, J. R., & Hoffman, A. N. 1989. The Network Structures of Organizations: Effects of Task Contigencies and Distributional Form. ***Human Relations***, 42: 43-66.

Siggelkow, N. and Levinthal, D. A. (2003). 'Temporarily divide to conquer: centralized, decentralized, and reintegrated organizational approaches to exploration and adaptation'. ***Organization Science***, 14: 650–69.

Simon, HA. 1945 ***Administrative Behavior.*** New York: Macmillan Press.

Simon, H. A. 1962 [1996]. ***The Sciences of the Artificial***. Cambridge, MA: MIT Press, 2^{nd} ed.

Simon, H.A., D.W. Smithburg, & V.A. Thompson, 1950. ***Public Administration***, New York: Alfred A. Knopf.

Singer JD, Willett JB. 2003. ***Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence***. New York: Oxford University Press.

Skyrms, B. 2004. ***The stag hunt and the evolution of social structure***. Cambridge, UK: Cambridge University Press.

Smith, A. 1776 [1999]. ***An Inquiry into the Nature and Causes of the Wealth of Nations***. London, UK: W Strahan & Cadell/ Penguin Classics, 8th ed.

Smith-Doerr, L., & Powell, W. W. 2005. Networks and Economic Life. In R. Swedberg (Ed.), ***The Handbook of Economic Sociology***: 379-402. New York: Russel Sage Foundation.

Stevenson, W. B. 1990. Formal Structure and Networks of interaction within Organizations. ***Social Science Research***, 19: 113-131.

Steward, D.V. 1981. ***Systems Analysis and Management: Structure, Strategy and Design***. New York: Petrocelli Books.

Stigler, G. 1951. The Division of Labor is Limited by the Extent of the Market, ***Journal of Political Economy***, 59(3): 185-193.

Terwiesch, C., C.H. Loch, & A. DeMeyer, 2002. Exchanging Preliminary Information in Concurrent Engineering: Alternative coordination strategies, ***Organization Science***, 13(4): 402-419.

Thompson JD. 1967. ***Organizations in Action***. New York: McGraw-Hill.

Tichy, N. M. 1980. ***Networks in Organizations***. London, UK: Oxford University Press.

Tushman, M.L. & D.A. Nadler, 1978. Information Processing as an Integrating Concept in Organizational Design, ***Academy of Management Review***, 3: 613-624.

Tushman, M. L., C. A. O'Reilly. 1996. Ambidextrous organizations: Managing evolutionary and revolutionary change. ***California Management Review*** 38(4): 8–30.

Van de Ven, A., Delbeq, A., & Koenig Jr., R. 1976. Determinants of Coordination Modes within Organizations. ***American Sociological Review***, 41(2): 322-338.

von Hippel, E. 1990. Task partitioning: an innovation process variable, ***Research Policy***, 19(5): 407-418.

Von Mises, L. 1949 [1996]. ***Human Action: A Treatise on Economics***. San Francisco, CA: Fox and Wilkes, 4th revised ed.

Von Neumann, J. & Morgenstern, O. 1944 ***Theory of Games and Economic Behavior***. Princeton University Press.

Wedel, M. & R. Pieters, 2000. Eye fixations on advertisements and memory for brands: A model and findings, ***Marketing Science***, 19: 297-312.

Weick, K. 1993. The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster. ***Administrative Science Quarterly,*** 38(4): 628-652.

Williams C, Mitchell W.2004. Focusing Firm Evolution: The Impact of Information Infrastructure on Market Entry by U.S. Telecommunications Companies, 1984-1998. ***Management Science***, 50: 1561–1575.

Williamson, O. E. 1975. ***Markets and hierarchies: Analysis and antitrust implications***. New York: Free Press.

Woodward, J. 1958. ***Management and technology: Problems and progress in technology***. London, UK: Her Majesty's Stationery Office.

Zammuto, R.F., T.L. Griffith, A. Majchrzak, D.J. Dougherty, & S. Faraj, 2007. Information Technology and the Changing Fabric of Organization, ***Organization Science***, 18(5): 749-762.

Zannetos, Z.S. 1965. On the Theory of Divisional Structures: Some aspects of centralization and decentralization of control and decision making, ***Management Science,*** 12(4): 49-68.

Zenger, T.R. & W.S. Hesterly, 1997. The Disaggregation of Corporations: Selective intervention, high-powered incentives, and molecular units, ***Organization Science***, 8: 209-222.

