STRATEGIC RENEWAL OF ACTIVITY SYSTEMS
AN INTERDEPENDENCY PERSPECTIVE

DISSERTATION
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St. Gallen, May 17, 2013

The President:

Prof. Dr. Thomas Bieger

To my parents

Rosemarie & Thomas Albert

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This dissertation has become its own little complex system consisting of ideas that interact in non-trivial ways. These ideas evolve at the "edge of chaos" – a state between structure and chaos, where the author throws parts of the initial plan and agenda overboard to explore new possibilities but also pulls everything together to achieve the overall goal. Complexity theory teaches us that one needs the right contextual conditions to stay at the "edge" and not drift away towards either extreme. In the following, I would like to give my many supporters and context-setters the credit they deserve.

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Philadelphia, August 2013 Daniel Albert

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List of Abbreviations

+	significance (level of 10%)
*	significance (level of 5%)
**	significance (level of 1%)
***	significance (level of 0.1%)
AMJ	Academy of Management Journal
AMR	Academy of Management Review
ASQ	Administrative Science Quarterly
b	coefficient
CEO	chief executive officer
cf.	compare (Latin *confer*)
Coeff.	coefficient
Ed./Eds.	editor/editors
e.g.	for example (Latin *exempli gratia*)
et al.	and others (Latin *et alii*)
etc.	and other things (Latin *et cetera*)
EUR	Euro (currency)
exp	exponential function
H	hypothesis
i.e.	that is (Latin *id est*)
IAS	International Accounting Standards
IASB	International Accounting Standards Board
IFRS	International Financial Reporting Standards
IT	information technology
JMS	Journal of Management Studies
JOM	Journal of Management
M&A	mergers and acquisitions
MBF	multi business firm
mn	million
MS	Management Science
N	number (sample size)
OrgScience	Organization Science

P	proposition
p	level of significance
R&D	research and development
s.d.	standard deviation
SMJ	Strategic Management Journal
t	time
TCE	Transaction Cost Economics
USA	United States of America
vs.	against (Latin *versus*)

Abstract

A growing literature stream conceptualizes organizations, their strategy, and business models as complex systems of interdependent activity choices. Accordingly, firms have to make decisions about which activities to engage in and to what extent. Choices made are interdependent with one another and thereby influence whether the system as a whole is internally consistent and fits its environment. The interdependencies among activity choices are found to be central to understanding sources of competitive advantage and the system's ability to undergo continuous strategic renewal. Despite the prominent role of interdependency in activity systems, little is known about the sources of interdependency in activity systems. Moreover, the literature does not agree on the role of interdependency on strategic renewal. While some studies suggest that interdependencies among activities lead to inertia, other studies suggest that they create variety and conflict, which can lead to strategic renewal.

In three essays, I revisit the extant literature on activity systems and strategic renewal with a particular focus on interdependency to address these gaps. In the first essay, I explore the constituting elements of an activity system and identify the influence they have on the overall interdependency design. In the second essay, a theoretical framework that distinguishes between interdependency structure and rules is proposed to reconcile paradox findings of the relationship between interdependency and strategic renewal. In the third essay, I analyze different types of interdependency modularity and concentration in activity systems on the likelihood of activity domain recombination. Hypotheses are tested and supported in a longitudinal sample of the European banking industry between the years 2000 and 2011. Overall, the central claim of this thesis is that interdependencies can enable and inhibit strategic renewal and that this is dependent upon the distribution of interdependencies and the set of rules they follow.

Zusammenfassung

Die Strategie und das Geschäftsmodell einer Organisation wird in der Literatur immer häufiger als ein komplexes System interdependenter Geschäftsaktivitäten, sogenannter „activity systems“, konzeptualisiert. Unternehmen müssen strategische Entscheidungen darüber treffen, welche Geschäftsaktivitäten sie verfolgen möchten und in welchem Ausmass. Dabei sind die getroffenen Entscheidungen abhängig voneinander und beeinflussen daher ob das System als Ganzes in sich konsistent ist und zu seiner Umwelt passt. Diese Interdependenzen zwischen den Geschäftsaktivitäten sind zentral für das Erlangen von Wettbewerbsvorteilen und die Fähigkeit eines Systems sich kontinuierlich zu erneuern. Trotz der zentralen Rolle von Interdependenzen zwischen Geschäftsaktivitäten, wissen wir sehr wenig über den Ursprung von diesen „activity systems“. Darüber hinaus gibt es in der Literatur unterschiedliche Ansichten, welchen Einfluss Interdependenzen auf strategischen Wandel haben. Während einige Studien zeigen, dass Interdependenzen zwischen Geschäftsaktivitäten Wandel verhindern, finden andere Studien, dass Interdependenzen die Vielfalt erhöhen und Konflikte fördern was den strategischen Wandel begünstigt.

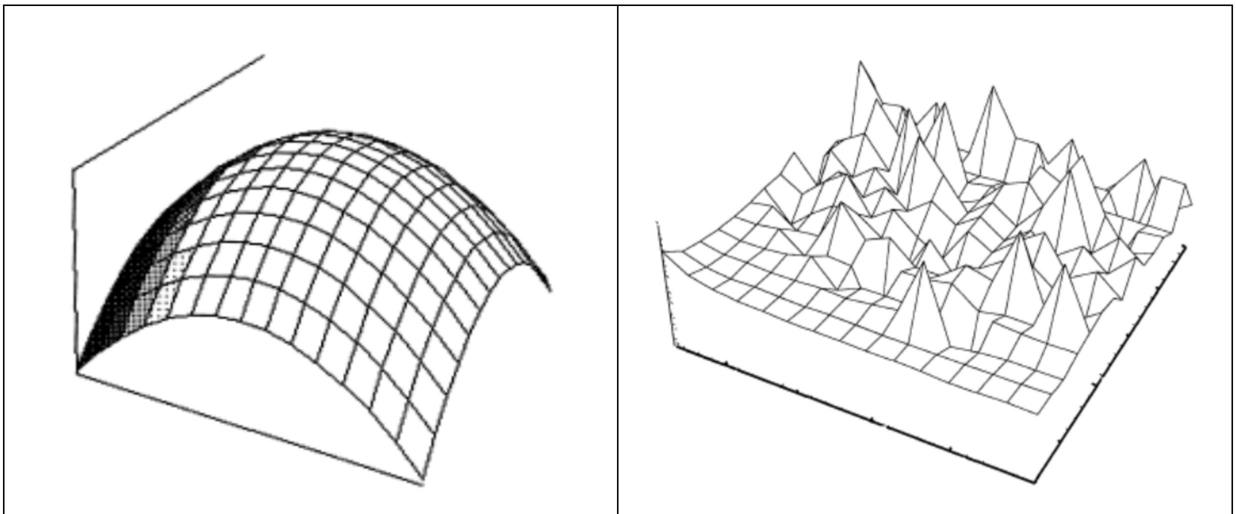
Die vorliegende Dissertation adressiert diese Forschungslücken in drei Studien. Dabei bauen die drei Studien auf der bestehende Literatur zu „activity systems“ sowie zu strategischem Wandel auf und erweitern diese. In der ersten Studie werden die Elemente, die einem „activity system“ zugrunde liegen, sowie deren Einfluss auf die Ausgestaltung der Interdependenzen im System genauer analysiert. In der zweiten Studie wird ein theoretisches Rahmenwerk, welches zwischen Interdependenzstruktur und –regeln unterscheidet, vorgeschlagen, um paradoxe Zusammenhänge zwischen Interdependenzen und strategischem Wandel erklären zu können. In der dritten Studie wird der Einfluss unterschiedlicher Arten der Modularität und Konzentration von Interdependenzen auf die Wahrscheinlichkeit der Rekombination von Aktivitätsdomänen empirisch untersucht. Die abgeleiteten Hypothesen werden anhand eines Datensatzes des Europäischen Bankensektors zwischen den Jahren 2000 und 2011 getestet und weitgehend unterstützt. Die zentrale Aussage dieser Dissertation ist, dass Interdependenzen strategischen Wandel sowohl begünstigen als auch verhindern können, je nachdem, wie sie verteilt sind und welchen Regeln sie folgen.

1. Overview and Introduction to This Dissertation

1.1 Introduction

Academics and managers have begun to adopt the view of organizations and strategy as complex systems of interdependent choices (Milgrom & Roberts, 1995; Siggelkow, 2011; Thompson, 1967). This view challenges the idea of firms as mechanistic entities that follow linear input-output relationships. Instead, the complexity science approach to organizations emphasizes non-linear dynamics and feedback loops among interdependent agents (Anderson, 1999; Plowman et al., 2007). This approach has opened entirely new perspectives on phenomena at the heart of strategic management. Porter (1996) demonstrates that firm strategy and competitive advantage are made up of a unique set of activity choices and high levels of fit among them. The degree of fit is a function of the underlying interdependencies among a firm's activities (Miller, 1981; Thompson, 1967). Moreover, large numbers of interdependencies among a set of consistent activity choices can exhibit reinforcing effects, i.e., the value of one activity increases in the presence of other choices, and vice versa (Milgrom & Roberts, 1990; Porter & Siggelkow, 2008). Such internal consistency can lead to inertia in the face of changing environments (Gilbert, 2005; Hannan & Freeman, 1989; Siggelkow, 2001), thwart exploratory search due to strong path-dependency (Anderson, 1999; Sydow, Schreyogg, & Koch, 2009), and increase myopia (Cyert & March, 1963; Levinthal, 1997; Levinthal & March, 1993; Tripsas & Gavetti, 2000). However, interdependency is considered essential in distinguishing the trivial from the non-trivial (Holland, 1975, 1995), as a potential source of internal variety (Ashby, 1956; Burgelman, 1991), and as a sensitive detector of changes in the environment (Weick, 1976). Hence, interdependency is a multifaceted phenomenon that can account for variety, survival, adaptability, and inertia.

Figure 1: Fitness (performance) landscapes



a) Single-peaked landscape | b) Rugged landscape (multiple peaks)

Source: Levinthal & Warglien (1999: 344-345)

The ambiguous understanding the literature currently has about interdependencies in activity systems is partly due to its inherent complexity. Research is limited in encompassing all choices a firm can make and whether and to what extent these choices are interdependent. Important attempts to grasp the complexity of activity systems have been longitudinal case studies (Siggelkow, 2001, 2002a) and agent-based computer simulations (Ethiraj, 2007; Ethiraj & Levinthal, 2004; Ethiraj, Levinthal, & Roy, 2008; Ghemawat & Levinthal, 2008; Levinthal, 1997; Rivkin, 2000; Rivkin & Siggelkow, 2003, 2007; Siggelkow & Levinthal, 2003; Siggelkow & Rivkin, 2005, 2006). These studies draw on the fitness (performance) landscape framework, established in evolutionary biology (Kauffman, 1993; Wright, 1931). The landscape encompasses all possible configurations of choices a firm can select from (Levinthal, 1997). In a world with only few interdependencies among choices, the likelihood increases of a single-optimal configuration to exist, as depicted as a single-peak landscape in Figure 1-a. The height of a peak corresponds to the pay-off or fitness in a given environment. With increasing interdependency among possible choices, the landscape becomes more rugged (Kauffman, 1993). As illustrated in Figure 1-b, multiple consistent configurations exist but with varying pay-offs (indicated by the different heights). The analogy of a multi-peaked landscape helps to understand why firms that occupy one peak, may have trouble to move toward a higher but possibly farther away peak. Assuming a boundedly-rational world, firms can only detect and process their local neighborhood (Cyert & March, 1963; March & Simon, 1958).

Moving from one end of the landscape to another, however, requires adaptation in all current choices simultaneously instead of a few once at a time.

Figure 2: Cumulated number of articles in the field of activity systems

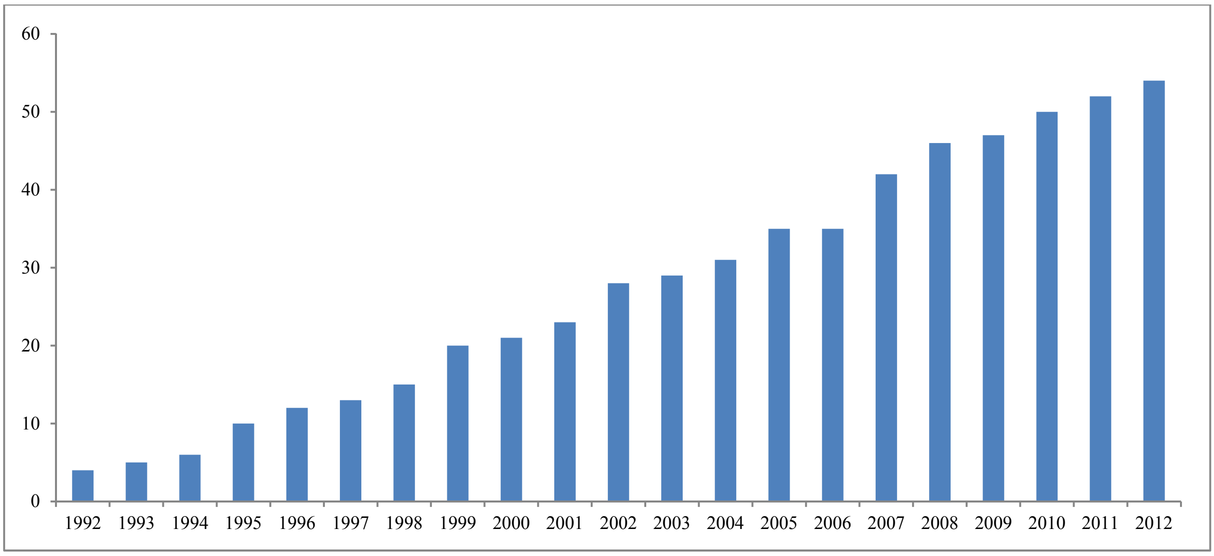
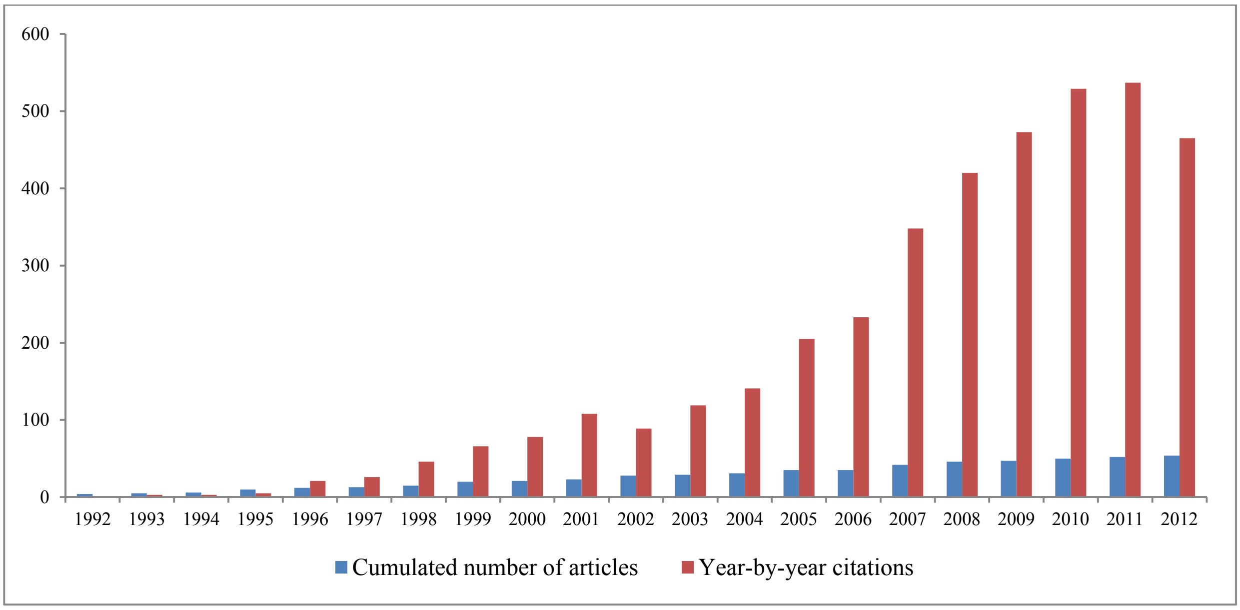


Figure 3: Impact of cumulated number of articles on management research



1.2 Impact of the concept of activity systems on the management field

The framework of performance landscapes is useful to study the phenomenon of activity systems because it combines strategic choices (Child, 1972) with the interdependency consequences (Milgrom & Roberts, 1990, 1995) that result from them (Miller, 1981, 1992; Thompson, 1967). Even though the number of scholars applying an activity system lens is rather small, their research has gained momentum because of its complexity-encompassing appeal which proposes implications for a broad range of management topics. To understand the development and reach of the activity system field, I conducted a keyword[1] search at the ISI Web of Knowledge database for the eight leading management journals[2]. Figure 2 shows that the field is rather small with slightly over 50 articles in the leading management journals. However, consulting Figure 3 draws a different picture. There, we can see that these few articles have been highly influential as measured in yearly citations. As the number of articles has doubled in less than a decade, the yearly citations have started to exceed way above the 200-citation mark in more recent years.

It remains difficult to delineate activity system research from other areas due to its broad implications. Therefore, I conducted a more fine-grained analysis of five articles that have had particular importance for the development of the activity system concept. Michael Porter's (1996) article "What is strategy?" has coined the term activity system for the strategy audience and emphasized trade-off decisions and interdependencies among choices as crucial sources of competitive advantage. Dan Levinthal (1997), acknowledges that firms face different levels of interdependency among their activity choices, thereby facing different configurational choices, which influence their adaptability. His approach is the first to embrace the complexity of activity systems by using computer simulation techniques – a methodology that has become of tremendous importance for the development of the field. Jan Rivkin (2000) further analyzes the role of interdependency in activity systems as a source of

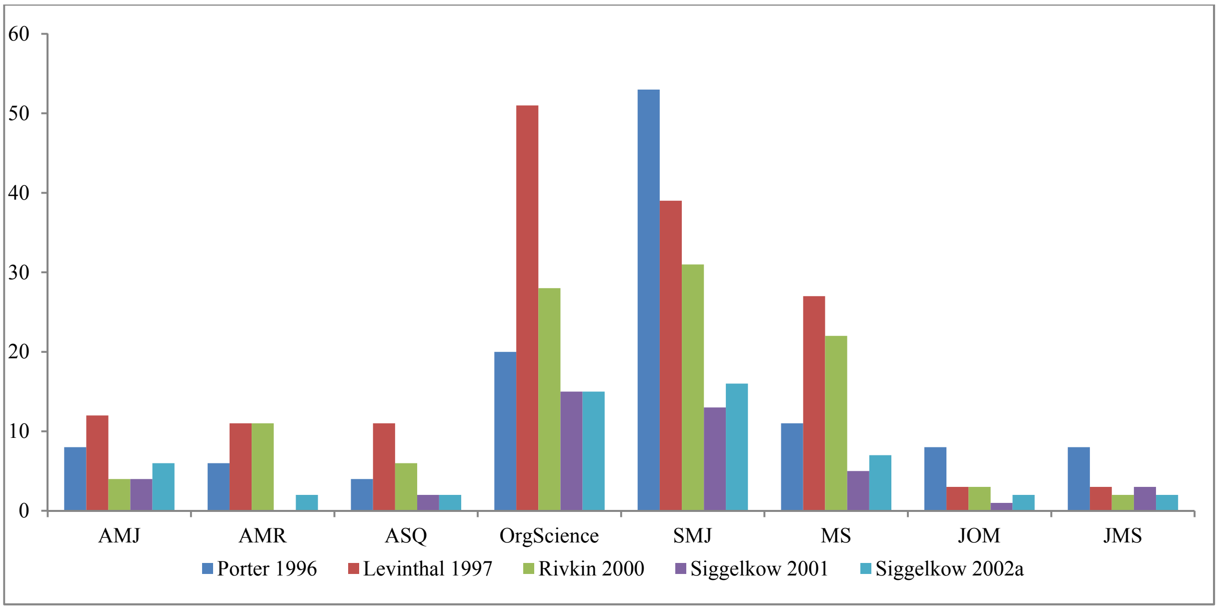
[1] The keyword search encompassed: "activity system" or "activity systems" or "system of interdependent activities" or "set of choices" or "set of interdependent choices" or "set of activities" or "set of activity choices" or "system of interdependent choices" or "complex adaptive system" or "complex adaptive systems" or "complex system" or "complex systems" or complementarity and fit.
[2] The journals were determined based on Tahai & Meyer (1999) with a core impact ranking of 1.0 or higher. I excluded journals, which publication focus was not on management/strategic management and academic research. Subsequently, the eight journals of interest are *Academy of Management Review, Academy of Management Journal, Administrative Science Quarterly, Organization Science, Strategic Management Journal, Journal of Management, and Journal of Management Studies*.

inimitability. He uses simulation techniques drawing on causal linkage ambiguity as a theoretical underpinning. Nicolaj Siggelkow (2001) explores how complementarities in activity systems can lead to inertia in the face of environmental change and how incremental changes in such systems can have detrimental consequences because of tight interdependency. He illustrates his theory using a longitudinal case study of the fashion apparel company Liz Claiborne. Another highly influential work in the field is Siggelkow's (2002a) longitudinal case study of the mutual fund provider Vanguard. This study provides the field with a terminology and mechanisms by which core-elements evolve in activity systems. Figure 4 shows the impact the five articles have had on the top management journals. All five of the papers have had a particular effect on the strategy field. However, Porter's (1996) work on strategy has the most impact with 53 citations in the Strategic Management Journal. Levinthal's (1997) introduction of the NK simulation methodology to study adaption of complex systems with varying levels of interdependency has influenced studies on organizational design and behavioral theory studies mainly published in Organization Science. Rivkin's (2000) and Levinthal's (1997) studies have the highest ratio of citations within the top management journals in relation to their total citations (43% and 41%, respectively). Despite the highest overall citation count (871), Porter's (1996) practitioner article is only 14% of the time cited in one of the top eight management journals, which shows that his paper has the broadest reach. While all five papers are highly influential on studies published in the Strategic Management Journal, Organization Science, and Management Science, they have had limited impact on theory-building outlets, such as Academy of Management Review and Administrative Science Quarterly.