APPENDICES

Appendix A

Instructions to Participants of Experiment 1

You will work in a group of four to assemble a Meccano model. We will provide you with the instructions, the tools, and all necessary parts to put the model together correctly. Your group will be evaluated on the basis of (1) the time needed to complete the model, and (2) accuracy of your model. You will have 5 minutes to plan the assembly of the model, followed by up to 45 minutes to plan and execute the assembly of the model.

- Your group will receive £40 if you finish building the model within the time limit. We will evaluate your model in terms of accuracy and functionality and deduct £2 for every inaccuracy.
- If you do not finish the model within the time limit, you will receive £20 and we will deduct a further £2 for every step in the instructions you have not completed and for every inaccuracy.

At the end of the session you will receive the final reward. Your group is then free to decide how to split the money between the four of you.

Appendix B

A Coding Example

For each firm, I started by establishing the current (2008) structure. This structure was usually displayed on the company's website or latest annual statement. I then started to search for the company's name and one of the following search terms (reorgani*, restruc*, change) in five-year intervals (bringing up several 1000 articles) and browse through the results. If this brought up a reorganization announcement, I would focus the time window around the date (+/- 6 months) and select articles that provide details on the reorganization, in terms of announcement date, rationales given, descriptions of the old structure and of the announced changes. For each reorganization I read about 100-150 articles, and selected about 20 that combined would provide sufficient level of detail on (1) descriptions of the old and new business units and the total structure; (2) whether or not the CEO changed within the last 12 months; (3) the CEO's statement on the change; and (4) whether or not the reorganization was accompanied by layoffs.

Below I provide exerts from various articles on a reorganization by Motorola Inc. in 2006.

Motorola 2006

"Motorola, Inc today announced a reorganization of its Networks and Government & Enterprise Mobility Solutions businesses into one organization, to be called the Networks & Enterprise business." "This reorganization will allow us to strengthen our position in providing end-to-end network infrastructure solutions to private, public and enterprise customers worldwide," said Ed Zander, Chairman and CEO. "The new business also will leverage key current and next-generation technologies across those various market segments. With a more streamlined structure, Motorola will move faster, improve the cost structure of the company, including general and administrative activities, and be more effective in meeting customer needs going forward.""

In PR Newswire (U.S.), 3/3/2006 "Motorola Combines Networks and Government & Enterprise Mobility Solutions Businesses; New Organization Will Further Advance Seamless Mobility Strategy, Improve Operational Efficiency and Cost Structure"

"Motorola Inc. , the world's No. 2 cell-phone maker, said on Friday it is combining its network equipment and government and corporate units in a bid to cut costs and win new business. The network unit sells equipment that runs cellphone networks, a segment that analysts say has become cutthroat because of too many suppliers. The other business sells wireless gear to government and large business clients. (…) "I believe it makes sense because it eliminates the duplicative research and development between the two divisions," [Oppenheimer analyst Lawrence] Harris said."

In Reuters News, 3/3/2006, "UPDATE 1-Motorola combining networks, government units"

""I believe it makes sense because it eliminates the duplicative research and development between the two divisions," said Oppenheimer analyst Lawrence Harris.

"The technologies and the pursuits of the two divisions have been coming closer together because the government unit has been pursuing bids to sell network equipment to public safety agencies and state governments," he said, noting that they previously focused more on selling walkie-talkie radios."

In CNET News.com, 3/3/2006, "Motorola combining networks, government units; Company hasn't yet said how move will help cut costs, but analyst says it will eliminate redundant R&D."

"The realignment stands to involve nearly 50 percent of the company's nearly 70,000 employees."

In CMP TechWeb, 3/3/2006, "Motorola Merges Two Businesses Units"

“John Slack, an analyst with Morningstar Inc. in Chicago, said: "It's somewhat of a surprise to see them moving to combine these businesses just after reorganizing them a year ago. I think what we're seeing are the lines blur between a lot of Motorola's business lines." Jane Zweig, president of Shosteck Associates, wireless industry analysts in Wheaton, Md., said the consolidation makes sense. "Both groups deal with networks," she said. "These products work for cellular carriers as well as public safety agencies so the combined group has synergies and makes sense strategically. Networks will be able to integrate products for several markets and make more use out of Motorola's R&D.””

In Chicago Sun-Times (Howard Wolinsky, 4/3/2006, “Motorola merges divisions; no word on layoffs”

Because all these articles assume that we know what the two old units did, I go back to the previous reorganization announcement, where those units where described in detail:

“Motorola will focus the company on the following areas: (…)

Networks. Motorola will consolidate its network businesses into a single seamless organization to leverage talent, R&D and operating efficiency. The new Networks business will focus on existing cellular radio access networks, core IP networks including next generation IMS/softswitch technologies, iDEN infrastructure, telco wireline access, embedded communications and computer platforms, a new 802.XX mobile broadband group and a services and an applications management services business. Adrian Nemcek, president, will lead the new Networks business.

Government and Enterprise. Building on the success of the company's mission-critical voice and data delivery to traditional and emerging customers, Motorola will consolidate its market- and solutions-oriented businesses into a new organization that will bring our most advanced seamless mobility applications to Fortune 500 class enterprises, governments and automobile manufacturers worldwide. Greg Brown, president, will lead the new Government and Enterprise business.”

In PR Newswire (U.S.), 13/12/2004, “Motorola Realigns Businesses to Drive Seamless Mobility Strategy”

Appendix C - Exploratory Survival Analysis

To gain a better understanding of the temporal nature of the data, I estimate the cumulative hazard rates for the main dependent variable (given that these data are comprised of repeatable events, estimating the survivor function does not make sense). The purpose of estimating the cumulative hazard rate is to investigate whether the hazard rate varies with time. Figure C.1 shows the Nelson-Aalen estimates of the cumulative hazard rate at which firms reorganize their structure over analysis time. If the hazard rate was time independent, the integrated hazard rate would display a straight line. We can clearly see from figure C.1 that the hazard rate is time dependent.

Figure C.1 - Cumulative Hazard Function for *Reorganization*

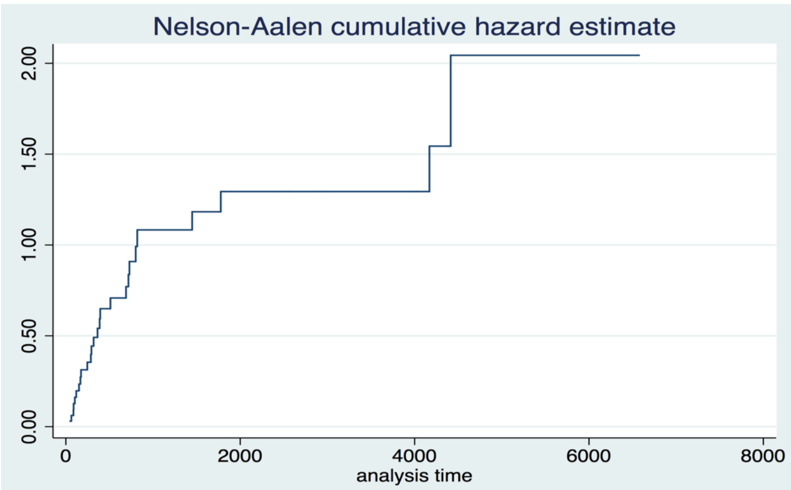
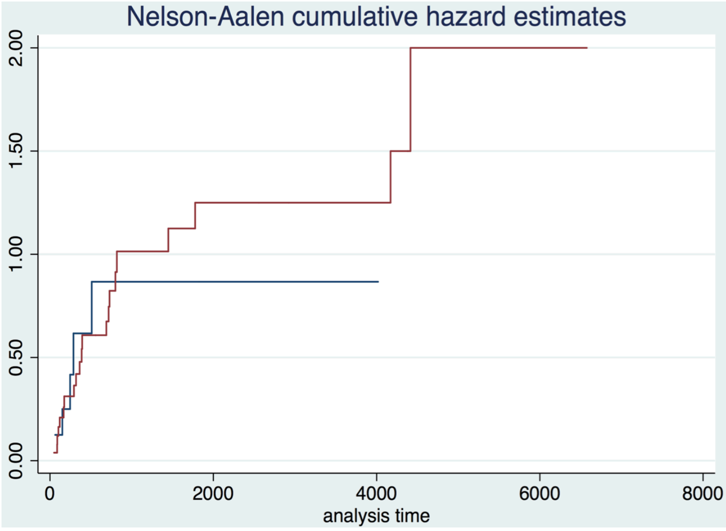


Figure C.2 shows the cumulative hazard rate for the same dependent variable (any kind of reorganization), split into two sub-samples by whether the previous structure (i.e. the organization structure prior to the focal reorganization) was predominantly comprised of cross-functional (red line) or intra-functional (blue line) units. The two curves are overlapping and we cannot discern any systematic pattern from it - note that the number of observations for longer periods between reorganizations drops dramatically, so that we cannot draw inferences from the tails of these functions.