Research Gaps and Motivation

As illustrated above, the research on activity systems is a growing and influential literature stream. At the heart of this stream is that the actual choices made by the firm and the resulting interdependency pattern among them are important to understand the current performance and the future ability to undergo strategic renewal. Yet, we know little about the nature and type of choices that constitute an activity system or how they relate to the occurring interdependency patterns. Prior studies on activity systems have encompassed choices that exceed the concept of an "activity", such as organizational policies (Porter, 1996), organizational structure (Siggelkow, 2002a), and managerial hierarchies (Rivkin & Siggelkow, 2003). Moreover, while the concept of interdependency has been acknowledged as crucial in understanding the evolution and strategic renewal of firms (Levinthal, 1997; Rivkin & Siggelkow, 2007; Simon, 1962), research has viewed interdependency designs mainly as given by nature (Zhou, 2013) and focused on a particular type, namely, complementarity (Milgrom & Roberts, 1995). The literature needs greater conceptualization and theorizing about the characteristics and types of interdependency in activity systems to resolve the paradoxical role that interdependencies among activities appear to play on the ability of an activity system to renew and evolve in continuously changing environments (Siggelkow, 2011). Finally, literature is short on empirical studies that actually capture and explore activity system-inherent mechanisms that drive strategic renewal. The literature has identified the phenomenon that previous choices and their interdependencies not only constitute a liability and source of inertia (Siggelkow, 2001) but also exhibit a source of endogenous, unintended renewal (Plowman et al., 2007). Prior research suggests that the distribution of interdependencies within the activity system can explain mechanisms of recombination of what is at hand (Ethiraj & Levinthal, 2004; Galunic & Eisenhardt, 2001; Thompson, 1967).

Figure 4: Citations in top management journals of activity system articles



The purpose of this dissertation is to address these shortcomings by theorizing about determining characteristics of activity systems and exploring their effect on strategic renewal. In particular, the concept of interdependency is taken as a common thread in this thesis. Finally, I propose an empirical research design of the European banking industry between the years 2000 and 2011 to examine system-inherent mechanisms of strategic renewal.

1.3 Overview of essays and their contributions

This dissertation provides three essays that all provide unique contributions to the field. Taken together these essays constitute an integrated contribution. In the first essay, I review the existing literature on activity systems to conceptualize different types of constituting elements and basic relationships between them. I find core-themes, activities, and policy choices to constitute the tenants of an activity system. Each of these elements caters to different dynamics and purposes. Together they explain how interdependency patterns and rules come about and thereby help to explain competitive advantage, strategic renewal, and the evolution of the firm. Theorizing about the constituting elements and relationships among them allows me to revisit and enrich existing findings as well as outline future directions to build upon. Hence, the first essay's main contribution is to provide a consistent terminology of elements and their relationship with key concepts of strategic management.

In the second essay, a theoretical model is developed in order to answer when interdependency in activity systems inhibits and when it enables strategic renewal. Prior literature has been contradictory about the role of interdependency and strategic renewal. One line of argumentation suggests that high levels of interdependency inhibit a system from deviating from its current path and will require system-wide overhaul because changes in one end affect the value and behavior in many other areas of the activity system. A second strand of argumentation contends that rich levels of interdependency are necessary to allow for information flows and conflicts that can lead to novel solutions. In this essay, these two perspectives are brought together and looked at in an integrated way. A multidimensional reconceptualization of an activity system's interdependency design into structural and rule-based dimensions allows reconciling both lines of argumentation. The main contribution is to argue theoretically that both, complexity-enhancing and complexity-reducing patterns of interdependency in activity systems can enable and inhibit strategic renewal depending on the interdependency rules in place.

In the third essay, applying a modularity perspective on activity systems, I explore how activity domains and their context within activity systems help to predict recombination, as a specific mechanism of strategic renewal. Analyzing a sample of 166 activity domains in 15 of the largest European banks between the years 2000 and 2011, I theorize and show that modularity and concentration of power can have opposing effects on the likelihood of recombination of an activity domain depending on which hierarchical level one considers. While modularity on an activity system level increases the likelihood of a focal activity domain to undergo recombination, it decreases with the decomposability of the very same domain into sub-domains. In addition, the more central an activity domain to the overall activity system, the less likely it will be subject to recombination. This changes, however, with an increase of sub-domains and centrality of these sub-domains to the activity system as a whole. The main contribution of this essay is to expand literature on modularity by emphasizing the individual module characteristics and their context. Therefore, this essay revisits the focus from "when" to "where" does modularity enable recombination.

As a whole, these three essays follow a common thread and provide integrative insights. The shared phenomenon of all three essays is the strategic renewal and evolution of activity systems. While essay one provides the terminology and general relationships that influence the evolution, essay two and three build on this by diving deeper into the role of the distribution and characteristics of interdependency. Taken together, interdependency is a multi-dimensional construct, which resides in a firm's strategic choices. However, the interdependency design is not purely given by nature but to some extent at the discretion of the firm. This thesis suggests that the interdependency design is to some extent a choice by itself, for example, through organizational policies that determine whether a set of activities is supposed to interact or not. By taking several decisions that influence the interdependency design, firms can set the right context for system-induced recombination as a source of continuous strategic renewal.

2. Activity Systems: A Review and Conceptualization[3]

Abstract

Scholars have used the notion of activity systems to study and illustrate several phenomena in strategic management, such as competitive advantage, adaptation, and evolution over time. However, prior literature does not agree on a consistent definition or methodological approach of studying activity systems. Hence, in this article I review and analyze the existing literature to identify three constituting elements and their relation with interdependency and interactions. (1) Core-elements define a firm's higher-order strategic themes, which are carried out by a set of (2) activities, which constitute economic processes of value creation. (3) Policies determine the rules interdependent activities are required to follow to coordinate the value creation in the activity system. The three elements represent different levels of an activity system and determine its overall interdependency design. Integrating the elements and their respective roles they play in an activity system helps to shed light on firms' sources of competitive advantage, ability to adapt to changes in the environment, and evolution over time. The central insights from this review and conceptualization are translated into baseline propositions and future research directions.

[3] **Acknowledgements**: I would like to thank Nicolaj Siggelkow for helpful comments on an earlier version of this chapter.

2.1 Introduction

In recent years, a complex adaptive systems perspective on management research has gained renewed momentum (Plowman et al., 2007; Porter & Siggelkow, 2008). Early on, Thompson (1967: 6) argued that "the complex organization is a set of interdependent parts which together make up a whole because each contributes something and receives something from the whole". Other scholars emphasized the role of individuals making up the pattern and repeating cycles of activities of social systems (Katz & Kahn, 1978), the contingency of environmental context and choices made (Miller, 1981), and the ordering and coupling of activities (Rousseau & Cooke, 1984; Weick, 1976). Studies in the field of strategy have focused on the set of interdependent choices a firm can select from, thereby designing its strategy and business model, which culminate into an *activity system* (Baumann & Siggelkow, 2013; Ghemawat & Levinthal, 2008; Porter, 1996; Rivkin, 2000; Rivkin & Siggelkow, 2007; Siggelkow, 2001, 2002a). For example, a retail bank can choose whether to engage solely in savings operations or expand into mortgages and other loans as well. The firm can decide to securitize its mortgages, sell it to a securitization agency, or keep them on its own balance sheet. Additional choices that constitute part of the activity system can include geographical decisions (where to operate), decisions regarding how much to invest in advertising and IT activities, how to train and compensate the sales force (Siggelkow, 2002a), and organizational choices such as levels of hierarchy and the operative role of the CEO (Rivkin & Siggelkow, 2003). Subsequently, all choices made by the firm influence the value and outcome of other choices to varying degrees.

Despite the growing use of the concept, the study of activity systems remains difficult because of methodological challenges that are rooted in the constituting elements and the interdependencies among them. Existing theory is built on rich single case studies (Porter, 1996; Siggelkow, 2001, 2002a) and computer simulations that can process complex assumptions about interactions among elements and firms' search behavior for alternative configurations (Ghemawat & Levinthal, 2008; Levinthal, 1997; Rivkin & Siggelkow, 2007). Elements included in prior analyses range from economic processes, such as manufacturing, to firm policies of incentive structures. Because of the variety and breadth of choices considered, the generalizability of activity system dynamics has been limited. In addition, case studies as well as simulation studies have constituted exploratory/inductive approaches to expand our knowledge on activity systems. As the concept has matured and addressed a wide range of related areas such as firm evolution and survival, further research is needed for greater clarity about the defining attributes of an activity system and the establishment of coherent theoretical building blocks that explain the system's evolution, adaptation, and sources of competitive advantage.

By reviewing and analyzing the existing literature, the purpose of this paper is to provide the field with a consistent conceptualization of activity systems, which not only is applicable to prior studies but also raises important questions to be addressed in future research. I conceptualize an activity system as a set of strategic, higher-order core-elements, value-chain activities, and policies. These three elements are not isolated from one another but operate on different levels of analysis. The core-elements represent the value-proposition and product/service offering, which define a set of activities that put the core-element into place. The policy choices act as governing rules, influencing the way activities interact with one another. I elaborate on these three elements' role in determining the interdependence structure and interaction rules among activities. I further demonstrate that a clarification on the constituting elements and the different interdependence patterns and interaction rules will help to explain variance in competitive advantage, evolution, and adaption of activity systems. Core elements and activity choices denote the overall interdependence structure of the system while the policies constitute the guiding interaction rules among activities. Consequently, competitive advantage resides in three orders of fit (cf. Porter 1996), namely the general consistency or homogeneity of core-elements (first-order), the complementarity between activities (second-order), and the efficient coordination among these activities as defined by the interaction rules (third-order). Further, the configuration of a set of choices determines the interdependency pattern and interaction rules and, taken together, the activity system's ability to adapt to changes in the environment. The evolution of the system's interdependence structure is influenced by the developmental path a firm follows, i.e., whether it follows a thin-to-thick or a patch-by-patch approach (Siggelkow, 2002a).

Table 1: Prior conceptualizations of activity systems

Author(s)	Activity System Definition/ Interpretation	Focus	Theoretical Foundation	View on change/renewal
Thompson, 1967, p. 6	"Approached as a natural system, the complex organization is a set of interdependent parts which together make up a whole because each contributes something and receives something from the whole, which in turn is interdependent with some larger environment"	interdependency	contingency/ open system	depends on the underlying interdependency regrouping of clusters
Katz & Kahn, 1978, p. 20	"All social systems, including organizations, consist of the patterned activities of a number of individuals. Moreover, these patterned activities are complementary or interdependent with respect to some common output or outcome; they are repeated, relatively enduring; and bounded in space and time"	patterns of activities individuals cycles of activities (repeating)	open-systems	changes in one part affects other parts (larger system can nullify local changes) changes can threaten the established power relationship in the system: inertia changes may threaten those groups in the system that profit from present allocation of resources and rewards (714)
Miller, 1981, JMS, p. 3	"We shall argue that researchers should search for different organizational configurations or adaptive patterns that are richly described by the dynamic interaction among variables of environment, organization, and strategy. These configurations or patterns are expected to have tightly interdependent and mutually supportive parts, the significance of which can best be understood by making reference to the whole. When such configurations represent very commonly occurring, and, therefore, predictively useful, adaptive patterns or scenarios, they will be called Gestalts".	environment organization strategy	contingency	
Rousseau & Cooke, 1984, p. 355	Discrete activities in organizations generally are ordered and coupled into sets of activities, and over time these patterned activities become visible as cycles (recurring sets of activities)	Actions performed by the 'concrete' system (humans and machines) recuring patterns	contingency/ open system	Major change cannot start on the activity system level but on the abstract and concrete system level
Blackler, 1993 p. 881	Organizations as activity systems "highlights the significance for organization theory of the social origions of motives, the nature and significance of mediating mechanisms in the enactment of activities, the active nature of participation, the relevnace of history, and the significance of inconsistency and conflict in activity systems"	importants of context (external network of activity systems) history of activities (emergence) 'reworking and rethinking the context'	activity theory	unrecognized inconsistencies and conflict provide major opportunities for review and re-conceptualization
Porter, 1996 p. 62	Differences among companies are grounded in the infinite number of activity choices made that are "required to create, produce, sell, and deliver their products or services [. In the end, competitive] advantage or disadvantage results from all a company's activities, not only a few"	choice of activities different degrees of fit	contingency/ fit	growth should be done by leveraging the existing activity system rather than simply add new elements
Spender, 1996 p. 59	"The firm as a knowledge-based activity system …. "	knowledge creation as ouctome of human activities (activity system)	konwledge-based-view	
Siggelkow, 2001 p.838	a system of interconnected choices: choices with respect to activities, policies and organizational structures, capabilities, and resources.		contingency/fit	environmental change has varying impact on activity system consistency mental maps limit the ability to adapt activity system sufficently
Zott & Amit, 2010 p. 217	… a set of interdependent organizational activities centered on a focal firm, including those conducted by the focal firm, its partners, vendors, or customers, etc..	design elements (content, structure, and governance of the system)	configuration	

2.2 Prior Research on Activity Systems

Researchers have used the concept of activity systems to examine the evolution and change of firm strategy (Carmeli & Tishler, 2004; Siggelkow, 2001, 2002a) and have examined it as a source of competitive advantage (Porter & Siggelkow, 2008). Table 1 summarizes central works using the terminology of activity system in their studies. Scholars have focused on the internal consistency and reinforcement of activity choices (Miller, 1981; Porter, 1996), the recurring patterns (Katz & Kahn, 1978; Rousseau & Cooke, 1984) and the different outcomes that occur from the interactions among elements (Spender, 1996). Scholars have shown that the environmental context and the founding conditions influence the evolution and adaptability of the activity system (Blackler, 1993; Miller, 1981; Siggelkow, 2001). Introducing the term "activity system" to the Strategic Management field and providing several case-based examples, Porter (1996) stated that the uniqueness of activities chosen and the different orders of fit account for competitive advantage or disadvantage. This idea has been put in a context of complex adaptive systems to show that with increasing complexity, organizations face a multi-dimensional decision-space with many consistent activity configurations. An increasing number of consistent configurations come with the caveat that they show significant variance in their performance (Levinthal, 1997). Accordingly, to achieve a competitive advantage, firms need to find an internally consistent high performing configuration, which is difficult to be imitated by other organizations. Inimitability is argued to be due to trade-off decisions (Porter, 1996), causal ambiguity (King & Zeithaml, 2001; Reed & Defillippi, 1990; Rivkin, 2000), and interdependencies that developed over time (Ganco & Agarwal, 2009).

In depth case studies and simulation techniques of firms' activity systems have shed light on the underlying mechanisms of adaptation and evolution. Prior research illustrates that the evolution of activity systems is influenced by the structure of the interdependence design (Ethiraj, 2007; Rivkin & Siggelkow, 2007), whether changes in the environment have an effect on the internal and/or external consistency among activities (Siggelkow, 2001), and the firms' choice of developmental paths (Siggelkow, 2002a). Siggelkow (2002a), for example, identifies different mechanisms that denote whether activity choices become core-elements and that firms follow different paths to elaborate them. Porter (1996) analyzed the activity systems of IKEA, Southwest Airline, and Vanguard to show that trade-off choices and choices that reinforce one another are crucial to achieve competitive advantage. The case of Liz Claiborne (Siggelkow, 2001) shows that inhibitors of strategic renewal reside in the tight fit among activity choices when environmental conditions change.

A commonality among these case studies is a particular interest in interdependencies and interactions among choices. The findings of these studies imply that firms attempt to find consistent configurations, i.e., "peaks", on the landscape of all possible choice configurations. The height of a peak corresponds to the value or pay-off of a particular activity system. On closer inspection, the actual choices included in the potential decision space are somewhat ambiguous. While the term activity implies actual activities conducted that constitute part of a firm's value chain (Porter, 1985), studies on activity systems also include various non-activity elements, such as in the case of Southwest-Airlines, "no-meals on board", "low-ticket prices" and "15 minute gate turn-around". The different nature of choices might not follow the same laws and dynamics of interaction thereby diluting the generalizability of the activity system concept. Further lack of consistency persists in the terminology of interdependency between activity system elements. While several studies use the term interdependency (Miller, 1981; Porter; 1996; Thompson, 1967) others use interactions (Rivkin & Siggelkow, 2007; Rousseau & Cooke, 1984; Siggelkow, 2001), which seem to be interchangeable but raise some theoretical issues that will be discussed later. As shown in Table 1, prior studies lack a consistent language of the constituting attributes of an activity system regarding their elements and interconnectedness. To create future research opportunities in strategy, we need (1) a clearer conceptualization of the framework, which encompasses a reconceptualization of its constituting elements and (2) attributes that allow describing and analyzing its systemic character. I address these issues in the next chapter.

2.3 Activity System Elements

Analyzing previous depictions of organizations and their activity maps identifies three recurring elements of activity systems: strategic core-elements, value-chain activities, and policies. In Table 2, I provide an excerpt of prior studies' activity system elements and assign them to the corresponding type (i.e., whether it is a core-element, an activity, or a policy). The three types of elements constitute what is required form an activity system. First, core-elements define the strategic themes, i.e. the value

Table 2: Analysis and categorization of prior studies' activity maps

Activity System Elements	Core-elements (higher-order choices)	Activities	Policies
Definition	- about how a firm positions itself (Ghemawat & Levinthal) - an element that interacts with many other current or future organizational elements (Siggelkow, 2002)	-discrete economic processes (Porter 1985; Porter & Siggelkow, 2008) - engagement of human, physical and/or capital resources […] to serve a specific purpose toward the fulfillment of the overall objective (Zott & Amit, 2010) - operating choices (Ghemawat & Levinthal, 2008)	- the way things "should" be done (Rousseau & Cooke, 1984)
Examples			
Southwest Airlines (Porter, 1996)	- limited passenger service - very low ticket prices - high aircraft utilization - frequent reliable departures	- fleet maintenance - boarding - passenger handling - check-in - loading (baggage)	- no meals - no seat assignment - 15-minute gate turnarounds - standardized fleet of 737 aircraft
IKEA (Porter, 1996)	- limited customer service - modular furniture design - self-selection by customers - low manufacturing cost	- Stocking - Display design - sales process	- 100% sourcing from long-term suppliers - year-round stocking - suburban locations with ample parking
Vanguard (Porter, 1996; Siggelkow, 2002)	- low cost/ strict cost control - direct distribution - candid communication - mutual structure	- distribution - account management - selling and marketing - information and customer services	- low rate of trading - limited advertising budget - no loads
Liz Claiborn (Siggelkow, 2001)	- lower total cost to the customer - fashion apparel for the professional woman	- production and distribution - selling - presentation - design - product portfolio (management) - marketing - design (collection management)	- no reording (early 90s) - no production to-order (early 90s) - sales only in NY - no cancelation policy - no splashy advertising

proposition and product/service offering, which, in turn, define the required set of activities to operationalize these themes. Second, activities transform inputs into outputs to create value-added. Third, policies, representing governing rules, coordinate the interplay between activities by determining the interactions between them. These three activity system elements reflect very closely Andrews' (1987: 14) notion of strategy as a pattern of interdependent "purposes, policies, and organized action" and Gavetti & Rivkin's (2007) values, heuristics, and activities. My analysis and definition of activity systems departs from prior research in two ways. First, I acknowledge that each of the three elements carries out a different role in the system thereby constituting a different level of analysis. Second, the three levels of an activity system interact in ways that require analysis beyond the commonly employed complementarity framework. In Figure 5, I relate the different levels of an activity system to one another. The three activity system elements and their general relation are discussed next.

Core-elements

On the most abstract (the strategic) level, the activity system shows "higher-order choices about how a firm positions itself" (Ghemawat & Levinthal, 2008: 1639). These higher-order objectives represent “core-elements” (Chatterjee, 2005; Siggelkow, 2002a), which influence future choices and exhibit many interdependencies with other existing elements of the activity system (Siggelkow, 2002a). Consequently, all higher-order themes of an activity system determine how value is created and imply the necessary interdependent activities, i.e., “activity domains” (Siggelkow, 2002a), that carry out the core-element’s objective (Porter, 1996: 70)[4]. Core-elements correspond to a firm’s strategic positioning in terms of its product offerings and the resulting proposition influencing the willingness to pay (Brandenburger & Stuart, 1996). For example, in the case of Vanguard’s activity system in 1997 (Siggelkow, 2002a), its value proposition was “candid communication”, “high quality service”, and “focus on long term performance” and its services were to offer “conservatively managed funds” and “direct distribution”. All of these choices were considered core to the firm. Also, the role of core-elements becomes salient in the case of Liz Claiborne (Siggelkow,

[4] Chatterjee (2005) captures this idea in what he calls core objectives of a business model.

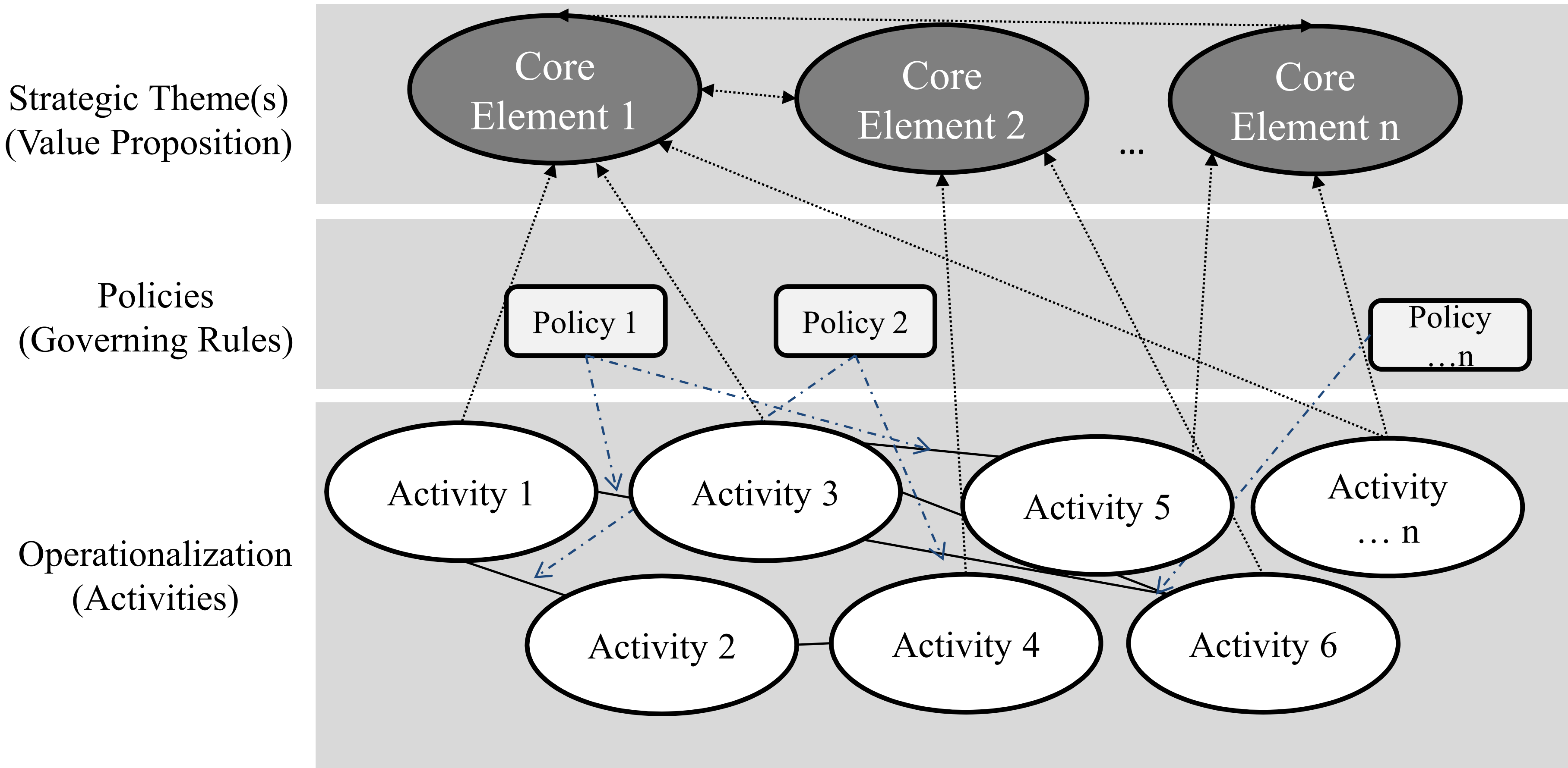
2001), where the two central themes were "lower total cost to customers" (value proposition) and "fashion apparel for the professional woman" (offering).

Strategy literature covers the idea of higher-order core-elements in similar ways. Andrews (1987), for example, emphasizes the goals and purpose of corporate strategy, which determines the required organizational action and policies. Gavetti and Rivkin (2007: 432) highlight the role of values and representations in managers' mind by stating:

> *"... by simplifying the space of possibilities in which the manager or team searches ... [f]or instance, at Lycos they ruled out regions of the space [...] focused attention on a subset of choice dimensions [...], or suppressed interactions across functional [...] domains. [...] Representations and personal values influence a manager's choice of heuristics, which then affect activities. Activities generate levels or patterns of performance that are detected selectively through sensors. Once interpreted through representations or personal values, this feedback from the world of action can alter elements in the world of cognition".*

In sum, core-elements represent the self-understanding of the company and define a range of activities that help to carry-out and reinforce the strategic theme determined by the core-element.

Figure 5: Constituting parts of an activity system



Activities

Activities represent the central elements firms' search behavior is geared toward (Gavetti & Rivkin, 2007) because they lead to the actual value creation (Porter, 1985) and the fulfillment of the strategic core themes (core-elements) of the firm. When referring to activities, scholars have used definitions such as "discrete economic processes" (Porter & Siggelkow, 2008: 34) and operational choices (Ghemawat & Levinthal, 2008), which can be performed in different ways. All these interpretations draw on Porter's (1985) value chain activities, which clearly represent operational processes converting inputs into outputs. Examples are the "sales process" and the "stocking" in the case of IKEA; or Vanguard's decisions to engage into "account management", "selling and marketing", and "distribution" (Siggelkow, 2002a). That is, activities are choices that have process character and determine what operations are carried out and to which extent. The magnitude of an activity can vary for example in terms of the geographical reach of operations and the breadth of desired outcomes (e.g., products and services). In addition, activities possess resource character because activities are the "engagement of human, physical and/or capital resources […] to serve a specific purpose toward the fulfillment of the overall objective" (Zott & Amit, 2010: 217). Activities transform inputs into outputs and also require other resources to fulfill this process. Hence, activities represent stocks of accumulated knowledge, information, and other types of resources (Dierickx & Cool, 1989), which might also be referred to as capabilities and routines of the firm (Nelson & Winter, 1982).

Policies

Policy choices determine how activities are supposed to be performed. Rousseau and Cooke (1984: 354) state that "activity systems must respond to […] constraints (e.g., policies regarding the way things "should" be done)". Activities are often dependent on policies in terms of how they are coupled and sequenced (Tersine, 1985). Accordingly, policies define the content and nature of interactions and represent an important contextuality-component within activity systems (Porter & Siggelkow, 2008). They "provid[e] more fine-tuned and narrower direction" for the actual activities than core-elements (Gavetti & Rivkin, 2007: 432). However, policies in an activity system also denote the flexibility of the strategic rules underlying the system's interactions (March, Schultz, & Zhou, 2000). This is because a policy may vary in

their degree of formality, i.e. whether it suggests guidance, leaves room for interpretation, or pre-defines exactly what to do. For example, Southwest Airline's policy of "no seat assignments" is stringent and constraining at such a magnitude that there is no room for interpretation: seats will neither be assigned by the IT-system nor the staff during boarding. The policy "flexible union contracts" on the other hand, gives guidance but no clear directions and allows greater interpretation and leeway in its consequences. Hence, policies have prescriptive character that influences when (time component) and how (constraining component) activities should interact and be performed.
Integrating all three elements, I formally define an activity system as follows:

> Baseline Proposition: *An activity system consists of (1) strategic, higher order core-elements that define how value will be created through which set of interdependent (2) discrete economic processes (i.e., activities), which in turn are guided by (3) policies that define when and how these activities should interact and be conducted.*

The above elaboration of the activity system concept clarifies the distinct role of each constituting element as well as general relationships between them. In order to understand the source of competitive advantage in an activity system and its ability to adapt, we need to understand the interplay between elements further, especially the concept of interdependency and the role it plays for fit among elements. Below, I discuss the difference between interdependency and interaction as well as the importance of viewing both on a system level instead of a mere dyadic level.

2.4 Activity System Interdependencies

Distinction between interdependency and interaction

Prior research has used the term interdependency and interaction interchangeably. Theoretically, the two terms share common assumptions but differ in their meaning significantly. If one activity is interdependent with another, the activity is either constrained in its actions or influenced by the action of the other activity, or both (Pfeffer & Salancik, 1978; Thompson, 1967). Interaction is the information or resource flow between interdependent activities. Hence, interaction makes the underlying interdependency visible and measurable. Interactions can be measured as transactions in terms of the number, amount, frequency, and direction of resources exchanged between activities (McCann & Ferry, 1979). Here, the term transaction is used differently than in Williamson's (1985) transaction cost economics (TCE). In TCE, a transaction refers to a contract between two activities but not the realization of it. In contrast, McCann & Ferry's (1979) refer to the resource flow when they elaborate on transactions within organizations. Accordingly, interdependency denotes general relationships between elements while the interactions reflect what Holland (1995) refers to as rules that guide agents (elements) in a complex system. Accordingly, complex systems vary in terms of the existence of interlinked agents and in the rules that they follow. In summary, interdependency denotes the presence of relationships between elements whereas interactions denote transactions (i.e., resource and information flows).

Carrying this thought further, interactions can lead to mutual adaptation between activities and thereby change the interdependency content. For example, a supplier and a buyer might write a contract determining which products the buyer will purchase and to which quality specifications. The contract constitutes a source of interdependency for both firms especially if these two firms engage into recurring business drawing on this contract. When both firms carry out the responsibilities defined in the contract, they may encounter problems and questions, for which solutions have not been defined ex ante. Once potential conflicts and issues have been settled, the firms are likely to alter the underlying contract for future transactions. This example is in line with research that shows that firm contracts are "repositories of knowledge" (Mayer & Argyres, 2004) and as such may change over time due to prior interactions. Recurring transactions often lead to revisions of the underlying contracts and to changes in the underlying interdependencies between the firms' activities. Hence, the distinction between interdependency and interaction bears enormous potential to shed light on the sources and evolution of interdependency patterns in activity systems. Accordingly, I argue that in order to cover interdependencies holistically, activity systems need to be analyzed in terms of their interdependency content, i.e., the underlying nature and consequence (interaction) of interdependency as well as the overall interdependency pattern. Below, I provide an overview of the existing interdependency literature and implications on the system-level design.

Table 3: Types of interdependency

Study	Type of interdependence	Unit of Analysis	Definition
Thompson (1967)	pooled	system	This is true when parts are not dependent on or support one another in a direct way. "Yet they may be interdependent in the sense that unless each performs adequately, the total organization is jeopardized; failure of any one can threaten the whole and thus the other parts. We can describe this situation as one in which each part renders a discrete contribution to the whole and each is supported by the whole"
	sequencial	dyadic/ sequential	"[D]irect interdependence can be pinpointed between [two parts] and the order of that interdependence can be specified"
	reciprocal	dyadic	"[S]ituation in which the outputs of each become inputs for the others"
Pfeffer & Salancik (1978)	outcome interdependence	dyadic-level/ sequential	The outcomes achieved by A are interdependent with, or jointly determined with, the outcome achieved by B.
	behavior interdependence	contextual	The activities are themselves dependent on the actions of another social actor.
McCann & Ferry (1979)	Dimension 1		"The number of different resources passed between the unit"
	Dimension 2		"The amount of resource exchanged per unit of time"
	Dimension 3		"The frequency of transactions per unit of time"
	Dimension 4		"The amount of time before the loss of a resource significantly impacts upon work unit outcomes (i.e., slack)"
	Dimension 5		"The composite value of the resource to the unit including: (a) the cost of substituting a different resource; (b) the cost of locating another supplier or user; (c) the qualitative importance of the resource for achieving desired work outcomes; and (d) the percentage of the time unit needs were satisfied in the past by this unit"
	Dimension 6		"The direction of the resource flow: into, out of, or both ways between the units"
Rousseau & Cooke (1984)	natural or technological dependence	dyadic-level/ sequential	"[O]ne action cannot take place until another is completed"
	resource dependence		"[D]ifferent activities require the use of the same resources and therefore cannot be performed simultaneously or until those resources become available again"
	policy dependence	contextual	"[R]esults from an organization's operational policies or rules"

Table 3: continued

Study	Type of interdependence	Unit of Analysis	Definition
Victor & Blackburn (1987)	Fate control over activities	dyadic/ sequential	"To the extent that Unit A requires an action by Unit B (e.g., delivery of materials, completion of a task), B can affect A's operations by either performing the required action or not."
	Behavior control over activities	dyadic/ contextual	"If A requires an action by B, contingent on A's own action (e.g., delivery of materials according to a production schedule, synchronized joint use of a machine), B again can affect A's performance by matching or not matching A's contingent response."
	Reflexive control over activities		"… to the extent that A can influence its own performance by taking a particular action (e.g., completing a task, stocking materials)"
Milgrom & Roberts (1990)	complementarity	dyadic-level	"The defining characteristic of these groups of complements is that if the levels of any subset of the activities are increased, then the marginal return to increases in any or all of the remaining activities rises. It then follows that if the marginal costs associated with some activities fall, it will be optimal to increase the level of all of the activities in the grouping."
	substitute	dyadic-level	"Two activities are said to interact as substiutes if the marginal benefit of each activity decreases in the level of the other activity"
Malone et al. (1999)	Flow dependencies	dyadic/ sequential	"arise whenever one activity produces a resource that is used by another activity"
	Sharing dependencies		"occur whenever multiple activities all use the same resource"
	Fit dependencies	contextual	"arise when multiple activities collectively produce a single resource"
Casciaro & Piskorski (2005: 170)	Mutual dependence vs. power imbalance	dyadic	"Power imbalance captures the difference in the power of each actor over the other. Formally, this construct can be defined as the difference between two actors' dependencies, or the ratio of the power of the more powerful actor to that of the less powerful actor (Lawler and Yoon, 1996). The second dimension of dyadic power, mutual dependence, captures the existence of bilateral dependencies in the dyad, regardless of whether the two actors' dependencies are balanced or imbalanced. Formally, this measure can be defined as the sum, or the average of actor i's dependence on actor j and actor j's dependence on actor i (Bacharach and Lawler, 1981)"
Porter & Siggelkow (2008)	contextuality of complementarities	contextual/ system	Value and type of interaction among activities is dependent on many other activity choices.

Prior literature on interdependencies between activities

Thompson (1967) examined and discussed three types of interdependencies that can occur between organizational elements. These types build a Guttman scale (i.e., an increasing scale where each rank also includes all lower ranks). First, *pooled* interdependency exists when there is no direct relationship between activities, however, they serve collectively a greater goal which may be jeopardized if not each of them performs adequately. Second, *sequential* interdependency exists when one activity cannot act if another one has not acted properly. Third, *reciprocal* interdependence exists when activities interact in complex loops with each other, i.e., the outputs of one activity becomes the input for the others and vice versa. Rousseau and Cooke (1984) provide a different classification of activity interdependencies drawing on production and operations research (Tersine, 1985). They refer to three types of interdependencies that determine the ordering of activities in an activity system. First, *natural dependence* exists when one activity cannot take place unless another given activity is completed. Take as an example a private bank. A customer relation manager (CRM) of a private bank certainly cannot allocate any assets until the client has approved and mandated the bank, i.e., made the assets accessible to the CRM. Second, *resource dependence* exists when more than one activity needs the same limited resources which make a simultaneous performance of these activities (partially) impossible. Regarding the private banking example, assume there is a limited number of CRMs. If all these CRMs engage in asset allocation they will not be able to acquire new customers simultaneously. Third, *policy dependence* exists when organization-specific rules and norms determine if an activity is performed or not. For example, private banks often have the policy not to allocate any assets until the risk profile of the client has been properly determined, even though a mandate already exists. Victor and Blackburn (1987) state that dependencies among activities can be understood as different types of control one activity has over one or more other activities. *Fate control* occurs when one activity requires the performed output of another activity. *Behavior control* occurs when one activity depends on the output of another activity under certain contingencies such as delivery of materials to a given time schedule. Malone and colleagues' (1999) classification of *flow*, *sharing*, and *fit dependencies* constitutes a mixture of Tersine's (1985) and Thompson's typologies.

Distinct from the aforementioned interdependencies is Milgrom and Robert's (1990) framework of complementarity, which examines the generated value (or outcome) of interdependency. They defined two activities as complementary if a higher level in one activity increases the marginal benefit of the other activity. The causal order (or dependence structure) of two complementary activities, i.e., what influences what, is not of interest for such calculations. The two activities interact and lead to higher benefits if both are on a higher level. The same is true in a reverse manner for substitutes. Two activities are defined as substitutes if a higher level in one activity decreases the marginal benefit of the other activity. More recent research expanded this view showing that the occurrence or absence of complementarity can depend on the remaining configuration of activities in an organization (Cassiman & Veugelers, 2006) as well as different levels of each activity (Porter & Siggelkow, 2008). Hence, complementarity represents a particular outcome of interdependencies and interactions between a set of activities.

Table 3 provides an overview of the reviewed interdependencies in the organizational literature. Interdependency can be pooled (also termed: fit dependency or reflexive control), sequential (also termed: flow dependent or fate control), or reciprocal. Further, some conceptualizations focus on the processes and flows between interdependent activities, i.e. the triggered interaction based on the underlying interdependency, which is a rule-based component. It can either be natural dependent or contextual dependent (also named: sharing dependency, resource dependency, or policy dependency), i.e., interdependencies that occur by virtue of a third factor (or activity) such as scarce resources or organizational policies. Hence, interaction rules determine the temporal as well as content component of interdependencies. Finally, some literature focusses on the outcome of interdependency in terms of the conceptualization of fit and complementarity as the value-consequences of existing and interacting interdependency relationships (Milgrom & Roberts, 1990, Miller, 1996, Siggelkow, 2001).

Interdependency on a system level

As shown in Table 3, most conceptualizations of interdependency are on a dyadic level. However, analyzing an activity system's interdependencies on an element by element basis is not accounting for contextualities that occur due to system's configuration as a whole (Porter & Siggelkow, 2008). The rich classification of interdependencies is therefore only limited transferable to the level of an activity system as a whole. Hence, proper dimensions to analyze the activity system level, need to be chosen differently from those of a dyadic one. Only a few studies examined interdependence structure (patterns) of entire systems (Baldwin & Clark, 2000; Rivkin & Siggelkow, 2007). Interdependency structure can be illustrated as a matrix of activities and their influence. An x in the matrix indicates interdependence between the horizontal and vertical activity[5]. An activity system with only independent activities would show only a diagonal interdependence pattern, since each activity is dependent on itself.

The most well-known pattern to occur in complex systems is modularity. It indicates the degree of decomposability of the system into consistent sub-system which shows no or few interdependencies with the remaining sub-systems (Simon, 1962). Besides the decomposability, however, the prevalence and distribution of interdependency have important influence of the rest of the interdependency structure of an activity system (Baldwin & Clark, 2000; Rivkin & Siggelkow, 2007; Zhou, 2013).

Figure 6: Interdependency patterns in a set of 20 activity choices

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	x																			
2	x	x																		
3	x	x	x																	
4	x	x	x	x																
5	x	x	x	x	x															
6					x	x														
7					x	x	x													
8					x	x	x	x												
9					x	x	x	x	x											
10					x	x	x	x	x	x										
11										x	x									
12										x	x	x								
13										x	x	x	x							
14										x	x	x	x	x						
15										x	x	x	x	x	x					
16															x	x				
17															x	x	x			
18															x	x	x	x		
19															x	x	x	x	x	
20															x	x	x	x	x	x

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	x																			
2	x	x																		
3	x	x	x																	
4	x	x	x	x																
5	x	x	x	x	x															
6					x	x														
7					x	x	x													
8					x	x	x	x												
9					x	x	x	x	x											
10					x	x	x	x	x	x										
11					x					x	x									
12					x					x	x	x								
13					x					x	x	x	x							
14					x					x	x	x	x	x						
15					x					x	x	x	x	x	x					
16					x										x	x				
17					x										x	x	x			
18					x										x	x	x	x		
19					x										x	x	x	x	x	
20					x										x	x	x	x	x	x

Figure 6 illustrates two activity systems with the same number of activity choices (N = 20). Interdependencies are assumed to be reciprocal and for the sake of simplicity

[5] For the sake of simplicity, I follow prior research and assume mutual interdependency between interdependent elements (e.g., Zhou, 2013).

shown only off-diagonal. The first activity system shows a typical modular structure, where activities can be clustered into modules of highly interdependent choices which are relatively independent of other choices. The second activity system shows the same set of choices and interdependency, however, one of the modules shows a higher centrality of one of its activities (activity '5'). The distribution of interdependencies therefore is part of but can exceed modularity.

I collected the underlying interdependency design of activity systems as published by prior scholars. Figure 7 shows the replicated activity system designs of IKEA, Southwest Airlines (Porter, 1996), Liz Claiborne in 1990 (Siggelkow, 2001), and Vanguard in 1997 (Siggelkow, 2002a). Vertical and horizontal sequences of 'X' indicate a cluster of interdependencies, which occur mainly around core-elements (in bold). However, because the structure of an influence matrix is influenced by the ordering of choices on the horizontal and vertical axes, I ran the clustering algorithm for Design Structure Matrices by Thebeau (2001)[6] using the software *Matlab* to identify more reliable and coherent design modules in each of the activity maps. I illustrate this technique using Siggelkow's (2002a) Vanguard case as the most complex and encompassing activity map available. After running the algorithm several times, the clustering results consistently report four prominent modules, which correspond to four of the seven core-elements in Siggelkow (2002a). One to two additional clusters are often identified and to varying degree correspond to the remaining core-elements in Siggelkow's (2002a) paper. In Figure 8, a typical re-clustered influence matrix is shown and in Figure 9, I illustrate the identified cluster in Siggelkow's (2002a) activity map showing Vanguard's system in 1997.

Analyzing the re-clustered activity maps shows that core-elements influence the overall structure of interdependencies of the system. Accordingly, core-elements can correspond to the decomposability of the activity system, i.e., represent relatively independent modules of choices within the system. However, homogeneity or similarity in the themes of core-elements (goal homogeneity) can result in a more integrated the system. This is because similar goals are more likely to share activity choices, i.e., exhibit a goal-overlap (homogeneity) of core-elements. For example, Vanguard's core-elements 'low-cost', 'direct distribution', and 'focus on conservatively managed funds' shared reinforcing choices such as 'no loads' and

[6] The algorithm and documentation can be accessed at http://www.dsmweb.org/?id=121.

‘servicing of defined benefits’ (Siggelkow, 2002a), which integrate the core-elements which all share a common thread of efficiency.