Figure C.2 - Cumulative Hazard Function for *Reorganization* by different types of structures held prior to the focal reorganization



Figures C.3 and C.4 show the cumulative hazard rates for the two types of reorganizations, respectively, split into the same two sub-samples as applied in figure C. 2. Figure C.3 shows that the cumulative risk rate of a shift toward more intra-functional focus is relatively flat if the current structure is predominantly intra-functional (blue line) and consistently below the cumulative risk rate for a shift toward more cross-functional focus in the case where the current structure is predominantly cross-functional (red line).

Figure C.3 - Cumulative Hazard Function for *Shift toward more intra-functional units* by different types of structures held prior to the focal reorganization

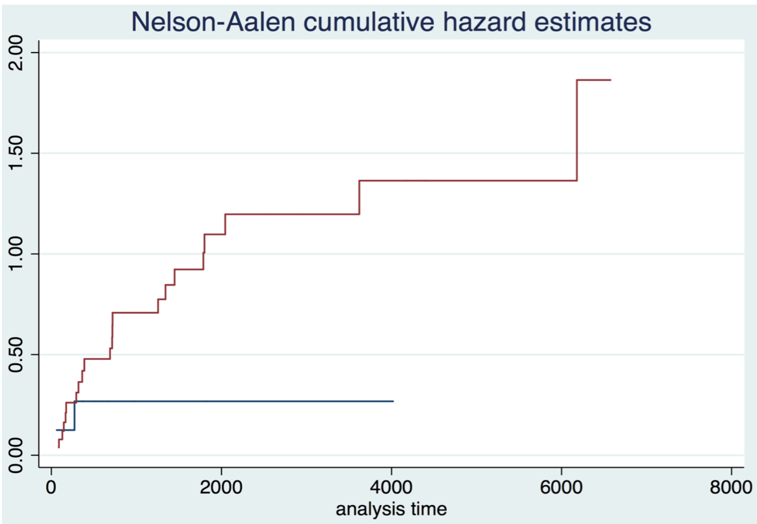


Figure C.4 shows the reverse effect for the relative shift toward more cross-functional focus: if the current structure is predominantly cross-functional, the cumulative hazard rate of shifting focus toward more cross-functional units is flatter and consistently below the cumulative hazard rate in the case of a predominantly intra-functional structure. Note that the functions appear to display a very small number of observations - this is because the data is stratified by firms. These exploratory analyses already hint toward the hypothesized reversal pattern, observable only when distinguishing between different types of reorganizations.

Figure C.4 - Cumulative Hazard Function for *Shift toward more cross-functional units* by different types of structures held prior to the focal reorganization