Important to note is that the pattern analysis of prior studies is limited to the structure of interdependency and does not include the interaction pattern that shows exchange of resources and information due to these interdependencies. The interaction rules represent concepts such as the system’s cycle time (Ancona & Chong, 1996) and its coupling (loose vs. tight coupling), i.e. the situation in which elements affect each other “suddenly (rather than continuously), occasionally (rather than constantly), negligibly (rather than significantly), indirectly (rather than directly) and eventually (rather than immediately)” (Weick, 1982: 380). These characteristics of activity systems are rooted in the policies that guide the actual interaction between activities and, thus, determine or at least manipulate the underlying rules of interdependency – i.e. denote the interactions. In the case of Southwest Airlines (Porter, 1996), the policy '15 minute gate turnarounds' paces interactions between activities such as boarding, flight schedule, and maintenance processes. In Liz Claiborne’s case (Siggelkow, 2001: 849), the policy in the 90’s “to invest little in design, distribution, and information technology” guided how production and sales activities interacted; leading to long lead times and no-reordering or production-to-order options. In addition, the structure of interdependency used in prior studies mainly focuses on complementarity as interdependencies and omits other types of interdependency such as shared resources and input-output relationships.

Figure 7: Interdependency matrices of IKEA, Southwest Airlines, Liz Claiborne, and Vanguard

	IKEA (Porter, 1996, p.13)	**1**	2	3	4	5	**6**	7	8	9	10	**11**	12	13	14	15	16	**17**	18	19	20
1	**Limited Customer Service**	x	x	x		x												x			x
2	Explanatory catalogues, informative displays and labels	x	x																		
3	Self-transport by customers	x		x	x															x	
4	Erase of transport and assembly			x	x	x	x	x													
5	Self-assembly by customers	x			x	x	x														
6	**Modular furniture design**				x	x	x	x	x	x	x	x									
7	"Knock-down" kit packaging				x		x	x	x												
8	Wide variety with ease of manufacturing						x	x	x												
9	Increased likelihood of future purchase						x			x								x			
10	In-house design focused on cost of manufacturing						x				x	x									
11	**Low manufacturing cost**						x				x	x	x		x						
12	100% sourcing from long-term suppliers											x	x	x							
13	Year-round stocking												x	x	x						
14	Ample inventory on site											x		x	x	x		x			
15	Most items in inventory														x	x	x	x			
16	More impulse buying															x	x		x		
17	**Self-selection by customers**	x								x					x	x		x		x	x
18	High-traffic store layout																x		x	x	
19	Suburban locations with ample parking			x														x	x	x	
20	Limited sales staffing	x																x			x

Figure 7: continued

	Southwest Airlines (Porter, 1996, p. 15)	**1**	2	**3**	4	5	6	**7**	8	**9**	10	**11**	12	13	**14**	15	16	17	18
1	**Frequent reliable departures**	x	x	x											x				
2	15-minute gate turnarounds	x	x	x									x		x				
3	**Lean, highly productive ground and gate crews**	x	x	x	x	x	x	x	x	x									
4	High compensation of employees			x	x														
5	High level of employee stock ownership			x		x													
6	Flexible union contracts			x			x												
7	**High aircraft utilization**			x				x	x	x									
8	Automatic ticketing machines			x				x	x							x			
9	**Very low ticket prices**			x				x		x	x	x	x		x	x			
10	"Southwest, the low-fare airline"									x	x	x							
11	**Short-haul, point-to-point routes (mids. cities & sec.airports)**									x	x	x	x	x	x				
12	Standardized fleet of 737 aircraft		x							x		x	x						
13	No connections with other airlines											x		x	x		x		
14	**Limited passenger service**	x	x							x		x		x	x	x	x	x	x
15	Limited use of travel agents								x	x					x	x			
16	No baggage transfers													x	x		x		
17	No meals														x			x	
18	No seat assignments														x				x

Figure 7: continued

	Liz Claiborne early 90s (Siggelkow, 2001, p.848)	**1**	2	3	4	5	6	7	8	9	**10**	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	**Fashion apparel for the professional woman**	x	x	x	x	x	x	x	x		x									x			x														
2	Liz & Co	x	x																																		
3	LizWear	x		x																																	
4	LizSport	x			x																																
5	Dana Buchman	x				x																															
6	Elizabeth	x					x																														
7	Accessories	x						x																													x
8	Image of friend	x							x		x																										
9	No splashy advertising									x	x	x																									
10	**Lower total cost to customers**	x							x	x	x	x	x	x	x	x	x	x			x	x															
11	Stylish yet conservative design									x	x	x																									
12	Consistency of color										x		x	x																							
13	Mix-and-match design										x		x	x												x					x						
14	Low design technology										x				x				x																		
15	Six collections										x					x			x	x				x		x											
16	Overseas suppliers										x						x		x	x	x			x													
17	Small suppliers										x							x		x		x															
18	Long lead times														x	x	x		x	x	x	x															
19	No production-to-order	x														x	x	x	x	x	x	x	x														
20	Late presentation and delivery										x						x		x	x	x																
21	Low spending on information systems and distribution										x							x	x	x		x	x														
22	No reordering	x																		x		x	x														
23	No cancellation policy															x	x							x													
24	SURF																								x	x											
25	Selling entire groups only													x		x									x	x	x	x	x		x						
26	Excellent sales force																									x	x										
27	Sales only in NY																									x		x	x								
28	Focus on large customers																									x		x	x	x							
29	Underproduction																												x	x							
30	Presentation as collection													x												x					x	x	x	x	x	x	
31	Claiboards																														x	x					
32	Sales consultants																														x		x				
33	Retail associates																														x			x			
34	LizWeek presentations																														x				x	x	
35	Concept shops																														x				x	x	x
36	Accessory concept shops							x																												x	x

Figure 7: continued

	Vanguard 1997 (Siggelkow, 2002a, p.146)	**1**	2	3	**4**	5	6	7	8	9	10	**11**	12	13	14	15	16	17	18	19	20	21	22	23	**24**	25	26	27	28	29	30	**31**	32	33	34	35	36	**37**	38	39	40	41	42	43	44	45	46	**47**	48	49
1	**Mutual Structure**	x	x	x	x							x																										x										x		
2	Administrative functions in-house	x	x										x																																					
3	First outside investment management company	x		x					x				x																																			x		
4	**Focus on conservatively managed funds**	x			x	x	x	x	x	x	x	x																				x																x		
5	Balanced funds				x	x																																												
6	Fixed-income funds, including municipal bond funds				x		x																																											
7	Money market funds				x			x																																										
8	Limited research			x	x				x								x																																	
9	Index funds				x					x																																								
10	Servicing of defined benefit plans				x						x	x																																						
11	**Low cost**	x			x						x	x	x		x	x	x			x	x	x	x	x								x													x	x	x	x		
12	Reduced fees for outside investment management company		x	x								x	x	x																																				
13	Incentive fees for outside investment managers												x	x																																				
14	Client services for retirement plan sponsors 1											x			x																																			
15	Bonuses based on cost savings											x				x																																		
16	Moderate wages								x			x					x	x																																
17	High esprit de corps																x	x	x		x															x														
18	Vanguard Award for Excellence																	x	x						x																									
19	Swiss Army											x								x					x																									
20	Scrunching											x						x			x																													
21	No perks for management											x										x																												
22	1-800 number											x											x		x																									
23	Little advertising											x												x													x	x												
24	**High-quality service**																		x	x			x		x	x	x	x	x	x	x							x								x				
25	Vanguard Quality Program																								x	x																								
26	Internalized personal shareholder accounting																								x		x																							
27	Internalized institutional shareholder accounting																								x			x																						
28	Bogle Barometers																								x				x																					
29	Hire primarily college graduates																								x					x																				
30	Do not hire from Wall Street																								x						x	x																		
31	**Focus on long-term performance**				x							x																			x	x	x	x	x			x												
32	Brokerage service																															x	x																	
33	Decline assets if considered "hot" money																															x		x																
34	No telephone exchange for Index 500																															x			x															
35	Missionary zeal to restructure the industry																	x																		x	x													
36	Bogle's openness to press																							x												x	x	x												
37	**Candid communication**	x																						x	x							x					x	x	x	x	x	x	x							
38	Clearly written annual reports																																					x	x											
39	Warning letters																																					x		x										
40	Plain talk brochures																																					x			x	x								
41	Investor education																																					x			x	x	x				x			x
42	Web University																																					x				x	x						x	
43	Investment adviser services																																											x				x		
44	Only three retail branches											x																																	x					
45	Client services for retirement plan sponsors 2											x													x																					x				
46	No load											x																														x					x	x		
47	**Direct distribution**	x		x	x							x																																x			x	x	x	
48	Invest in on-line technology																																										x					x	x	
49	Fee-based one-time investment advice																																									x						x		x

Figure 8: Re-clustered activity choices of Vanguard in 1997

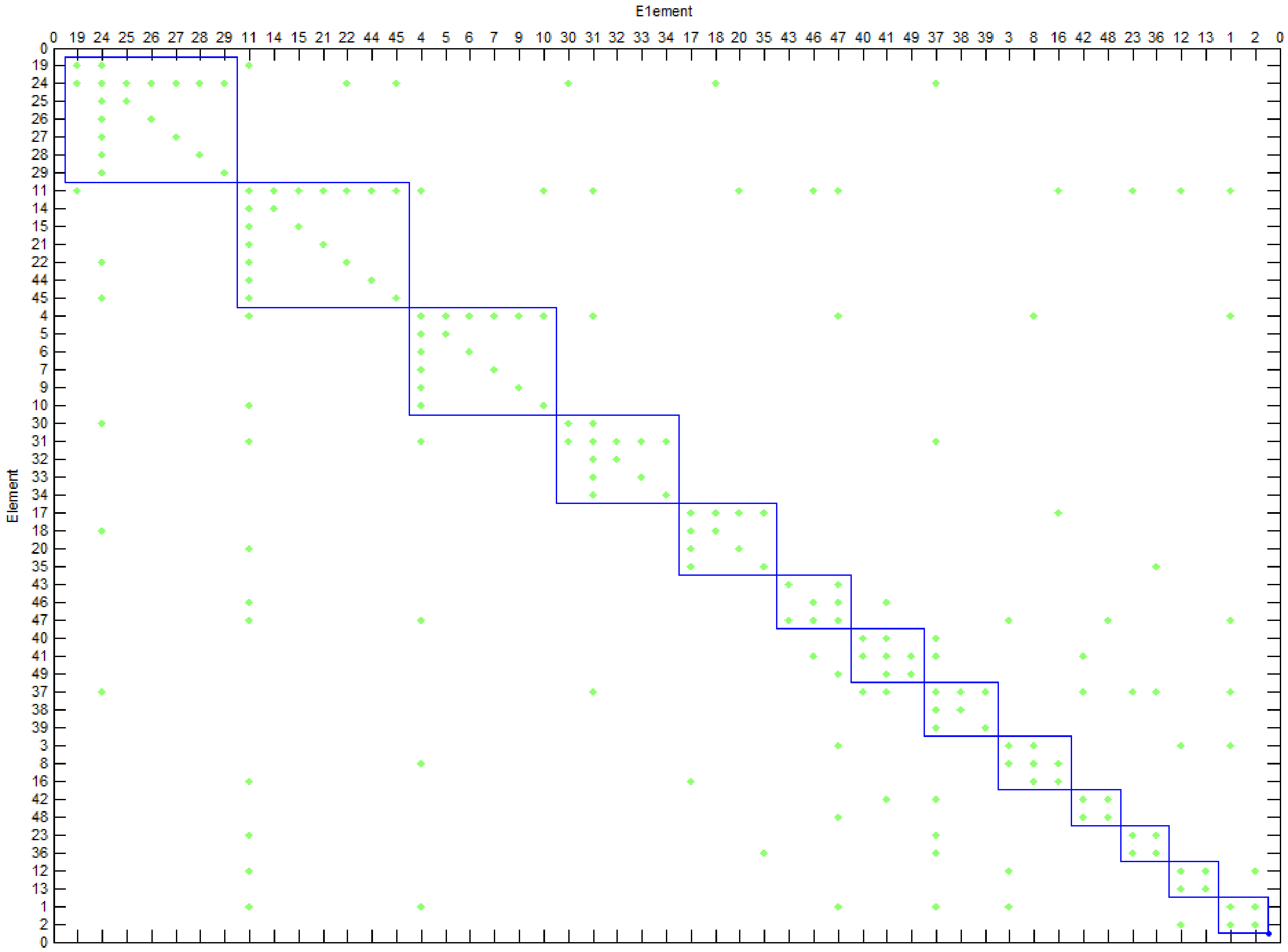
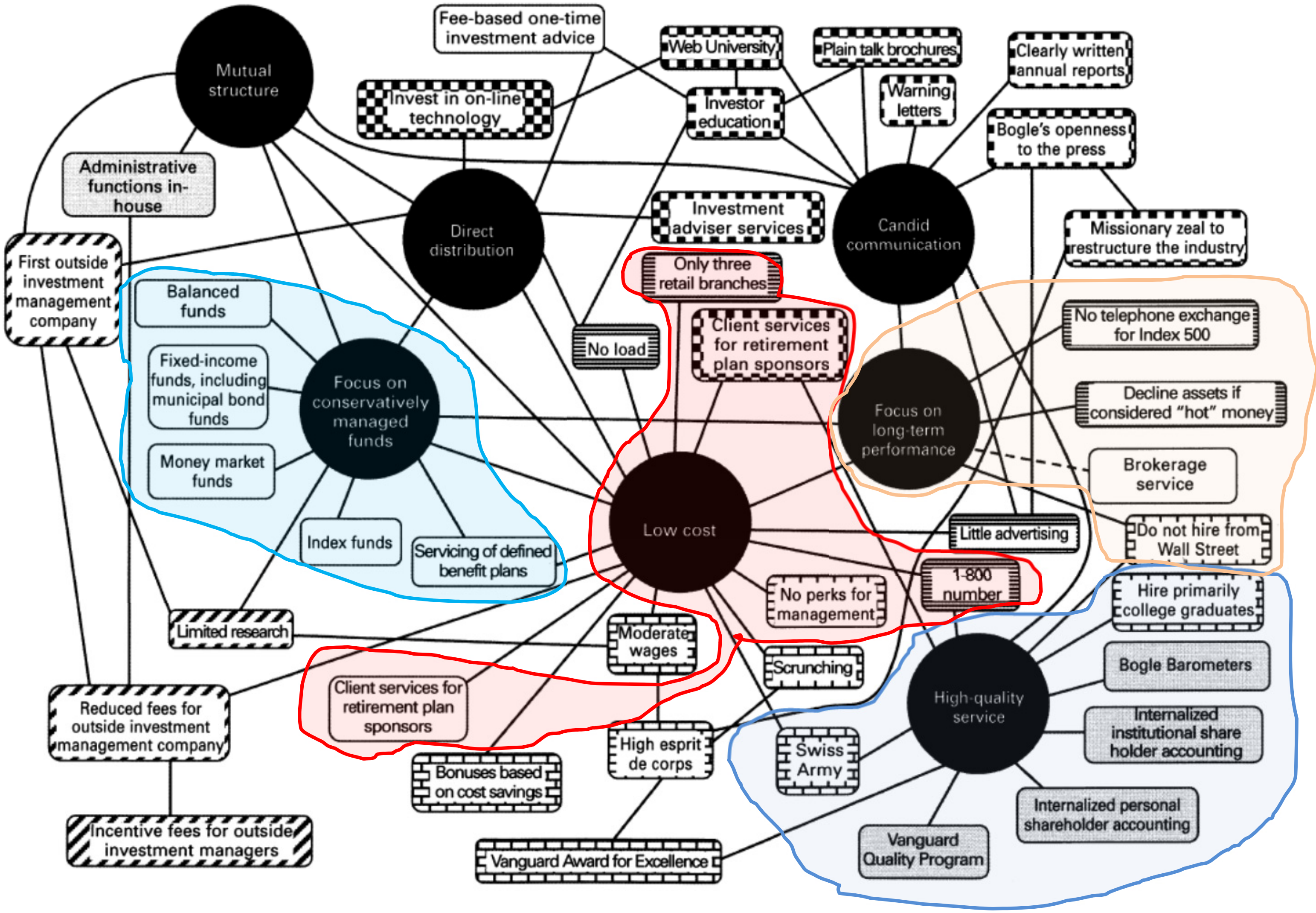


Figure 9: Vanguard's activity map identified clusters



Source: Modified figure from Siggelkow (2002a: 146).

2.5 Activity System Competitive Advantage, Adaptation, and Evolution

Competitive Advantage

Performance and competitive advantage of activities is related to the concept of fit. Fit refers to the positive relationship among activity choices. Porter (1996) illustrates and analyzes types of fit occurring in activity systems. The most studied type of fit is complementarity (second-order fit) among activities, which means that one activity's value increases in the presences of one or several other activities and vice versa (Milgrom & Roberts, 1990). It is important to note that fit can also result from consistency among activities not undermining one another (first-order fit) as well as the optimization of the interaction among activities (third-order fit). These three types of fit in activity systems can constitute a potential source of competitive advantage.

First, competitive advantage resides in a unique set of consistent (**first-order fit**) activity choices, which is difficult to imitate for competitors. That is, some trade-off between the activities chosen is required. Hence, players in the industry cannot easily implement these activities into their own business models. For example, IKEA's decision to combine display space and inventory space in stores is in conflict with traditional furniture stores' business model (fancy in-store design, which allows upscale pricing). Core-elements and policies denote these trade-off decisions, as they are the strategic themes defining the source of value creation and product and service offerings. The required activities are then the consequence of core-elements and policies chosen. For example, Southwest Airline's core elements 'low ticket pricing' and 'limited customer service' require policies such as no-meals on board, no seat assignments and standardized fleet, which are all in severe conflict with premium carriers such as Lufthansa or Singapore Airlines. Their core-elements are more pleasant flight experience, full on board service, and attractive frequent flyer pricing. Consequently, the trade-off in both cases (low-cost and premium) is strengthened by clear-cut, stringent polices.

Second, a further source of competitive advantage is the homogeneity among core-themes. Core-elements that are more homogenous, i.e. their goals are directed towards the same overall objective, constitute what Porter (1996) calls consistency or first-order fit. Homogenous core-decisions are more likely to reinforce (**second-order fit**)

one another and draw from similar and often the same activities. The result is that these activities are more likely to show complementary effects, draw from the same pool of resources, and exhibit more interdependencies with one another. A more complex interdependent pattern builds up a natural barrier of imitation (Rivkin, 2000) because managers' mental models that miss interdependencies or that contain non-existing interdependencies (Siggelkow, 2002b).
Third, efficiently operationalization of interdependent activities can lead to competitive advantage. This is the result of well determined interaction rules in place (**third-order fit**). These rules define the speed and content of the interactions; thereby reduce slack as well as redundancies and perfect coordination. This is illustrated in Porter's (1996) analysis of the company Gap:

> *"The Gap, a retailer of casual clothes, considers product availability in its stores a critical element of its strategy. The Gap could keep products either by holding store inventory or by restocking from warehouses. The Gap has optimized its effort across these activities by restocking its selection of basic clothing almost daily out of three warehouses, thereby minimizing the need to carry large in-store inventories. The emphasis is on restocking because the Gap's merchandising strategy sticks to basic items in relatively few colors. While comparable retailers achieve turns of three to four times per year, the Gap turns its inventory seven and a half times per year. Rapid restocking, moreover, reduces the cost of implementing the Gap's short model cycle, which is six to eight weeks long" (Porter, 1996: 72-73).*

In the case of Liz Claiborne it is well documented that competitive advantage was high when strict policies were in place such as "no production to order", "no reordering", and only "strict underproduction" to avoid putting merchandise on sale and decrease customer power (Siggelkow, 2001). Liz Claiborne's competitive advantage drastically decreased when these policies were loosened to "partly production to order", for example. That was the consequence of an occurring misfit between the core-element homogeneity and the highly interdependent activity choices. Vanguard, as another example, showed several homogenous core-elements (Low Cost, Direct Distribution, Focus on Conservatively Managed Funds, and Focus on Long-term performance), which were reinforcing. However, the most recent patched core-element “high quality service” was substitutional to the “low cost” theme. Interestingly, Vanguard solved this challenge by integrating these heterogeneous core-elements through shared choices. Accordingly, the decision to assign each employee (independent of rank) several hours a month to phone service improved the quality of the service as it kept employees in practice. It also prevented from increasing the fixed phone personnel while continuing to be flexible to handle short-term peaks in incoming calls (Siggelkow, 2002a).

> *Proposition 1: Activity systems composed of homogenous core-elements, highly interdependent activities, and strictly defined policies are more likely to achieve a competitive advantage.*

Adaptation

While homogeneity and consistency among elements can lead to a competitive advantage, it can come at the cost of adaptability in times of changing environments. With respect to core-elements, the likelihood of adaptation in an activity system increases in relation to the number of core-elements that co-exist in the system. I argued (and illustrated) earlier that core-elements influence the modularity of activity systems. Modularity enables recombination through the mixing and matching of modules and, moreover, allows local adaptation to changes in sub-environments for each module without affecting the rest of the system (Ethiraj & Levinthal, 2004). Recombination of core-elements, in turn, requires activity choices to adapt, be replaced, deleted, and added to put the new core-element into place. On the activity-level, higher heterogeneity of activities increase the number of combinatory alternatives (Galunic & Eisenhardt, 2001; Penrose, 1959). Heterogeneity refers to the content of activity choices but also to the ways that they are interdependent or *potentially* interdependent. Such heterogeneity among activity choices provides the requisite variety in complex systems to respond to and seize opportunities in complex and changing environments (Ashby, 1956; Thietart & Forgues, 1995). In the case study on the radical transformation of “Mission Church”, Plowman and colleagues (2007) describe how an arising heterogeneity of identities, activities, and conflicting views of the organization’s mission led the system towards instability and eventual change. The following statement of the church leader illustrates the ongoing power struggle among core-elements:

> *"Now along that time [in reference to when the breakfast started] there were similar processes going on . . . there was a rapid grotesque attrition of the money . . . there was white flight to the periphery . . . and the struggle to find a vision [....] We had to make a conscious decision of . . . do we go after numbers, which basically meant more in terms of warehousing, or did we want to go after an intentionality of transforming human lives?" (Plowman et al., 2007: 529).*

Once activities occur in different configurations and new linkages among them, they can also alter the current core-elements in place. That is, changes in core-elements as well as changes in activities can trigger change in one another and subsequently the entire system.