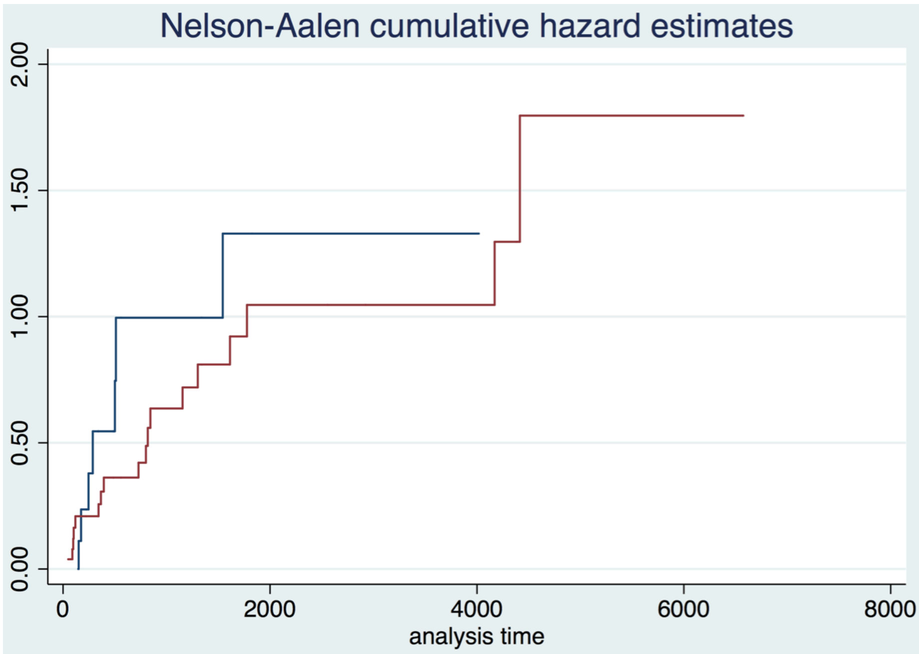
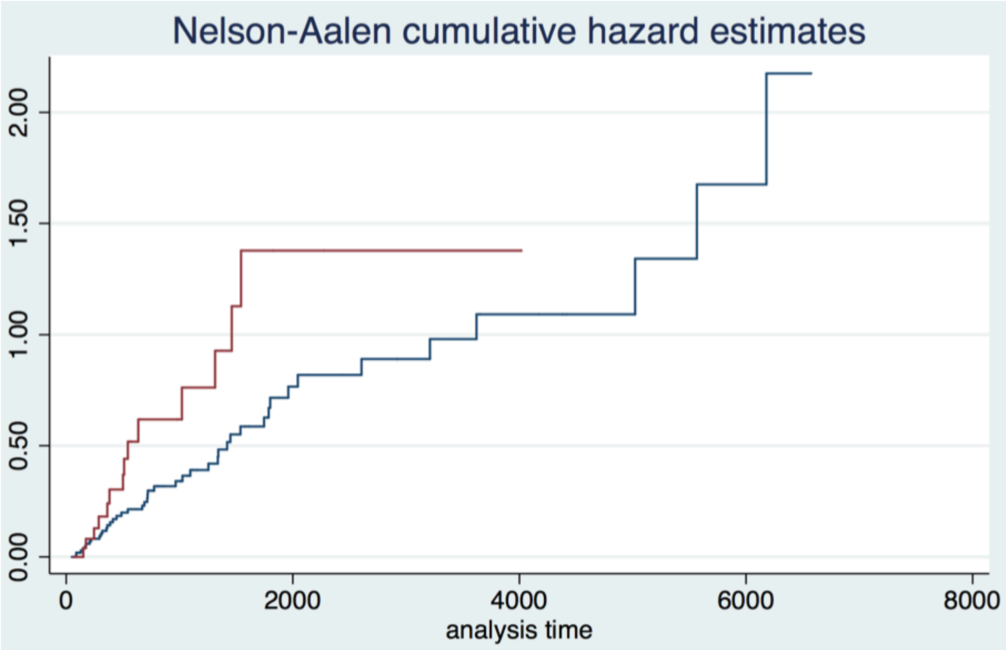


Figure C.5 shows the cumulative hazard function for the dependent variable ‘reversal’ (used for testing Hypothesis 2). The figures displays the cumulative hazard function split by the type of structure held prior to the focal reversal. Note that those structures that were predominantly organized into intra-functional units (red line) showed a consistently higher risk of reversal relative to those structures that were predominantly organized into cross-functional units (blue line).

Figure C.5 - Cumulative Hazard Function for *Reversal* by different dominant structures held prior to the focal reversal



Appendix D: Residual Analyses

D.1 Accelerated Failure Time Model: Choosing a distribution

The accelerated failure time model is a survival model, which describes the survivor functions of two individuals relative to each other. Thus, in this context I estimate the difference in the rate at which the firms experience different kinds of events. These models require the specification of the functional form of the baseline hazard. The distributions of the event time T can be linear (Weibull or exponential models), follow an inverted U-shape (log-normal or log-logistic models), or be estimated with a generalized gamma distribution (of which all but the log-logistic distribution are a special case). Note that the generalized gamma distribution, while the most general one, is harder to interpret and has a reputation for convergence problems, which also applies to the data in this paper (Allison, 1995).