> Proposition 2a: *Activity systems composed of many instead of few core-elements are more likely to adapt to changes in the environment and potentially alter the current activity configuration.*

> Proposition 2b: *Activity systems composed of heterogeneous instead of homogenous activity choices are more likely to adapt to changes in the environment and potentially alter the higher-order core-elements.*

The role of policies in the process of adaptation is different from the two other constituting elements of an activity system. The policy's guiding role among interacting activities can inhibit and enable adaptation based on the context of environmental change. Strict policies are sensitive to changes in the environment and therefore can highlight inappropriate interactions among activities early to trigger adaptation among activities and core-elements (Levinthal & March, 1993). Similarly, less strict policies allow for interpretation among interdependent activities which can more easily seize new opportunities in the environment. Policies have the role to increase efficiency and foster inimitability of the activity system by putting into place and emphasizing trade-off choices (Porter, 1996). Policies' relationship with activity system adaptation is tied to revisions in the very same policies. Changes in policies often have an immediate effect on the interplay between activity choices. This effect on the interactions of activities pushes the system away from equilibrium – a state detrimental to firm performance but necessary to allow the system to reconfigure (Anderson, 1999). For example, Liz Claiborne's decision to loosen its "no reordering" policy to "partial reordering" led to severe interaction problems among the tightly designed production activities, inhibiting the fast settling into a new equilibrium state (Siggelkow, 2001). Partial reordering required a different production cycle-time and different paced activities. That is, the interaction within the reordering process was out of sync with the rest of the activity system. A change in production activities would have further conflicted with the current core-element "Fashion apparel for the professional woman" because it relied on a restricted mix-and-match collection. Also, it would have conflicted with the core-element "low cost to the customer" because the cost and price structure of products depend on the purchasing strategy. Moreover, changes in policies alter the search behavior for new activity configurations and core-elements. An alteration of the process and timing of activities' interactions has a direct influence on the feedback and adaptation process itself. Going back to the case of Liz Claiborne, when the company attempted to slightly alter the "no production-to-order" policy, it unveiled misfits and reaction along interlinked activities such as the "long lead times" and the "small supplier network" because the system's cycle-time got out of sync. This led to a step-by-step adaptation of these related activities. This initial piecemeal approach was necessary to highlight the tightly coupled activities and their effects in order to make required changes visible. The result is a cascade of changes in policies throughout the activity system. In turn, changes in activities can refer to new activities arising or existing ones being performed differently. In both cases, change is more incremental as these activities connect to the existing system and often adjust to fit the context of the current system. However, change in activities can require an adaptation of the policies, which again may lead to cascades of adaptation in the system. That is, activities can trigger radical change if catalyzed by the systems policies.

> Proposition 2c: *Changes in policies induce cascades of incremental adjustments, leading adaptation in activities and core-elements to strategic renewal.*

Evolution over time

Orton and Weick (1990: 204) point out “that any location in an organization (top, middle, or bottom) contains interdependent elements that vary in the number and strength of their interdependencies”. Similarly, Fleming and Sorenson (2001) argue that interdependencies in social systems will never be equally distributed and that varying patterns will have different implications. Contextual dependencies, such as resources and policies, are obvious characteristics that differ among even the most similar companies. Interdependency rules grow in organizations over time and are determined by an infinite number of past decisions and experiences. Each path differently influences the evolution of the activity system. Porter (1985: 49) states that "[l]inkages among value activities arise from a number of generic causes". This ‘evolution’ of interdependencies helps to explain why new market entries often have to approach the targeted market with a different business model than the incumbents. This is not only because the incumbents’ business model is difficult to understand but because many interdependencies simply cannot be imitated as they have to develop and establish over time (Ganco & Agarwal, 2009). The historically grown context of activity configurations thus can also influence the value of interdependency, i.e., whether two activities mutually reinforce each other (Cassiman & Veugelers, 2006; Porter & Siggelkow, 2008). The “history matters” logic is inherent in different literature streams. For example, institutional theorists identified various tracks of organizations’ change and development (Hinings & Greenwood, 1988). Each of these tracks leads to different configurations and implications of the activity system. Path dependence research shows that a firm’s choices lead to lock-in effects that further determine future decisions (Sydow et al., 2009). Complexity theory provides strong support through the emphasis on the deterministic character of a system’s initial conditions. It is argued that even small variations in these conditions affect the system’s development enormously in the long-run (e.g., Holland, 2002). For example, Eisenhardt and Schoonhoven (1990) show that a firms’ growth path tremendously depends on their founding conditions.

In a similar vein, Siggelkow (2002a) identified two (ideal) developmental paths that organizations take to develop their core and elaborating activities. One is called ‘from thin-to-thick’, which means that an activity system is founded with a number of not-yet elaborated core elements. Subsequently, these core-elements will be thickened simultaneously. Organizations that follow a ‘from thin-to-thick’ approach have a clear understanding of the content of their core-elements. Such activity system development follows the positioning school (Brandenburger & Stuart, 1996; Porter, 1985) by defining their value proposition and product/service offerings in the beginning and elaborate them over time. Following this approach, organizations are more likely to make developmental (elaborating) decisions integratively. Resource constraints might urge decision makers to invest into new activity choices that will elaborate simultaneously all or many core-elements in the activity system to avoid an unwanted prioritization of single elements. The different core-elements also often reflect interest-groups in the company, which will fight over strategic development decisions and likely end-up with the least common denominator. The new activity choices require clear-cut rules that determine how priorities and resources are distributed among the new and existing activities to ensure proper coordination.

> *Proposition 4: Activity systems that follow a “from thin-to-thick” developmental path are more likely to exhibit an integrated interdependency structure and strict policies.*

The other is called patch-by-patch, which means that an organization creates a core element at a time and focuses entirely on its elaboration (Siggelkow, 2002a). When the organization is done elaborating its latest core-element, a new one is patched and will be elaborated.

Organizations that follow a patch-by-patch approach let strategic core-themes evolve. While one theme is being elaborated the next one might not have been determined yet. Such activity system development follows evolutionary economics (Nelson & Winter, 1982; Winter, 2000) by growing their value proposition and product/service offerings over time and making new core-element decisions based on the current situation in the environment and the status quo. Following this approach, organizations are more likely to make isolated decisions whenever one core-element is fully elaborated and a new one is searched for. Trends in the environment and opinions about products and services might have changed over time since the last core-element was patched and managers might feel the urge to respond to the current context they are exposed to. Further, since the former core-elements are seen to be “finished” there is no need to bring in new activity choices that strengthen previous core-elements. However, managers still have to motivate how these new core-elements and their activities fit the overall system. To allow this loose coupling between relatively independent core-element domains of activities, the system will require flexible interaction rules among them.

> Proposition 5: *Activity systems that follow a "patch-by-patch" developmental path are more likely to exhibit a modular interdependency structure and flexible policies.*

2.6 Future Research Directions

The extant literature has acknowledged and adopted the view of firms and their strategy as complex systems of interdependent activity choices (e.g., Miller, 1981; Siggelkow, 2011; Thompson, 1967; Zott & Amit, 2010). However, prior literature has not provided a clear terminology of the building blocks that make up an activity system, which has limited the comparability and replicability of prior studies and most importantly the use and development of the concept. This article contributes to resolving these shortcomings by providing more theoretical clarity about an activity system's constituting elements and the interplay among them. In particular, I provide the foundation for future research based on three central contributions of this paper.

First, by reviewing and analyzing prior work, I derived three types of elements (core-elements, policies, and activities) that constitute an activity system and help to conceptualize prior and future activity maps in a consistent and comparable way. Core-elements are strategic themes around the value proposition and product/service offerings. Core elements determine the set of activities which are needed to carry out the respective strategic-theme. Moreover, policies define the process and timing of interactions among activities. For future directions, the distinction of these three elements is promising because each element addresses a different level and role of strategy making. Core-elements come about through changes in activity choices or through the deliberate patching of a new theme (Siggelkow, 2002a). Activities come into place as deliberate decisions in order to carry out a given theme. However, activities can also come into place somewhat randomly as heritage over time, thereby determining future core-elements (i.e., strategic themes). In addition, policies are choices to guide activities and solve constraints by setting priorities, such as timing and resource allocation. Because policies influence the resource and information flow among interdependent activities, the overall interdependency design changes and thereby affecting activity configurations and core-elements. Future research should focus empirically on the relationship of the constituting elements for each of the three levels in order to obtain further insights about the cross-level origins of strategy. More specifically, it would be interesting to analyze the effects of varying numbers and content of each type of element on the two other levels of elements, respectively. For example, how does the activity design differ between having three homogenous (heterogeneous) core-elements versus having six of them? Does such a system require more or less strict policies with increasing size? And is an activity system with a larger number of core-elements more likely to sustain a competitive advantage or does it--even under homogenous themes—increase the modularity and make imitation more likely? Similar questions will consequently arise for activity and policy choices.

Second, the distinction between interdependency and interaction provide a foundation to understand sources of competitive advantage and the ability to adapt. The configuration of core-elements, activities, and policies defines the activity system's interdependency design and thereby a potential barrier to imitation but also a potential inhibitor to change. Prior research has ambiguous implications about the role of interdependencies in times of change (Siggelkow, 2011). The distinction between interdependency and interaction provides a fruitful starting point for future theorizing about their interplay and implications on strategic change outcomes. Most studies have assumed that interdependencies are given by nature and therefore apply to all organizations similarly. In addition, studies have primarily investigated the complementarity of activities (Baumann & Siggelkow, 2011; Carmeli & Tishler, 2004; Porter & Siggelkow, 2008) as one important but specific value outcome of interdependency. Complementarity is given if the value of one decision increases in the presence of another decision and vice versa (Milgrom & Roberts, 1990). We need a better understanding of what other value consequences can occur between interdependent activities that extend the complementarity framework. A research agenda for studying interdependency may cover such questions as (1) what are sources and types of interdependency; (2) what are the value consequences of different types of interdependency; and (3) how do different types and their value consequences evolve over time? A starting point to address these questions can be to build on the literature reviewed in this paper and further classify types of interdependency and link them to the different choices in activity systems. For example, I find different types of fit can occur due to the design of core-elements (first-order), activities (second-order), and policies (third-order).

Third, this article argues that the evolution of an activity system is influenced by the developmental path it follows. The path will have a tremendous effect on the interdependence structure and the interactions, whether core-elements are pre-defined and simultaneously strengthened (from thin-to-thick) or created and developed before the next one will be created (patch-by-patch). To deepen our understanding of the evolution of activity systems, further insights into the content of elements may provide a fruitful avenue for future research. Prior literature suggests that elements are patched, deleted, or thickened by introducing new supporting elements (Siggelkow, 2002a). However, it is intuitive to reason that elements can change their content but continue to exist. By thickening a core-element over time, the content of the core-element might become more specialized or broader without undermining the initial content. For example, a universal bank might have as one of its core-elements "high quality private banking services" and decide to expand into asset management operations bringing them together. The core-element would still exist but alter its content to "high quality wealth management services". This example raises the question of when and under which conditions do core-elements come into place and when do they stop existing? Because core-elements represent higher-order themes, they are important building blocks of a firm's strategy. Changes in these building blocks will alter the value creation and the positioning of the activity system. While higher order themes can change "evolutionarily" through new and altered activity choices, they may also be deleted or recombined with other themes. Such re-shuffling of the current configuration enables the creation of a new interdependency design and value proposition.

In addition, the evolutionary change of core-elements in the banking example described above points to another interesting research area: the study of activity systems on a corporate, multi-business level. Existing activity system studies have examined single-business firms, all of which have a "low-cost" strategy in place. Analyzing firms that operate in multi-businesses (MBF) as well as firms that have a differentiator instead of a low-cost strategy in place may offer interesting insights. One may argue that a MBF possesses for each business unit a different activity system. However, this would neglect the entire literature stream on corporate strategy. The question is then, how does an activity system on a corporate level differ from a business unit level? For example, a MBF will certainly be restricted in the degree of homogeneity among core-elements due to differences in businesses. Further, while we have seen that low-cost activity systems often benefit from strict and fast interaction policies, the question arises as to what extent this is true for a differentiator/premium strategy. Similar questions arise for core-elements as well as actual activity choices. This would again point to different levels of strategy, which interact to build the overall activity system.

2.7 Conclusion

In this paper, I reviewed the existing literature on activity systems and interdependencies. I revealed shortcomings in the consistency of constituting elements of an activity system and how these elements relate to the overall interdependency design. Distinguishing between core-elements, activities, and policies offers a more coherent terminology of activity system elements, which are consistent with prior literature. These elements allow the outlining of baseline propositions in regards to their relationships, thereby permitting the examination of their role in the phenomena of strategic management. This includes such topics as competitive advantage, adaptation, and evolution. It is my hope that the proposed research directions will provide further elucidation to the field and allow more scholars to apply a complexity approach on strategy and organizational design.

3. Resolving the Paradox of Interdependency and Strategic Renewal: Integrating Interdependence Structure and Interaction Rules in Activity Systems[7]

Abstract

There are two apparently conflicting perspectives regarding the relationship between interdependency in activity systems and the likelihood of strategic renewal, which is understood as an evolutionary, incremental process of exploring new activity configurations. Some scholars have argued that interdependency increases inertia and thus inhibits deviations from the current state. This inhibition in turn increases the need for punctuated transformation, which often has detrimental effects. Other scholars have argued that rich levels of interdependency are necessary for a system to evolve and develop novel solutions to enable strategic renewal. In this paper, we demonstrate that both strands of research have some validity but that because they focus on different components of interdependency design, they have arrived at divergent conclusions. To resolve this paradox, we distinguish between interdependency structure and interdependency rules and propose a framework in which the interdependency structure sets the context in which interdependency rules determine the exchange of resources and information among interdependent activities. The integration of these two components of interdependency design leads to a "dual understanding" of interdependency as both structure and rule and allows for the opposing perspectives to be reconciled.

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3.1 Introduction

Strategy can be considered the result of activity choices that, as an interdependent system, determine the current and future performance of a firm (Gavetti & Rivkin, 2007; Porter & Siggelkow, 2008; Rivkin, 2000). Changing environments require activity systems to engage in strategic renewal, which is defined as the evolutionary, incremental process of continuously adapting and exploring to invoke change in a firm's activity choices and outputs (Floyd & Lane, 2000; Huff, Huff, & Thomas, 1992). If organizations fail to renew their activity system continuously, they will encounter a need for punctuated transformation, which often has detrimental performance effects (Brown & Eisenhardt, 1997; Romanelli & Tushman, 1994).

While it is acknowledged that interdependency[8] among activity choices plays a key role in an organization's adaptation behavior (Levinthal, 1997; Simon, 1962; Weick, 1976), two conflicting perspectives regarding the consequences of interdependency exist (Siggelkow, 2011): one line of research argues that the inherent momentum of an activity system will reinforce the configuration currently in place (Miller & Friesen, 1980) and increase inertial forces (Hannan & Freeman, 1984; Leonard-Barton, 1992). Reliability and accountability among interdependent activities make it more difficult to alter established patterns (Hannan & Freeman, 1984; Thompson, 1967). This rigidity increases over time, exploration is less likely to occur, and the need for system-wide, rather than piecemeal, change becomes inevitable (Whittington, Pettigrew, Peck, Fenton, & Conyon, 1999).

The other line of research argues that high degrees of interdependency are necessary for activity systems to evolve and continuously adapt to changing conditions (Weick, 1979). Greater interdependency increases a system's internal variety of combinations (Ashby, 1956; Holland, 1975; Martin & Eisenhardt, 2010; Rivkin & Siggelkow, 2003), makes the system more sensitive to changes and error detection (Levinthal & March, 1993; Weick, 1976), and fosters the flow and exchange of information and resources. Interdependency enables constructive conflicts (Ashmos, Duchon, McDaniel, &

[8] In this paper, interdependency refers to any type of recurring resource and information relationship that exists because of natural, policy, or resource dependence (Rousseau & Cooke, 1984). Hence, an activity that is interdependent with another influences its value and behavior (Pfeffer & Salancik, 1978). This definition of interdependency extends beyond the often-studied concept of complementarity (Milgrom & Roberts, 1990), which captures only a specific value-outcome of interdependent activities.

Huonker, 2002) and amplifies cascades of feedback throughout the system, which leads to self-organization (Martin & Eisenhardt, 2010; Plowman et al., 2007).

The challenges that arise from the predictions of these opposing perspectives are relevant not only for theory but also for managerial design choices. For example, a firm's decision to reduce complexity by designing activity modules with little or no interdependency among them might limit rich information exchange and amplification effects. Alternatively, a firm's decision to enhance complexity by designing rich information flow throughout the entire system might weaken established interdependency patterns and destabilize the activity system.

Thus, the purpose of this paper is to resolve this paradox of interdependency and strategic renewal. In particular, we strive to answer the following research question: ***when does interdependency in an activity system enable or inhibit strategic renewal?*** We argue that the key to solving this paradox is to thoroughly understand the two perspectives' underlying assumptions and then integrate them. Put differently, we propose an understanding of interdependency as a *duality* comprised of both structural and rule-related components. As we will demonstrate, a close examination of the first view reveals that its arguments are based on *interdependency structure*, i.e., the spatial distribution of interdependent activities in a given system. Scholars that subscribe to this view assume interdependency in general, and the resulting pattern in particular, to be rather static and given (Levinthal & Warglien, 1999). Consequently, the structural pattern determines the amount of exploration and coordination of an activity system (Rivkin & Siggelkow, 2007). The second view is primarily concerned with *interdependency rules*. These rules denote the behavior through which interdependent activities exchange resources and information. Interdependency rules capture the dynamic nature of interdependent activities and influence the manner in which they "communicate" and exchange information (Holland, 1995). Interdependency rules are therefore a mechanism for self-organization.

Resolving the paradox, however, requires more than merely distinguishing between interdependency structure and interdependency rules. Because both components "work" simultaneously and in interplay with each other, we must also explore their effects in an integrated manner. More concretely, we will demonstrate that the effect of the interdependency structure on strategic renewal is moderated by the underlying interdependency rules, i.e., the behavioral rules that the interdependent activities follow. Our central argument is therefore that different structural patterns require different sets of rules to enable strategic renewal.

To demonstrate these causal relationships, we must acknowledge that the notions of "interdependency structure" and "interdependency rules" are too broad to enable the development of a theoretical framework with clear propositions. We thus build upon prior contributions and conceptualize the interdependencies of an activity system as being composed of three dimensions of interdependency structure and two dimensions of interdependency rules. Structural patterns are conceptualized by the activity system's degree of *modularity* (defined as the extent to which the system is decomposable into identity-retaining sub-systems), *concentration* (defined as the extent to which only a few central activities are interdependent with many peripheral activities), and *openness* (defined as the extent to which a focal activity system exhibits co-evolutionary interdependency with other activity systems beyond its own boundaries). Interdependency rules are characterized by the level of *stringency (*defined as the extent to which activities are subject to pre-specified responses to pre-defined stimuli) and *immediacy* (defined as the speed with which activities exchange information and resources).

In resolving the paradox, we contribute to the research concerning strategic renewal by demonstrating that interdependency can both enable and inhibit continuous strategic renewal depending on its underlying structural pattern and interdependency rules. In doing so, we clarify the conditions under which the opposing perspectives become valid or invalid. This clarification helps advance a long-standing debate in the literature regarding strategic renewal. By providing an integrated, multi-dimensional view of the structure and rule dimensions of interdependency, we identify system-underlying mechanisms to advance our knowledge about the adaptive behavior of activity systems. In particular, we demonstrate that complexity-reducing structural components (i.e., those that are more modular, less concentrated, and less open) combined with less stringent and more immediate interdependency rules increase the likelihood of continuous strategic renewal. In contrast, for complexity-enhancing structural components (i.e., those that are less modular, more concentrated, and more open), more stringent and less immediate interdependency rules increase the likelihood of continuous strategic renewal. With this analysis, we are able to provide theoretical support for design decisions relevant to shaping complex systems.

The remainder of the paper is organized as follows. In the next section, we provide a brief overview of the theoretical underpinnings of the concept of activity systems. Then, we examine prior accounts' theory about the relationship between interdependency and strategic renewal by elaborating on the distinction between interdependency structure and rules and deriving the relevant dimensions. We continue with presenting the theoretical baseline for our framework, where we propose the effect of interdependency structure on strategic renewal. Next, we integrate the effects of interdependency structure and interdependency rules to explain when activity systems are more or less likely to enable strategic renewal. Finally, we discuss several implications and outline directions for future research.

3.2. Interdependency and Activity Systems

Researchers have begun to conceptualize strategy as a system of interdependent choices from which a focal firm can choose (Gavetti & Rivkin, 2007; Rivkin, 2000; Siggelkow, 2011). This concept is based on work by Porter (1996), who explicitly links the production of services and products to the design and execution of interdependent activities. Choices include not only which activities to engage in and how to perform them but also whether to take full control over an activity or rely on another firm's performance instead (Amit & Zott, 2001).