In order to choose among the four distributions that do converge (Weibull, exponential, log-normal, and log-logistic), I compute and compare the Cox-Snell residuals, defined as

$$e_i = -\log S(t_i \mid x_i)$$

where S(t) is the estimated probability of surviving to time t based on the fitted model, t_i the observed event time for individual i, and x_i is the vector of covariates for i. If the model fits the data well, the resulting plot of the Cox-Snell residuals should be a straight line, with origin zero and a slope equal to one. The fitted model for which the Cox-Snell residuals were estimated was:

$$h(t_{ij}) = [\lambda\gamma(\lambda t)^{\gamma-1}]/[1+(\lambda t)^{\gamma}]$$

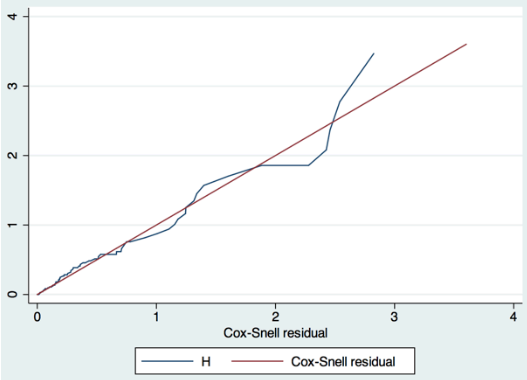
where $\gamma = 1/\sigma$ and $\lambda = exp(-[\beta_0 + \beta_1\ type\ of\ prior\ structure_j + \beta_2\ controls_j\ ])$

for firm i in time period j.

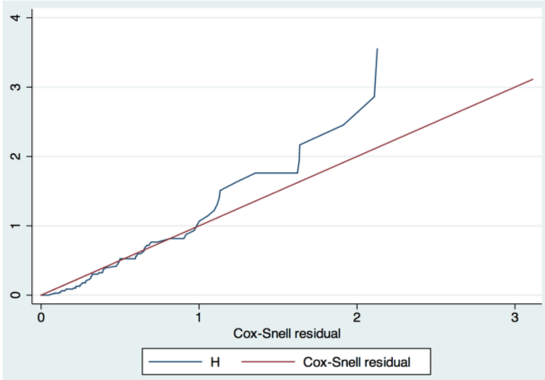
with the following control variables: performance, change in CEO, age (ln), number of employees (ln), degree of diversification, and firm dummies. The log-logistic model appears to be the most appropriate one, as shown in Figure D.1.

Figure D.1 – Cox-Snell Residuals for the Accelerated Failure Time models with different distributions

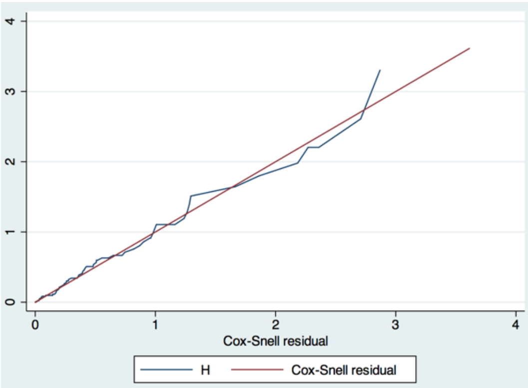
Weibull model



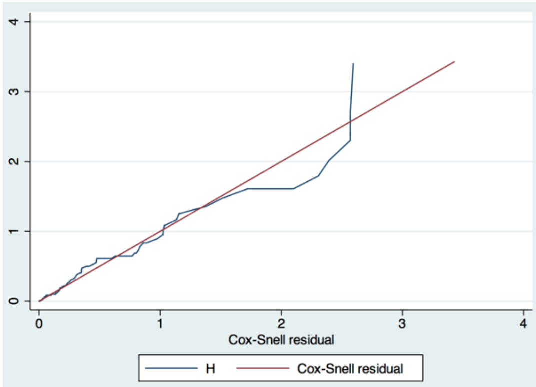
Exponential model



Log-logistic model



Log-normal model



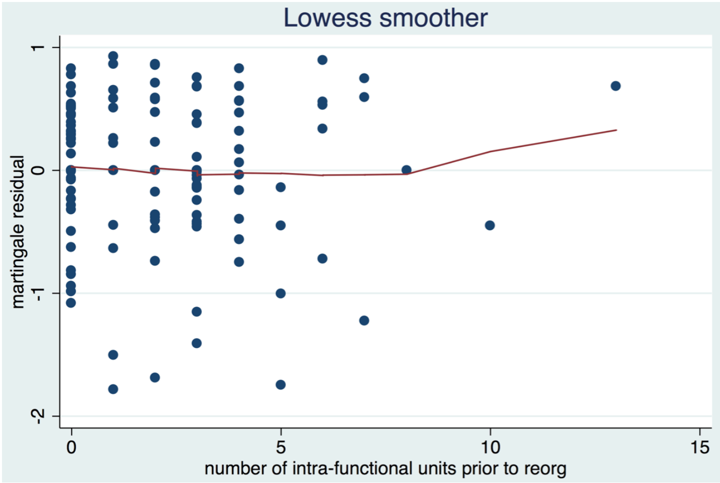
D.2 Residual Analyses for Hypothesis 1: Fixed-Effects Partial Likelihood Model

One of the main concerns when fitting a Cox regression model is the appropriateness of the proportionality assumption of the hazard rates. However, as outlined in the main text, I relax this assumption by stratifying the model by firm.

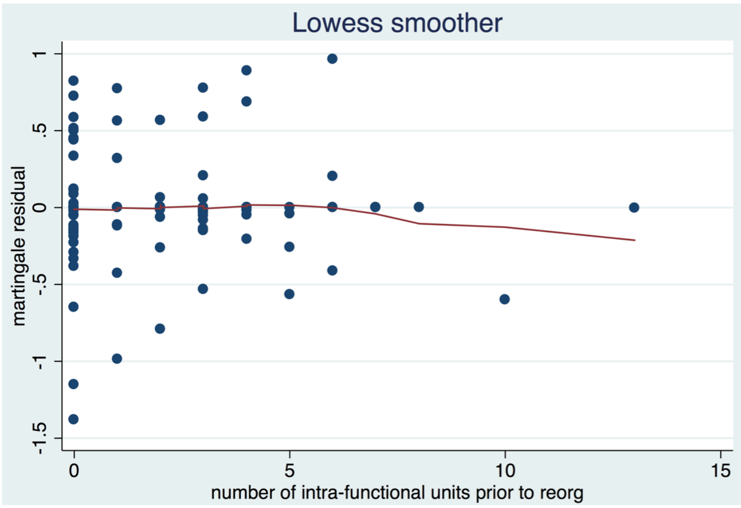
A second concern is whether we need to adjust the functional form of the continuous predictors. The Martingale residual compares the number of events actually experienced against the expected number of events (for each firm). Based on this analysis, I can conclude that the main predictors in the models run do not need to be transformed (as shown in Figure D.2). Note that I identified the outliers in panels (a) and (b); excluding that reorganization as well as the firm that included that outlier did not alter the significance of the results.

Figure D.2 - Martingale residuals for *intra-functional units*

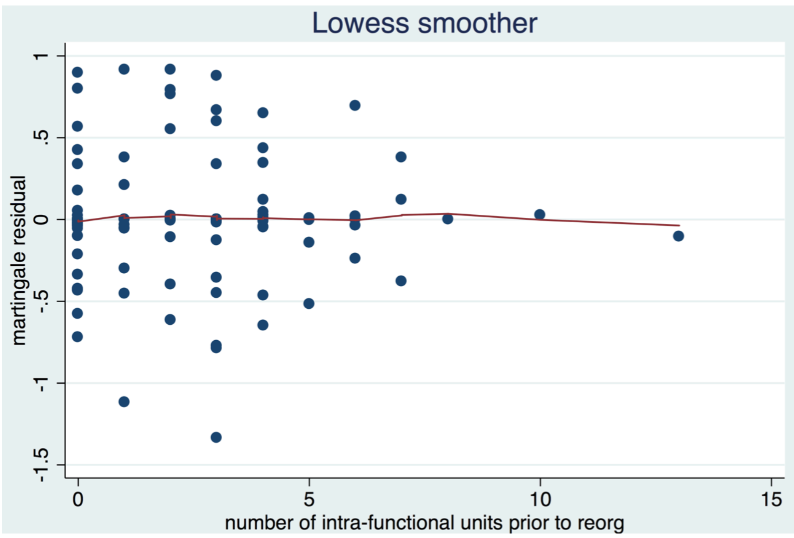
Panel (a)- Dependent variable: 'any reorganization'



Panel (b): Dependent variable: 'shift toward intra-functional focus'



panel (c): Dependent variable: 'shift toward cross-functional focus'