Firms can only make decisions if they have at least partial decision rights over such activities (Aggarwal, Siggelkow, & Singh, 2011; Siggelkow, 2011). Therefore, the decision rights regarding a set of activity choices determine the boundaries of a focal firm's activity system. This restriction also encompasses co-performed activities in which decision rights are shared, for example, in the form of an alliance or joint venture (Aggarwal et al., 2011)[9]. Formally, we define the *boundaries of a focal firm's activity system as all activity choices over which it has at least partial decision rights.*

[9] To illustrate, assume that there are three firms, A, B, and C, all of which have full decision rights over the choice of how to manufacture their products. Furthermore, assume that the following decisions are taken: firm A will conduct manufacturing in-house, firm B will produce its products through a joint venture together with a partner firm, and firm C will outsource its manufacturing to an overseas contractor. Firm A's decision falls within the scope of a focal firm's activity system because the firm holds the full decision rights over the content and process of the manufacturing activities. Firm B's decision to engage in a joint venture decreases its control over the content and process of the manufacturing activity, i.e., the manufacturing outcome becomes co-dependent on the decisions made by another firm. However, manufacturing still constitutes part of firm B's activity system because it retains certain control and influence on the conduct of this activity. Finally, firm C's decision to outsource manufacturing to another firm removes this activity from its activity system scope. Firm C will no longer conduct even parts of this activity but only source it from outside. We argue that firm C has full

Research has focused not only on specific activity choices (such as manufacturing and research and development (R&D)) and their outcomes but also on the role of interdependencies among activities. This focus originates both from the system level, which is inherent to any analysis of activity systems, and from the assumption that the economic value and contribution to performance-related outcomes are a consequence of the interplay among activities (e.g., Rivkin, 2000; Rivkin & Siggelkow, 2003, 2006, 2007; Siggelkow, 2002b; Siggelkow & Levinthal, 2003).

To study and explain activity system dynamics, scholars have borrowed the conceptual framework of performance (or fitness) landscapes from evolutionary biology (Wright, 1931) and applied it in case studies and computer simulations. These landscapes represent multi-dimensional mappings of all possible degrees of the considered activity decisions and their resulting effects on performance (Kauffman, 1993; Levinthal, 1997). In the context of organizational science, landscapes can occur in different shapes (i.e., they can exhibit a small or large number of peaks). Peaks in the landscape represent consistency among a certain set of activity choices, and a change in a single activity leads to a performance decline (Porter & Siggelkow, 2008). As the degree of interdependence among activities increases, the landscape's shape shifts from a single peak (one configuration leads to a global peak) to a more rugged landscape with several peaks, which decreases the overall likelihood of achieving the global peak. Accordingly, studies that have employed the performance landscape framework have demonstrated that interdependencies among activity choices determine the outcome variance in search behaviors and performance-related outcomes (Levinthal, 1997; Porter & Siggelkow, 2008). Furthermore, prior research has implied that interdependencies influence how much exploration is required to strategically renew (Levinthal, 1997; Rivkin & Siggelkow, 2007).

3.3 Interdependency and Strategic Renewal

The interdependency/strategic renewal paradox

Strategic renewal is the continuous and evolutionary process that invokes change in a firm's activity choices and outputs (Floyd & Lane, 2000). The evolutionary nature of strategic renewal implies that activity system-inherent characteristics influence

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decision rights over the choice of whether to outsource, but once the choice is made, it defines whether the actual manufacturing activity is considered within the firm's activity system boundaries.

whether firms engage in strategic renewal because "it grows out of the current situation and is accomplished over time" (Huff et al., 1992: 55). The importance of interdependency as a system-inherent attribute has long been recognized in the strategic renewal literature. It is interesting to note, however, that one line of research identifies interdependency as the primary "culprit" for creating inertia and rigidity, whereas another view emphasizes interdependency's role in enabling continuous strategic renewal.

The punctuated equilibrium model literature suggests that firms undergo abrupt and radical renewal after long periods of incremental changes and strategy reinforcement (Gersick, 1991; Tushman & Romanelli, 1985). The underlying reason for this phenomenon is that over time, organizations reinforce and increase interdependency among activities, which generates momentum (Miller & Friesen, 1980, 1982a) and leads the firm into core competencies. Adaptation to newly emerging peaks in the landscape becomes less likely for more complex activity systems because mutual interdependencies among activities require iterative adjustments and can result in negative feedback in response to deviations from the status quo and co-evolutionary lock-in with partners (Barnett & Freeman, 2001; Burgelman, 2002; Carroll & Teo, 1996; Hannan & Freeman, 1984; Henderson & Clark, 1990; Levinthal, 1997; Whittington et al., 1999). New peaks of activity configurations that change the industry landscapes often emerge slowly and continuously and do not immediately render prior configurations obsolete (Levinthal, 1998). Existing performance peaks often slowly decline as new peaks arise (Siggelkow, 2001). Therefore, firms may further reinforce their existing activity system even when its value is declining in light of more innovative activity configurations. Firms must eventually respond through punctuated radical renewal when external pressure has grown sufficiently to overcome inertia. Such abrupt turnovers bear the risk of maladaptation and further performance decline (Hannan & Freeman, 1984; Romanelli & Tushman, 1994) because they are threat driven and occur under immense time pressure. Well-known examples include the slow deterioration of classical mass production when modern lean manufacturing emerged (Milgrom & Roberts, 1990) and the continuous decline in the circulation of printed newspapers because of free online news (Gilbert, 2005).

However, scholars have argued that firms can escape inertial forces and environmental selection if they allow for early and continuous exploration of alternative configurations (Floyd & Lane, 2000). They argue that interdependencies are necessary to proactively address the required complexity of changing environments (Ashby, 1956). Studies have suggested that some level of "unintended" or "unnecessary" interdependency can increase autonomous behavior and self-organization among activities (Martin & Eisenhardt, 2010; Rivkin & Siggelkow, 2003). Burgelman (1991) argues that organizations require autonomous bottom-up exploration to provide the system with sufficient internal variety to meet the environment's changing selection attributes. Such experimentation is an important mechanism for early apprehension of and response to changes in the environment. Floyd & Lane (2000: 155) write the following: "These experiments with new skills or market opportunities diverge from official strategy and are triggered by shifts in factor or product markets. Autonomous initiatives provide "early warning signals" of the need for change and simultaneously lay the foundation for the organization's response". Similarly, Brown and Eisenhardt (1997: 25) demonstrate that firms in high-velocity environments engage in continuous radical change by using a variety of low-cost experiments to "probe into the future".

Interdependencies can foster constructive conflict that increases intensive exchange of information and knowledge and thus leads to innovative solutions (Ashmos et al., 2002; Plowman et al., 2007). Furthermore, interdependencies can increase information flow and sensitivity to environmental changes, thereby providing incentives for organizations to strategically renew their systems earlier. Similarly, Levinthal and March (1993) argue that systems composed of tight interdependencies are good for early system-wide error detection. Plowman et al. (2007) find that rich levels of interdependency dynamically amplify initially small changes, which can destabilize the system, and thereby enable self-organization and cascade effects that result in continuous strategic renewal.

Distinguishing interdependency structure and rules

Examining the two views of interdependency within activity systems suggests that both are interested in the same phenomenon – explaining strategic renewal. However, they focus on different components of an activity system's interdependency design. The first view is driven by the existence of interdependency among activities and how the resulting "interdependency structure" constrains or potentially allows for exploration and experimentation. As a more static view of interdependency, this literature recommends an activity system with a particular structural pattern, namely, one that limits the system-wide relationships of activities, to achieve strategic renewal. This structural pattern can be "built" by separating related activities into modules (Sanchez & Mahoney, 1996), lowering the influence of more powerful activities (Leonard-Barton, 1992; Pfeffer & Salancik, 1974), and reducing co-evolutionary lock-in with external dependencies (Burgelman, 2002).

The second view is driven by the exchange of information and resources that occurs between interdependent activities and focuses on "interdependency rules". As a more dynamic view, this literature recommends achieving strategic renewal through the use of activity systems that have interdependency rules in place, which allow for the use of relationships among activities to trigger non-linear and system-wide effects. For these effects to occur, interdependency rules must guide the sensitivity of interactions and the timing of feedback according to changes in activity choices (Levinthal & March, 1993; Sastry, 1997; Weick & Quinn, 1999).

Taken together, these two views imply that the interdependency design of an activity system encompasses both structural and rule-based components. These components cannot be "played" against each other; rather, they represent equally important and simultaneously influential components of interdependency designs.

This crucial distinction is supported by prior studies that acknowledge, for example, the difference between the structure of interdependencies and communication patterns (Levinthal & Warglien, 1999), task interdependency and information processing (Puranam, Raveendran, & Knudsen, 2012), and interdependency and the resulting resource flows (McCann & Ferry, 1979). In the realm of institutional research, Greenwood and Hinings (1996) study the interaction of structure and action to explain radical renewal. Furthermore, this distinction is also related to the attention-based view (Ocasio, 1997; Stinchcombe, 1968), in which the amount of management attention depends on the causal relationships among activities. These causal relationships are interdependencies that extend beyond natural dependencies and "are often deliberately organized by officials […] to increase their influence on the actions and attitudes of members" (Stinchcombe, 1968: 236). Attention designs are composed of spatial, temporal, and procedural components (Stinchcombe, 1968). In our research, the spatial component corresponds to the interdependency structure, whereas interdependency rules encompass the temporal and procedural components of attention within activity systems.

Structure. The underlying structure of interdependency defines the context within which activities must be coordinated to explore and strategically renew. As such, it defines a system's predisposition to strategic renewal and inertial forces. Research studying complex adaptive systems in general and organizations in particular has indicated the importance of structural dimensions that capture a system's degree of hierarchy and distribution of power and the boundaries of the firm (Santos & Eisenhardt, 2005; Thompson, 1967; Williamson, 1975).

We argue that these structural characteristics are captured by (1) the degree of ***modularity***, i.e., the decomposability of the entire system into sub-systems (Simon, 1962), (2) the degree of ***concentration***, i.e., the relative influence or centrality of single activity choices (Siggelkow, 2002a), and (3) the degree of ***openness***, i.e., the extent to which the focal firm is interdependent with other organizations' activity systems (Kauffman, 1993; McKelvey, 1999).

Theoretically, these dimensions are independent from one another; i.e., they co-exist and their effects can be studied separately. An activity system can vary in its degree of modularity, whereas the power distribution (concentration) of activities remains static. We argue that in a modular activity system, for example, interdependencies may be imbalanced toward one module that contains a high concentration of interdependencies. In addition, neither the modularity nor concentration is influenced by or influences activity choices to exhibit co-evolutionary interdependencies with external activity systems. This lack of influence is because a highly integrated or highly modular activity system can exhibit few or many interdependencies with external activity systems through, for example, supplier relationships, outsourcing of activities, and activities that influence industry standards.

Rules. The interdependency rules govern how and when interdependent activities exchange information and resources within a given interdependency structure. We distinguish between two dimensions of interdependency rules, which are comparable with the procedural and temporal aspects of attention among activities (Stinchcombe, 1968). First, interactions among activities follow rules that can vary in their stringency of application. The dimension of ***stringency*** denotes the degree to which interdependencies are subject to predefined if-then rules (Choi, Dooley, &

Rungtusanatham, 2001; Dooley & Van de Ven, 1999). Thus, stringency rules define the extent to which resource flow among interdependent activities is contingent on specified conditions, i.e., activities have an automated response to predefined stimuli in interdependent activities (March & Simon, 1958).

Second, activities can vary in their temporal relationships, i.e., the time since the action taken in one activity affects the value and behavior of another activity. The dimension of ***immediacy*** denotes the speed with which activities exchange resources and information (Hickson, Hinings, Lee, Schneck, & Pennings, 1971). Thus, immediacy rules define the internal pace with which activities depend on one another and are subject to feedback loops.

Integrating interdependency structure and rules

Building upon this distinction, we argue that these two design components of interdependency interplay with one another. Hence, these two components cannot be considered separately or in opposition to each other but must be analyzed in a complementary manner. Suggestions for integrating interdependency structure and rules can also be found in prior research. For example, Stinchombe (1968: 236) argues that "the effect of someone else's activity on [one's] actions and attitudes is a function of the probability [they] will pay attention to it" and is determined by not only spatial attributes but also temporal and procedural attributes. Greenwood and Hinnings (1996) integrate the new and old institutionalism to better understand radical strategic change. They theorize that the organizational context, such as the structure in which the firm is embedded, interacts with the organizational actions, such as influencing activities and competing values. In particular, they argue that institutional structures can be a major source of inertia and resistance to change but that this effect varies depending on the "internal organizational dynamics" of firms. Using field data, Brown and Eisenhardt (1997) demonstrate that in the high-velocity computer industry, firms that had semi-structured processes with intensive interaction in place were able to innovate in a continuous manner. Rivkin and Siggelkow (2007) demonstrate that the benefit of a given level of exploratory action depends remarkably on the structural pattern of interdependent activities in place, regardless of the number of interdependencies.

3.4. Interdependency Structure

Modularity

Activity systems can vary in the extent to which they are decomposable into sub-systems of interdependent activities with few interdependencies among them (Sanchez & Mahoney, 1996; Simon, 1962). The dimension of *modularity* denotes the decomposability of an activity system into separate identity-retaining sub-systems of elements (Baldwin & Clark, 2000; Orton & Weick, 1990; Weick, 1976). Possible patterns range from entirely integrated, i.e., every activity is interdependent with all other activities, to entirely modular, i.e., every activity is independent of all other activities. Given a certain number of interdependencies, an integrated, i.e., less modular, structure is viewed as complexity-enhancing because activities reach system wide, whereas a more modular structure is viewed as complexity-reducing because it allows for decomposition into smaller sub-systems.

We argue that all else being equal, integration in the interdependency structure decreases (and modularity increases) the likelihood of strategic renewal. More integrated systems exhibit low or no decomposability into separate identity-retaining sub-systems (Baldwin & Clark, 2000; Sanchez & Mahoney, 1996). Hence, activity choices in integrated systems rely on a coherent logic of the system's structure that only functions as a unified whole (Barki & Pinsonneault, 2005). Therefore, experimentation to allow for spontaneous recombination and deviation from the status quo in one activity choice depends on adaptation and innovation in all others, i.e., system-wide coordination is required. Furthermore, because of this dependence on the rest of the system, adaptation in activities will instead be local and reinforce the existing state of the activity system rather than deviate from it.

In contrast, in more decomposable systems, each module faces its own 'sub-landscape', which is less rugged than the entire system landscape. Changes in the environment can likely be addressed locally by altering and recombining modules. Because each module improves its current configuration without considering the rest of the system, local search is more beneficial than in integrated systems (Ethiraj & Levinthal, 2004; Siggelkow & Levinthal, 2003). Local adaptation within all of the constituting modules then has the potential to explore new system configurations, deviate from the current state, and avoid getting stuck on a low peak (Siggelkow & Levinthal, 2003).

In addition, when modularity is high, modules can mix and match, which entails the decoupling, addition, modification, or removal of sub-systems (Karim, 2006), without necessarily affecting the remaining modules. More design options regarding how activity modules can be combined and ordered result in greater diversity of evolutionary paths (Baldwin & Clark, 2000; Brown & Eisenhardt, 1998; Pil & Cohen, 2006). Galunic & Eisenhardt (2001) demonstrate how a large Fortune 100 multi-business firm continuously explored emerging opportunities in the environment through the recombination and reshuffling of the responsibilities of its business divisions. Each division constituted a source of innovation but also a source of recombination. In their case analysis, they note, *"Modularity within Omni generated diversity among the various divisions. This diversity originated with each division having its own unique product-market domain that demanded different kinds of skills and so encouraged divisions to develop them. […] Thus, as divisions […] pursued their different charters in largely independent fashion and evolved with their markets, they replenished Omni's corporate stock of diversity and generated a changing set of recombinant opportunities" (Galunic & Eisenhardt, 2001: 1243).*

The potential recombination of modules alters the configuration of several activity choices and can thus enable a global search of the performance landscape. Such recombination can even alter the topology of the landscape as it changes the relationships among activities. This altered landscape topology in turn inhibits path dependency and lock-in effects and fosters continuous adaptation.

> ***Proposition 1:*** *Activity systems with a less modular interdependency structure are less likely to enable strategic renewal.*

Concentration

The dimension of *concentration* can be defined as the extent to which only a few central activities in a system are interdependent with many peripheral activities, i.e., there is a high centrality or core-ness of activity choices, which have a stronger influence on current and future activities (Siggelkow, 2002a). Possible patterns range from completely concentrated systems, in which the dependence structure is imbalanced toward one influential activity, to completely diffuse systems, in which every activity exhibits the same number of interdependencies with other activities.

Given a certain number of interdependencies, a concentrated structure is viewed as complexity-enhancing because core activities exhibit a system-wide role as “interdependency hubs”, whereas a diffuse structure is viewed as complexity-reducing because it restricts the relative influence of each activity choice to a few others.

We argue that all else being equal, concentration decreases the likelihood of strategic renewal. The asymmetric distribution of interdependencies in concentrated activity systems provides the few central activities with more power over the behavior of the remaining activities.[10] These powerful activities reward other activities if they reinforce the current strategy but regulate them if they deviate from the current strategy. A higher-power activity choice is likely to resist any attempt by lower-power activities to absorb constraints that underlie their dependence, which would cause the activity system to undergo strategic renewal (Casciaro & Piskorski, 2005). Similarly, potential self-organization of activity choices, which can guide the activity system toward new configurations, is constrained in a concentrated system. Self-organization is constrained because rather than exploring alternative configurations, central activities incentivize a predictive evolutionary path that favors the elaboration of the system’s current “distinctive competence” (Levinthal & March, 1993).

Concentration in activity systems reduces the number of fitness peaks because of the central role and influence of a few dominating elements (Rivkin & Siggelkow, 2007). In the absence of changes in the landscape itself by, for example, introducing new activity choices or altering the influence distribution among activities, local adaptation and reinforcement of the existing competences are the most desirable and rewarding behaviors. This concentration leads to a greater likelihood of an induced, reinforcing development of strategy, which is exemplified by the case of Intel (Burgelman, 1983a). From 1987 to 1998, Intel developed a “narrow business strategy” – entirely focused on the production of microprocessors – that constrained the evolution of new business ideas: *“Resource allocation favored the core business, and new businesses were constantly in danger of experiencing random shocks when critical resources were taken away to cope with a perceived threat to the core business” (Burgelman, 2002: 351)*

[10] If many activities are interdependent with one common activity, then they cannot change easily without indirectly affecting many other parts of the system. In this respect, the concentrated activity constrains, i.e., it exhibits power over the development of other activities.

In contrast, a more diffuse interdependency structure limits the influence of single activities on the development of current and future choices. Such systems can trigger conflict over resources and alternative responses to environmental changes. Conflicts are likely to amplify deviations from the current path and stimulate exploration because they push the system toward instability and self-organization to resolve the tensions (Anderson, 1999; Plowman et al., 2007). Whereas concentrated systems maintain stability by following a common attractor (the central choices), more diffuse systems are more in flux because there are several attractive choices, i.e., the alignment forces between activities are weaker, which enables activities to explore and experiment more autonomously (Burgelman, 2002).

> ***Proposition 2:*** *Activity systems with a more concentrated interdependency structure are less likely to enable strategic renewal.*

Openness

A focal firm's activity system can encompass activity choices that are interdependent with activities outside of a system's boundaries. Hence, the dimension of *openness* captures the extent to which a focal activity system exhibits co-evolutionary interdependencies with external organizations' activity systems beyond its own boundaries. Co-evolution requires that the influence between two interdependent activities is mutual, i.e., choices taken in one activity system change the performance landscape of the other and vice versa (Kauffman, 1993: 244)[11]. These co-evolutionary interdependencies fall outside a focal firm's activity system because there are no shared decision rights over each other's choices. For example, a firm that decides to outsource its manufacturing activities to another firm exhibits co-evolutionary interdependencies with this supplying firm in terms of product design characteristics. The focal firm's decision to change its product design software or use a different mix of materials might influence the required activity configuration of the supplier. In turn, the supplier firm's decision to change its batch sizes or production-to-order time will affect the sales and distribution activities on the focal firm's side. However, it is the

[11] We delineate co-evolutionary interdependency from a focal firm's environment in line with Siggelkow's (2001: 840) argument that "[e]nvironmental conditions encompass all factors that affect the relative profitability of a firm's set of choices, including competitors' actions, customer preferences, and available technologies". These factors, however, exhibit normally no mutual interdependency with a focal firm and are therefore "given".

focal firm's deliberate activity choice whether such co-evolutionary interdependencies occur. In our example, the focal firm chose to outsource manufacturing and therefore engaged in mutual interdependency between the two activity systems. Shared decision rights in the form of alliances constitute another example of creating co-evolutionary interdependencies among multiple activity systems. The activities with shared decision rights might act as links among activity system landscapes.

Possible patterns of openness range from entirely closed systems, which have no co-evolutionary interdependencies with external activities, to entirely open systems, in which every activity is co-evolutionarily interdependent on the behavior of other firms' activity systems. Given a certain number of interdependencies, an open structure is viewed as complexity-enhancing because the focal firm's choices are indirectly subject to multiple outside decisions taken by interdependent firms, whereas a closed structure is viewed as complexity-reducing because it limits the influence on activity choices to the focal firm.