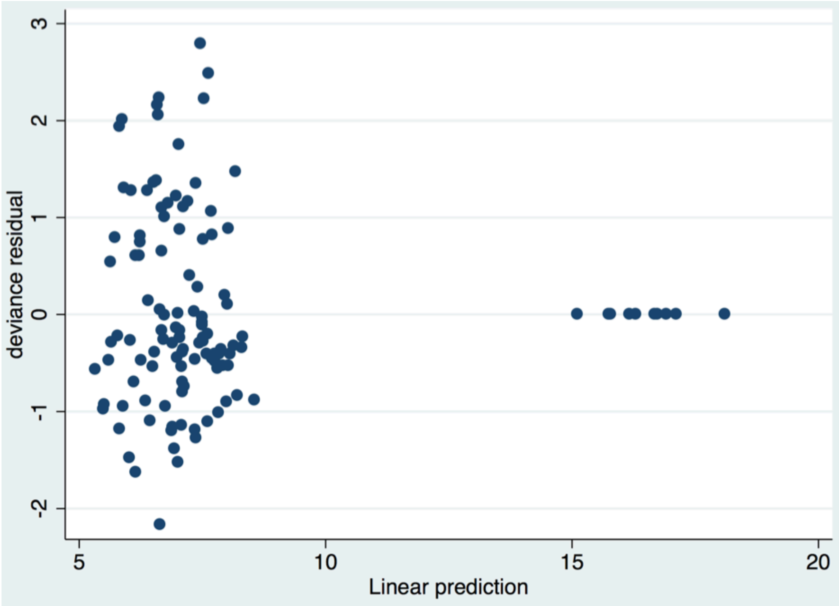
I used score residuals and deviance residuals (rescaled Martingale residuals) to identify outliers and individual firms whose outcomes were poorly predicted. The deviance residuals confirm the analysis of the Martingale residual analysis. The score residuals allowed me to identify the outlier mentioned above, and flagged a couple of additional outliers, with similar effects - removing those observations (or firms) from the analysis did not alter the significance of the results.

D.3 Residual Analyses for Hypothesis 2: Accelerated Failure Time Model

I repeated the same residual analyses with the predictors included in the fixed-effects partial likelihood and Accelerated Failure Time models used to test Hypothesis 2. The accelerated failure time model is a proportional hazard model, hence the Schoenfeld residuals do not apply to this model. Again, by stratifying by firm (or including firm dummies in the model) I effectively allow for cross-firm variation. Again, I only report the results for the main predictor here, namely the extent to which *the structure prior to the focal reorganization was predominantly intra-functional*. Given that this is a dichotomous measure, the Martingale residuals are not very informative.

While I already identified the outliers with the residual analyses for H1, I used deviance residuals to identify individual firms whose outcomes were poorly predicted. The deviance residuals shown in Figure D.3 are evenly spread around zero. Note that the plots on the far right of the graph on the zero-line are censored observations. Running the analyses without any of the top three firms on the top left (close to deviance residual = 3) did not alter the statistical significance of the results.

Figure D.3 - Deviance Residuals for the Accelerated Failure Time Model



Appendix E

Figure E.1 - Systematic Reversal: with *total number of cross-functional units in the old structure*

Cox Non-Proportional Hazard Model	any reorg Model 1	shift toward intra-functional focus Model 2	shift toward cross-functional focus Model 3
total number of cross-functional units in the old	-0.00812 (0.142)	0.450*** (0.146)	-0.895*** (0.196)
total number of units in the old structure	0.0631 (0.103)	-0.120 (0.133)	0.469*** (0.115)
change in CEO during the spell leading to the reorg	-0.194 (0.300)	-0.425 (0.514)	-1.611*** (0.609)
age (ln)	-6.937*** (1.721)	-7.794** (3.789)	-14.26*** (3.993)
employees (ln)	-0.914 (0.758)	-2.478*** (0.848)	1.667 (1.285)
degree of firm diversification	-0.353 (0.347)	0.385 (0.441)	-1.538 (0.950)
number of reorgs in the industry within 1 year	0.0486 (0.0768)	0.233* (0.133)	-0.149 (0.134)
number of entrants during the spell leading to the reorg	-0.339*** (0.0482)	-0.530*** (0.138)	-0.303*** (0.109)
number of competitors during the spell leading to the reorg	0.107*** (0.0339)	0.0868 (0.0654)	0.289*** (0.0737)
strata	firm	firm	firm
number of observations	132	132	132
Log-pseudolikelihood	-76.30	-25.51	-31.57
Chi-square	206.9	92.37	407.3
number of clusters	34	34	34
number of failures	102	48	54
days at risk	151598	151598	151598
degrees of freedom	9	9	9

Standard errors in parentheses, * p<0.10, ** p<0.05, *** p<0.01