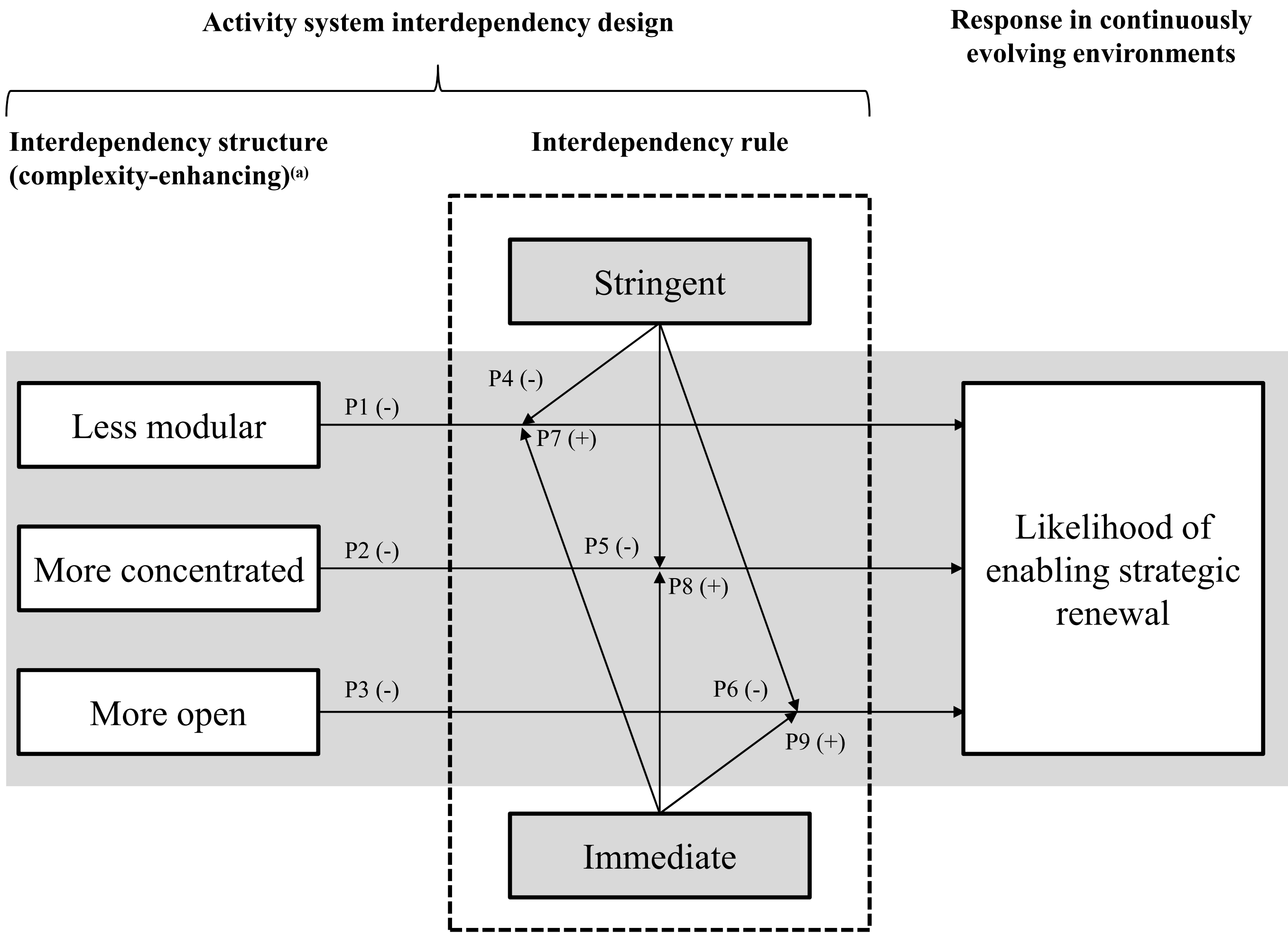
We argue that all else being equal, openness in the interdependency structure decreases and a more closed structure increases the likelihood of strategic renewal. Interdependencies with externally co-performed activities increase the dynamics of a focal activity system because of coupled landscapes (Kauffman, 1993). In coupled landscapes, a decision that is made with respect to one landscape affects the topography of interdependent landscapes of other firms and vice versa (Kauffman, 1993; McKelvey, 1999). Hence, co-evolving activity systems adapt both to their own configurative choices and to the decisions that are made by other systems. With an increase in interdependencies with external activities, an activity system and its network are more likely to share a common developmental fate and identity (Kim, Oh, & Swaminathan, 2006) and constrain internal activity choices (Noda & Bower, 1996; Pfeffer & Salancik, 1978). Therefore, recurring investments in the interdependencies among coupled systems become more rewarding and lead to co-evolutionary lock-in, i.e., increasing inertial forces (Burgelman, 2002). Following a similar line of argument, high degrees of external linkage indicate high co-evolutionary complexity in contrast to relatively lower internal complexity. Previous scholars have argued that the mismatch of low internal complexity and high external complexity leads to inferior performance (Ashby, 1956; Burgelman, 1991; McKelvey, 1999).

Applying a chaos theory perspective, Thietart and Forgues (1995: 26) argue that "[p]articularly in the case of dissipative systems which exchange energy with their environment (as it is the case of organizations), islands of stability are likely to emerge in a sea of chaos. These islands are the strange attractors. It is admitted that the greater the dissipation is, i.e., the greater the exchange of energy and resources with the environment, the faster the system tends towards its attractor". The activity system under consideration is incentivized to adapt to and reinforce the existing network structure rather than to explore new opportunities or respond to potential changes in the environment. In open systems, attempts to break loose or deviate in a different direction lead to "knock-on effects", which consist of negative feedback from external interconnections (Stacey, 2003). For example, between 1987 and 1997, Intel had strong ties with the personal computer (PC) market segment and software companies, such as Microsoft. These interdependencies required "increasingly large capital and R&D investments that needed to be made to keep [...] the coevolutionary process [driving]" and subsequently inhibited strategic deviation from Intel's narrow microprocessor business focus at that time (Burgelman, 2002: 342): *"[...] Intel's dependence on the OEM customers as a distribution channel for its microprocessor products made forward integration into systems products difficult. Intel's strong interdependence with Microsoft impeded strategic initiatives in the software area. In one widely noted case – Intel's Native Signal Processing (NSP) initiative to augment the microprocessor's video capability [...] – Grove admitted that Intel 'caved' in the face of Microsoft's displeasure (Schlender, 1996)".*

In contrast, in more closed systems, firms' fitness landscapes are more stable because other firms' choices do not immediately alter the topography and dynamics among activity choices. A focal firm exhibits fewer liabilities to external partners and can explore new activity domains without jeopardizing existing relations and the need to coordinate with other firms' set of choices.

> ***Proposition 3:*** *Activity systems with more open interdependencies are less likely to enable strategic renewal.*

Figure 10: The role of interdependency structure and rules in enabling strategic renewal



[a] Propositions P1 to P9 switch signs for complexity-reducing structures (i.e., more modular, less concentrated, and less open).

3.5. The Influence of Interdependency Rules

Stringency

Interactions between activities follow rules that can vary in their stringency of application. The dimension of *stringency* denotes the degree to which interdependent activities are subject to pre-specified if-then rules (Choi et al., 2001; Dooley & Van de Ven, 1999). March, Schultz, and Zhou (2000: 8-9) state that "[r]ules routinize organizational activities and define authority relations, connections among subunits, and decision-making structures". Thus, if-then rules define the extent to which interactions among interdependent activities are formalized, i.e., are likely to follow an automated response to a predefined stimuli (March & Simon, 1958). An example of a less stringent rule is "contact product development when a customer asks for a customized product", whereas an example of a more stringent rule is "submit digital form C, including product category, type of customization, and exact budget available, when a customer asks for a customized product".

The lower end of the interaction stringency continuum is comprised of entirely flexible interactions, i.e., interdependent activities are subject to unspecified conditions and consequences that enable interpretation and a higher likelihood of interaction variance. The higher end of the continuum entails entirely stringent interactions, i.e., interdependent activities are subject to completely specified conditions and consequences that dampen the need for interpretation and the likelihood of interaction variance.

Stringency refers to a high level of specification and codification in rules and therefore leaves little room for interpretation. As "codings of history", rules are "carriers of knowledge [which] gives [them] some claim to wisdom since they may summarize a broader range of considerations than any current actor can recognize and evaluate" (March et al., 2000: 16). Such historically accumulated knowledge increases the general legitimacy of these rules within the firm. Legitimacy of rules increases the likelihood that activities are carried out according to these rules because they are taken for granted (DiMaggio & Powell, 1983)[12]. Furthermore, stringent rules that govern the

[12] This argument is also consistent with the idea of credit assignment for competing rules in complex adaptive systems. Holland (2002: 33) argues that rules compete against each other and that only those rules that lead to a desirable outcome are rewarded and thereby become stronger than competing rules. Consequently, as rewarded "rules become stronger they are more likely to win the bidding process [against alternative rules], so their messages are more likely to influence system behavior […] and will come to control the system".

exchange of information and resources make a system more transparent for failure detection (Bigley & Roberts, 2001; Levinthal & March, 1993). In contrast, lower stringency in interactions refers to less specified rules, which allow for more variance in interpretation when enacting them. We believe that this distinction is consistent with Rerup and Feldman's (2011) "ostensive" and "performative" patterns. These authors argue that actors make sense of ostensive patterns, which influence their enactment, which in turn reshapes the ostensive patterns. We refer to an ostensive pattern that does not leave much room for sense-making because of its highly prescriptive character as a stringent interdependency rule. While an ostensive pattern that leads to more individual sense-making behavior is here referred to as a more flexible interdependency rule.

Hence, interdependency stringency can influence the adaptation behavior of interdependent activities in two different ways. First, stringency self-reinforces the current activity system configuration because the conditions and actions are well defined, reduces variety in interactions, and thus decreases the likelihood of reconfiguring the system in a manner that would conflict with its current routines (Leonard-Barton, 1992). In contrast, if a highly specified set of conditions is no longer appropriate for its consequences or vice versa, then a stringent rule will perturb the system's routines, escalate conflict, and require that interaction rules be displaced (Holland, 1995), thereby triggering a cascade of rule changes to overhaul the existing patterns of interaction (Feldman, 2000). Flexibility allows for alternative interpretation and action and thus self-organization. However, because of the increase of activities involved, flexibility can result in many time-consuming trial-and-error attempts, which hampers continuous renewal (Davis, Eisenhardt, & Bingham, 2009). Furthermore, flexible exchange of resources and information in response to changing conditions may motivate the firm to postpone exploration of new configurations. This postponement is possible because of interpretive buffers in the interactions that "fix the problem" locally by circumventing the actual renewal, which will eventually increase the pressure to undergo radical strategic renewal.

Modularity and stringency. We argue that stringency in interdependency rules increases the likelihood of strategic renewal for less modular (integrated) activity systems and decreases the likelihood for more modular activity systems. Integrated systems subject to stringent rules become more sensitive to environmental changes that affect pre-defined relations among activities (Weick, 1976). Changes in a few activities can already trigger cascade effects for the entire system because a change in the interaction between two activities also affects all other interactions. Such cascade effects propagate system-wide adaptation as an emergent and self-organizing process that is not coordinated by the firm but rather by the activities' interaction. For example, Toyota implemented automated response rules for manufacturing equipment and its workers at the assembly line to stop operations when deviation from the intended output occurs (Adler et al., 2009). In combination with the integrated interdependency structure of Toyota's manufacturing system, this stringent rule increases the likelihood of renewal because it allows for problems to be identified locally, continuously, and early at any point in the system (Axelrod & Cohen, 1999).

In contrast, for a more modular interdependency structure, stringency can inhibit strategic renewal. When modules adapt simultaneously, the coordination and eventual coherence of a system can suffer (Ethiraj et al., 2008; Kauffman, 1995), which eventually requires radical change of the entire system. The restricted number of within-module activities in modular systems ensures that more flexible interactions are paid the attention they require for experimenting and limiting the number of trial-and-error iterations (Davis et al., 2009).

More flexible rules allow for alternative interpretations and, more broadly, the inclusion and interpretation of less well-defined stimuli from the rest of the system. This more flexible adaptation constitutes a mechanism for module self-organization that can lead to mixing and matching of modules to recombine and avoid incoherence. Mixing and matching of modules require interpretive buffers to allow for the recombination of sets of interdependent activities. The merging of modules changes the if-then conditions for interactions among activities. Stringent rules define specific conditions that must apply to enable interaction among activities, i.e., stringent rules within an activity system denote activity-specific conditions and consequences that do not apply to recombined modules. For example, Martin and Eisenhardt (2010) demonstrate how modular structured multi-business firms evolve more successfully by incentivizing modules to collaborate through flexible business unit-centric rules that allow for interpreting interactions with one another in a less pre-defined manner.

Proposition 4: *Activity systems with a less (more) modular interdependency structure are more likely to enable strategic renewal in the presence of more (less) stringent interdependency rules.*

Concentration and stringency. We argue that stringency in interdependency rules increases the likelihood of strategic renewal for concentrated activity systems and decreases the likelihood for diffuse activity systems. Although concentrated activity systems reward local adaptation and conformity, stringent interaction rules can perturb this homogeneity, trigger conflict among interdependent activities, and eventually change the landscape topography. Central activities act as integrating elements that harmonize and influence the rest of the system. A deviation in the input-output relations of the central and peripheral activities will lead to continued normal operation only if flexible interaction rules alter the interaction such that conformity between the core and peripheral activities is maintained, thus circumventing the actual source of the deviation. Concentrated systems with stringent interaction rules are more likely to enable continuous strategic renewal because of early failure detection in changing conditions (Levinthal & March, 1993). When if-then conditions no longer apply, the actual source (i.e., the stimulus or outcome that is no longer applicable) is identified as a misfit, which leads to a conflict within the current core paradigm. The altering conditions are unambiguous in the sense that there is no doubt regarding the source of "failure". Consequently, the system alternates, eliminates, or decouples these activities to prevent the system from being halted. These actions can lead to a new set of activity choices and allow new competencies or a new position to emerge. Less stringent rules bear the risk that the concentrated system will be reinforced despite changing conditions as a result of interpretative buffers that circumvent the actual source of the deviation in the input-output relation. This situation is illustrated in the case of Polaroid's response to the changing landscape caused by the transition from analog to digital photography (Tripsas & Gavetti, 2000). One of Polaroid's most dominant choices that influenced many other activities was to build its business model on a razor/razor blade revenue model, which means that most of the revenues and profits were supposed to come from selling film and immediate prints. Tripsas and Gavetti (2000) demonstrate that Polaroid experienced very little strategic renewal even though it invested in new activities and knowledge. The problem occurred because the new activities were broadly interpreted as being in alignment with the core choice to generate revenue from instantaneous photos and films instead of hardware. We argue that the rules put in place by Polaroid allowed for innovation and new choices but allowed for too broad of an interpretation to make the new evolving knowledge and technology fit its current context of printed photos: *"The 1985 Letter to Shareholders states, 'As electronic imaging becomes more prevalent, there remains a basic human need for a permanent visual record.' Similarly, an employee who joined the firm's electronic imaging area in 1990 commented, 'another truth [I encountered] was that people really value an instant print. This was also an ontological truth.'" (Tripsas & Gavetti, 2000: 1154).*

In contrast, in more diffuse activity systems, more equally influential activity choices are needed to find consensus and resolve conflict over resources and priorities. Stringent rules would regulate the consensus finding and artificially create priorities, thereby undermining self-organization among activities. Flexible rules allow for self-organization because a high degree of interpretation can resolve conflicts by providing a variety of interactions with similar outcomes (Pentland, 2003) that address the variety of activities.

> ***Proposition 5:*** *Activity systems with a more (less) concentrated interdependency structure are more likely to enable strategic renewal in the presence of more (less) stringent interdependency rules.*

Openness and stringency. We argue that stringency in interdependency rules increases the likelihood of strategic renewal for open activity systems and decreases the likelihood for more closed activity systems. In open activity systems, the current landscape topology is co-dependent on other firms' activity systems and vice versa. Co-evolution benefits from flexible interactions among dependent activity systems because each firm's behavior has an effect on the other firms involved. Because flexible interactions encourage interpretation to find a common path and identity between activity choices taken on both landscape sides, open activity systems are more likely to experience lock-in between firms as they adapt to changes in each other's activity system instead of to changes in the environment. Hence, flexible interactions with many external activity systems will either accommodate all partners' changes and result in lock-in or be disrupted constantly without being able to ever reach a stable configuration. For example, Gulati, Sytch, and Mehrotra (2008) demonstrate that if there are unclear and unspecified deliverables among alliance partners, they may continue allying even though an exit would be more appropriate.

Specifying more stringent rules increases the chance of highlighting conflicts among partner firms and revising the current shared activity choices or even terminating existing relations. When interdependencies among coupled landscapes are more pre-defined and automated in their if-then relations, knock-on effects are more likely to disrupt the existing configuration of both activity systems because a stable condition is less likely to be reached if the pre-defined response is not applicable. Consequently, stringency in interactions among co-dependent activity systems highlights and constantly tests the appropriateness of the existing relationship and thereby mitigates potential lock-in effects. Firms with large alliance portfolios, such as pharmaceutical or chemical firms, constitute a good example. The literature suggests that firms with a large number of alliances and partnerships as part of their activity system benefit in their evolution from developing alliance routines, institutionalized mechanisms of coordination, and constant re-evaluation of the value and fit of partnerships in the entire portfolio and firm configuration (e.g., Dyer & Hatch, 2004; Heimeriks, Klijn, & Reuer, 2009; Kale, Dyer, & Singh, 2002; Wassmer, 2010).

In contrast, flexibility in interdependency rules can be beneficial for more closed activity systems. Few external links, which allow for a more flexible interpretation of their relationship to the rest of the focal activity system, can constitute a source of experimentation to import novel energy. Facing only few interdependencies with other activity systems, less automated responses to pre-defined stimuli allow for the mutual discovery of new areas of the landscape. These few sources of reconfiguration impulses keep the co-dependent landscapes "dancing" (Kauffman, 1993; McKelvey, 1999) and constantly challenge each activity system's configuration.

> ***Proposition 6:*** *Activity systems with a more (less) open interdependency structure are more likely to enable strategic renewal in the presence of more (less) stringent interdependency rules.*

Immediacy

Activities can vary in their temporal relationships, i.e., the time between the cause and effect among activity behaviors. The dimension of *immediacy* denotes the speed with which activities exchange resources and information (Hickson et al., 1971). That is, this dimension refers to the time period after which the behavior or value change of one activity has an effect on the behavior or value of other interdependent activities (Casadesus-Masanell & Ricart, 2010; Pfeffer & Salancik, 1978). If x denotes the time between the triggering event, t, and the actual interaction, then the outcome is measurable at time t+x. The continuum ranges from highly lagged interactions, in which the effect of the behavior of one activity on the value and behavior of other interdependent activities occurs after a long time period (x is high), to immediate interactions, in which a change in the value of one activity instantaneously affects the behavior and value of other activities (x equals zero). An example of a delayed interaction is the interdependency among traditional marketing and sales activities in business-to-business markets. When a firm advertises a new product, it often takes a relatively long time before the sales team encounters increasing demand. Reasons for the lag include, for example, that potential customers will not make a purchase decision right away but rather evaluate and compare the new product with existing alternatives first. Hence, the interaction between marketing and sales can exhibit a time lag.

The interdependency immediacy can be influenced by the technology used to coordinate and communicate among activities. Electronic interactions based on Internet protocols, for example, may lead to smaller time lags between activities than personal interactions. Interdependency immediacy further reflects the internal pace or 'rhythm' of an activity system, i.e., "a dominant temporal ordering" (Ancona & Chong, 1996: 253). Pacers of organizations' internal rhythm and tempo are important for understanding feedback patterns in activity systems' interdependencies. For example, Cyert and March (1963: 218) state that "feedback can take many different kinds of forms, but some of the most important come from routine monthly financial, production, and sales statements". In addition to the fiscal year, there are many other conceivable pacers that determine the interdependency immediacy of an activity system, such as customer demand habits, investors' schedules, competitors' speed, market dynamism, product complexity, and budgeting cycles (Ancona & Chong, 1996).

The interaction immediacy can influence the adaptation behavior of interdependent activities in two different manners. First, immediate interactions have a strong influence on the current activity system configurations (Hickson et al., 1971). Immediacy can inhibit deviations from the current strategy and force a system to be aligned with (to reinforce) the current strategy. This alignment entails the system engaging in "fast learning" and the homogenization of beliefs, values, and practices (Ancona & Chong, 1996; March, 1991). These conditions cause activity systems to engage only in adaptive moves that lead to an instant increase in performance because changes in the behaviors and values of activities are immediately available and measurable. Such search behavior rules out the delayed performance effects that often underlie exploratory searches. In contrast, immediate interactions may increase the responsiveness to changing conditions that require early coordination and alignment to enable strategic renewal. Immediate resource and information flow can foster learning and detect resource conflicts, thereby providing instant feedback and identifying the required action. Fast learning can enable strategic renewal when local adaptation to fewer peaks in the landscape can cause an overall reconfiguration of the activity systems.

Modularity and immediacy. We argue that immediacy in interdependency rules decreases the likelihood of strategic renewal for less modular (integrated) activity systems and increases the likelihood for more modular activity systems. Immediate interactions within an integrated system foster stability and self-reinforcement of the current state because actions in one activity affect and are subject to instantaneous feedback from all remaining activities in the system. Strategy-enhancing actions encounter reinforcement, whereas deviations encounter immediate re-alignment. Fast learning among activities further incentivizes local adaptation for single activities and eventually the entire network of activities. Adaptive moves are made only if there is a predictable and immediate pay-off, which limits experimentation and exploration. In contrast, low levels of immediacy can create an artificial separation of parts of the activity system because there is a longer time span before activities' actions are subject to system-wide evaluation (Lazer & Friedman, 2007). Without immediate responses, activities can deviate from current behaviors and generate momentum, which will amplify misfit with the rest of the system after “re-integration” and thus destabilize the system, thereby triggering continuous renewal that leads to new activity system configurations. For example, Plowman and colleagues illustrate using their case of “Mission Church” how a system of integrated activities emerged from a “‘silk-stockings’ church attended by the wealthiest in the city“ and resulted in a church that offers free breakfasts, medical assistance, and other services to homeless people. Small initial changes developed into a cascade throughout the system because of rich interactions and achieved momentum, which amplified throughout the system because these small changes were not immediately regulated. Approximately a year passed before the initial deviations of some of the developments had an effect on the church’s official budget. At this time, the development had gained some momentum, and its inclusion in the budget amplified further changes in services, such as more commitment to the free meal services and an expansion of the medical services provided (Plowman et al., 2007: 530).

In modular activity systems, each module faces a less rugged landscape than that of the overall system (because of separated problem spaces). Local search and simultaneous adaptation across modules become rewarding (Siggelkow & Levinthal, 2003). A high level of interaction immediacy allows for rapid learning (i.e., local adaptation) because information regarding activity behavior and outcomes is transmitted instantaneously. Activity modules discover their sub-landscapes and increase their respective fitness. The simultaneous adaptation of individual modules can lead to a lack of coordination among modules and eventually to incoherence. Modules interacting immediately, however, can allow for early detection of this incoherence and stimulate recombination (mixing and matching) of these modules to “consolidate” their overall lack of fit. This argument is consistent with the research of Brown and Eisenhardt (1997), who find that constantly renewing companies use limited structure and complement it with extensive communication, which leads to cross-collaboration and idea sharing. In our terminology, modularity presents limited structure, whereas immediate interaction refers to the intensive exchange of information, which can trigger the recombination of modules.

Proposition 7: *Activity systems with a less (more) modular interdependency structure are more likely to enable strategic renewal in the presence of less (more) immediate interdependency rules.*

Concentration and immediacy. We argue that immediacy in interdependency rules decreases the likelihood of strategic renewal for concentrated activity systems and increases the likelihood for diffuse activity systems. In concentrated activity systems, the power of central activities forces less central activities to conform and thus enables only reinforcement and local adaptation. Immediate interactions strengthen this link because information about any change or deviation in activities is instantaneously detected and leads to negative feedback. However, under time-lagged interaction rules, less central activities can self-organize autonomously, gain momentum, and emerge "under the radar" in a more powerful position in the system. Peripheral activities exhibit fewer interdependencies than the core activities and thus allow for autonomous development (Burgelman, 1983b), which may enable the peripheral activities to gain sufficient momentum to challenge the current core choices. Altering the power structure (or at least departing from the realm of influence of the initially central activities) can change the topography of the landscape and thus allow for the exploration of new configurations and render local search less rewarding under these new conditions. Therefore, lagged interdependency in concentrated systems fosters the elaboration and evolution of initially less powerful activities as a source of strategic renewal.

In contrast, in diffuse activity systems, immediate interactions enable quick information flow, which fosters mutual adaptation among multiple, less central activity choices. Furthermore, fast information exchange can amplify existing conflicts and urge the exploration of alternatives. Low immediacy can delay the occurrence of tensions between equally powerful elements and consequently hinder self-coordination for the system as a whole.

Proposition 8: *Activity systems with a more (less) concentrated interdependency structure are more likely to enable strategic renewal in the presence of less (more) immediate interdependency rules.*

Openness and immediacy. We argue that immediacy in interdependency rules decreases the likelihood of strategic renewal for open activity systems and increases the likelihood for more closed activity systems. Immediate interactions increase learning among internal and external activities because of the intense resource and information flows that develop and distribute a common identity at the expense of potential exploration (March, 1991). Mutual and immediate adaptation among coupled landscapes results in local adaptation behavior, i.e., the lock-in effect between internal and external configurations is more likely to occur. In turn, local adaption is more likely to find equilibrium (lock-in) among interconnected landscape configurations (Kauffman, 1993). The lock-in effect is even stronger because immediate interactions gradually increase the reliance of the focal system on suppliers' resources because of a strong dependence on the timely resource flow (Pfeffer & Salancik, 1978). This increasing dependence makes "knock-on effects" more severe because alterations in one system in a network immediately receive negative feedback from one or many of the remaining systems.

In contrast, systems with low openness benefit from the fast exchange of information with external activities as a source of energy import. This immediate interaction with few external activity systems ensures that the landscape is continuously subject to moderate alteration. Consequently, firms alter their activity system configuration in response to changes in co-dependent systems rather than changes in the larger environment. This dynamic can constitute an important source of early exploration and proactive adaption (Gilbert, 2005).

> ***Proposition 9:*** *Activity systems with a more (less) open interdependency structure are more likely to enable strategic renewal in the presence of less (more) immediate interdependency rules.*

3.6. Discussion

The purpose of this paper has been to resolve the paradox of interdependency and strategic renewal. To do so, we have conceptually explored the assumptions underlying the concept of interdependency to determine when interdependency enables and inhibits strategic renewal. As a result of our endeavor to reconcile the paradox, we have arrived at a theoretical framework, depicted in Figure 10, that provides several important insights that are relevant to the management literature. First, we augment the research on strategic renewal by proposing a “dual understanding” of interdependency as both structure and rule. We argue that the fundamental differences in the opposing accounts result from their divergent conceptualization of interdependency. Whereas one view focuses on arguments related to interdependency structure, the other view emphasizes interdependency rules. Because both lines of argument are valid and legitimate, we argue for an approach that understands interdependency as a duality comprised of both a stable structure (e.g., Hannan & Freeman, 1984) and a dynamic process guided by rules (e.g., Plowman et al., 2007). The two perspectives on interdependency are complementary and not contrary to each other. Therefore, we reconcile the paradox because we demonstrate that both literature views are accurate in their predictions when the integrated effects of the other view are considered. The structure and rules do not act in isolation but rather jointly determine the likelihood of strategic renewal. Whereas the interdependency structure determines the predisposition to the likelihood of strategic renewal (propositions 1-3), interdependency rules determine whether and how activity systems can utilize a structural design (propositions 4-9).

Second, another implication from resolving the paradox allows extending the research regarding activity systems with an emphasis on the role of interdependencies (Porter & Siggelkow, 2008; Rivkin & Siggelkow, 2007). Whereas most studies have exclusively focused on one or a few dimensions, we offer a fine-grained but comprehensive analysis of interdependency design as an integrated set of multiple co-existing dimensions. Our multi-dimensional conceptualization of interdependency design helps to uncover the underlying processes that enable strategic renewal, such as system-wide cascade effects, constructive conflict, and self-organization (Plowman et al., 2007; Thietart & Forgues, 1995). Accordingly, we have identified modularity, concentration, and openness as the crucial dimensions of interdependency structure and stringency and immediacy as the determining dimensions of interdependency rules. Integrating these dimensions, we show in Figure 10 that a complexity-enhancing design, such as a less modular, more concentrated, and more open interdependency structure, benefits mostly from stringent and time-lagged interdependency rules; in contrast, a complexity-reducing design, such as a more modular, less concentrated, and less open interdependency structure, is more likely to enable strategic renewal in conjunction with flexible and immediate rules. This approach allows us to advance the notions of "internal fit" and "adaptation" because we are able to specify the internal conditions under which designs of activity systems are likely to foster or inhibit adaptation processes. Our approach therefore provides conceptual orientation for activity systems as they move and evolve on their fitness landscapes.

Third, we extend research concerning "loose coupling" as an enabler of strategic renewal (Weick, 1976) by identifying rule-related "trade-offs" as an important characteristic of interdependency designs. Prior literature has argued that loosely coupled systems exhibit greater self-determination (low stringency) and are delayed rather than immediate (low immediacy) in their responses to one another (Weick & Quinn, 1999). Our framework, however, suggests that there is a reversed trade-off between stringency and immediacy for complexity-enhancing and complexity-reducing designs. If activity systems are complexity-enhancing, then the combination of stringent but low-immediacy rules is beneficial for strategic renewal, whereas the opposite is true for complexity-reducing patterns. Thus, stringency and immediacy relate to each other as trade-offs, with the consequence that activity designs must balance the two. The contradictory effect of the two sets of rules can act as a source for reversing momentum and triggering exploration instead (Miller & Friesen, 1980; Wiebe, Suddaby, & Foster, 2012). Such trade-offs are well-established in organizational research, such as in studies of exploratory/exploitative learning and ambidexterity (Holland, 1975; March, 1991) or trust/control. For example, March (1991) demonstrates that greater knowledge is attained in organizations that exhibit either rapid learning in an environment of lower belief and value socialization or vice versa. Furthermore, Lechner and Kreutzer (2010) demonstrate that stringent rules in the form of process control are detrimental to the performance of strategic initiatives when these rules are embedded in frequent and well-developed informal interactions and vice versa.

Fourth, our paper augments the research concerning complexity theories of organizations (Davis et al., 2009; Martin & Eisenhardt, 2010; Porter & Siggelkow, 2008; Rivkin, 2000). We rejuvenate and extend this research by incorporating temporal aspects as not only a system outcome but also a design parameter of the system itself. Complexity theories often imply that time is exogenously given as

processes unfold over time (Anderson, 1999). We stress, however, that the internal pace of an organization's business activities is able to substantially change its evolutionary path and should be considered as a design parameter of its own right. The internal pace or cycle-time of a system is often determined by pace givers, such as fiscal years, which are the same for most firms and therefore exogenous; however, there are many temporal choices that determine the interactions among activities within a focal firm (Ancona & Chong, 1996). For example, firms differ in their policies for internal board meetings, product development processes, time-to-market schedules, and supplier/buyer delivery agreements. This internal pace is the result of choices that influence the temporal attribute of interactions, which we have conceptualized as interdependency immediacy. We suggest that including the temporal dimension in the analysis of complex systems adds to the explanation of organizational adaptation behavior. In particular, we argue that time-lagged interactions, i.e., a low internal responsiveness, constitute a strong source for altering complex systems' paths.
Finally, in resolving the paradox we extend the research on co-evolutionary linkages and the boundaries of the system by conceptualizing what constitutes a focal firm's activity system and how it relates to "external" choices. Following a systems approach, we emphasize that a firm's evolution and position on the performance landscape is determined by all of its activities and their interdependencies rather than only by a few (cf. Porter, 1996). We also argue that a focal firm's activity system is delineated from its environment through the concept of decision rights (Aggarwal et al., 2011). A focal firm's activity system composes all activity choices over which it holds at least partial decision rights. Once a firm has decision rights over an activity choice, it can take deliberate decisions that result in mutual interdependencies with other activity systems and cause co-evolutionary adaptions without having explicit decision rights over each other's choices. For example, co-evolutionary linkages emerged in Intel's activity system between 1987 and 1997 because of investment and R&D choices related to the PC market and Microsoft (Burgelman, 2002). These co-evolutionary linkages exist as activity system choices of one firm that influence the appropriateness of a given activity system configuration for another firm and vice versa. For co-evolutionary interdependencies, each firm's choices are a function of the other firm's landscape (Kauffman, 1993).

3.7 Limitations and Future Directions

Our paper has some limitations that suggest a path for future research endeavors. First, our theory assumes that the environment is a function of potential interdependency pattern configurations and thereby determines the topology of the fitness landscape (Kauffman, 1993; Levinthal, 1997; Rivkin & Siggelkow, 2007). The pay-off of a given set of activity choices is determined by exogenous variables, such as customer preferences and available technologies, and thereby determines the height of the configuration peaks on the fitness landscape (Siggelkow, 2001: 840). We imply that this environmental function undergoes constant evolution. Changes in interdependency patterns and exogenous conditions alter the topology of the fitness landscape, which means that some new peaks might arise, while others might decline and again others might increase in size. Hence, we assume that the alternation of the fitness landscape topology is a rather continuous and smooth process. Our framework has therefore limited generalizability for situations of episodic environmental shocks that change firms' environments dramatically over a short period of time. Future research might therefore address such landscape-altering events and study the impact of market, technological, and regulatory shocks (Haveman, Russo, & Meyer, 2001). Potential research topics include the effects of such environmental changes on existing interdependencies. For example, regulations that prohibit the exploitation of complementary effects between commercial and investment banking will "delete" interdependencies, whereas deregulation in that respect will "create" new interdependencies among activities. In addition, future research may examine how different sub-factors of the environment affect the role of a given interdependency design. For example, McCarthy and colleagues (2010) suggest that an industry's technology, regulation, products, competition, and demand and the coupling among these environmental dimensions can influence the appropriateness of an activity system's characteristics. Future studies could increase the complexity of our framework by linking each dimension to different causes of environmental change in the context of different sub-sets of environments, e.g., one in which these environmental factors are tightly linked versus one in which they are almost independent.

Second, we have applied an activity system lens and viewed an activity choice as aggregated behavior on the system level that represents the sum of individual actors' behavior (Stinchcombe, 1968). However, activity choices might also encompass non-human activities, such as information technology (IT) systems, and individual behavior might not always be easily aggregated into coherent system behavior because of its own complexity. Although we were limited in our treatment of individual behavior, we believe that a deeper analysis of the differences between the activity system set-up and day-to-day human operations would be fruitful. Studying this relationship is a promising path for bridging the more macro- or system-level approach that we have chosen in this paper with more micro-level research, such as the "strategy-as-practice" view. In particular, we identify two areas that could be addressed in future research. First, when managers make strategic choices and perform activities, they might face cognitive misperceptions of interdependency structure and rules. For example, they might misinterpret existing or non-existing interdependencies or perceive peaks as high even though they are small in the greater scheme. Rules that allow for interpretation and the actual behavior that follows from these rules should be studied further. In particular, the distinction between the ostensible and performative parts of rules (Feldman & Pentland, 2003) could help in exploring the dynamics between the activity system on a firm level and the behavioral aspects of individuals and groups.

Third, our theory implies that interdependency structure and rules are the result of activity choices made by the firm. However, we have neglected the origin of these interdependencies. Although structural interdependency patterns are often assumed to be given, prior studies (e.g., Levinthal & Warglien, 1999) have suggested that decision makers can shape these patterns to some extent. Ashmos et al. (2002) imply that a change in rules (i.e., engaging in participative decision making) can increase interdependencies between agents and thus change an existing pattern. Ganco and Agarwal (2009) suggest that firms that make the same choices might still have different interdependencies because some interdependencies develop and are established over time. Furthermore, interdependencies can also have different value implications. Whereas the existing literature identifies complementarities and substitutes (Milgrom & Roberts, 1990), the intermediate values between these two extremes have not received much attention. For studying the nature and consequence of interdependency further, the work of Rousseau and Cooke (1984) might be a good starting point. They demonstrate that interdependency can originate from natural (e.g., technology), resource, or organizational policies. Future research may address these and other potential sources of interdependency and examine how they influence one another and how they change value perceptions.

3.8. Conclusion

By demonstrating that interdependency structure constitutes the context for strategic renewal and is manipulated by the rules that interdependent activities follow, we provide a rationale for the opposing perspectives regarding the role of interdependencies in enabling strategic renewal. Our model suggests that neither interdependency structure nor interdependency rules alone can sufficiently explain when interdependency in activity systems will enable or inhibit strategic renewal. Rather, we suggest that the structure presents a certain predisposition to strategic renewal, whereas the rules influence the behavior that the activity system follows. We think that a “dual understanding” of interdependency design, with the structural and rule components interacting, offers a platform for future research concerning strategic renewal.

4. Recombining Activity Domains in Activity Systems: A Modularity Perspective [13]

Abstract:

Modularity research suggests that activity systems can be decomposed into sub-systems, called activity domains, which can adapt and innovate almost independently from one another because there are few interdependencies across domains. Such activity domains can be subject to recombination; that is, they can merge with other domains or even exit the activity system. While recombination has been identified as a powerful mechanism of system-wide renewal enabled through a modular design, it is less clear what role the individual modules play in this mechanism. Hence, in this study, I address this gap by focusing on the characteristics of activity domains, representing the modules in activity systems, to theorize about the likelihood of the recombination of a focal domain. Applying a Cox semi-parametric model to test the hazard-rate of recombination in a sample of 1027 activity domain years in 166 individual activity domains in the European banking industry between 2000 and 2011, I find modularity to have opposing effects depending on which hierarchical level of a focal activity domain one considers. External modularity, the number of co-existing domains in the same activity system, increases the likelihood that an activity domain will undergo recombination. Internal modularity, the decomposability of the domain, decreases the likelihood of recombination. Moreover, the more the activity system is concentrated toward a given domain, the less likely this domain is to recombine. Activity domains with greater internal modularity and a concentration of power toward these sub-modules, however, are found to show an increased likelihood of recombination. These findings contribute to the literature on modularity in activity systems, multi-unit firms, and strategic renewal.

[13] **Acknowledgements**: I would like to thank Arjan Markus, Christine Scheef, Henry Han, Johannes Luger, Linda Rademaker, and Michael Boppel for helpful comments and discussions on earlier versions of this chapter.

4.1 Introduction

The recombination of activity domains constitutes a powerful mechanism for firms to redeploy and alter their current activity system (Galunic & Eisenhardt, 2001; Karim, 2006). Activity domains are modules of activity choices that define strategic core-themes, which, taken together, constitute a firm's activity system (Ghemawat & Levinthal, 2008; Miller & Friesen, 1982b). Activity systems often encompass several activity domains, which can correspond to their operating product and market activities and are often reflected in the organizational structure. Activities that constitute the activity domain show higher degrees of interdependency among one another than across activity domains because they revolve around a joint core-theme (Siggelkow, 2002a; Simon, 1962).

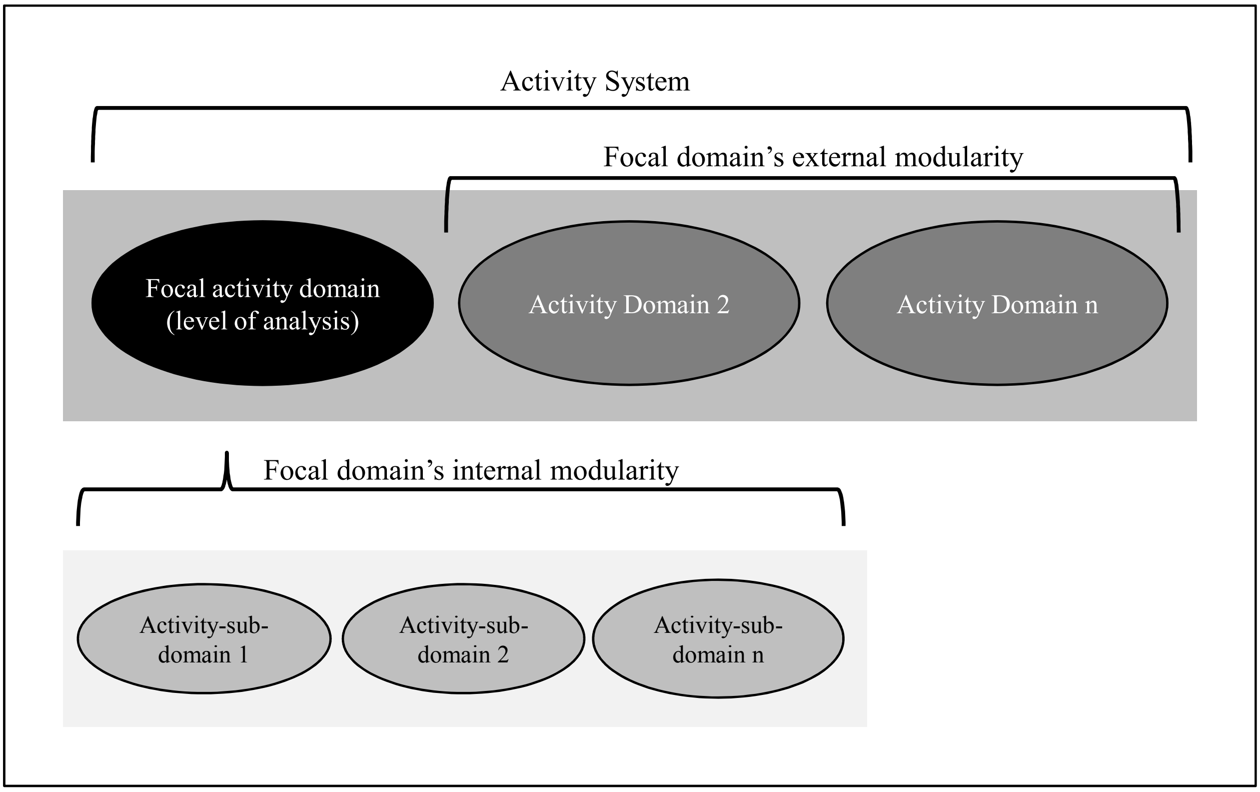
The literature suggests that the decomposability of an activity system into activity domains facilitates recombination through the dissolution and merging of domains into other domains within the same system (Eisenhardt & Brown, 1999; Ethiraj & Levinthal, 2004; Karim, 2006). That is, a modular activity system can enable the recombination of hitherto identity-retaining activity domains, which results in new activity domains. Recombination can thereby be a powerful mechanism for firms to renew their existing strategies to meet current and future developments in the environment. The enabling nature of recombination and its limitations in modular systems are well studied (Baldwin & Clark, 2000; Ethiraj et al., 2008; Sanchez & Mahoney, 1996), yet we do not know much about the characteristics that explain why some modules are more likely to be subject to recombination than others (Galunic & Eisenhardt, 2001). While some modules in a system can be relatively resistant to recombination and instead absorb other modules, others dissolve into the system, lose their identity, and stop existing in their previous form (Karim, 2006). Recent advancements in studying the property, process, and cognitive frame of modularity have emphasized that understanding different aspects of modular systems is important to avoid inconsistent predictions (MacDuffie, 2013). Module-characteristics constitute an aspect of a system that can explain varying predictions in activity system renewal. For example, how do two equally modular activity systems differ in their strategic renewal path if one has equally contributing activity domains (e.g., in terms of revenues or profit), while the other is concentrated toward one activity domain earning the lion's share? Such questions have gained particular attention in the financial service industry with respect to the dominant role of investment banking divisions (Economist, 2011).

The purpose of this study is to explore the role of activity domain characteristics on the likelihood of recombination within the activity system. Applying an activity domain/activity system perspective can help to predict the emergence and evolution of modules in complex systems (Brusoni & Prencipe, 2006). The literature on the interdependency patterns in activity systems suggests that the relative distribution of interdependencies influences the evolutionary path of firms by influencing the required amount of exploratory and local search (Rivkin & Siggelkow, 2007). In particular, I distinguish between the external and internal modularity of an activity domain as two important characteristics with different implications for recombination. While external modularity, i.e., the co-existence of other activity domains within the same system, is predicted to enable recombination, I argue that internal modularity, i.e., the activity domain's decomposability into sub-domains, inhibits activity domain recombination. In addition, I examine the role of activity domain concentration, i.e., the power-centrality of an activity domain to the overall activity system. I argue that concentration is generally an inhibitor of recombination, but on the sub-domain level, it can reverse the effect of internal modularity.

The empirical setting is the data from 15 European banks during the years 2000 and 2011. The analysis covers 166 individual activity domains resulting in 1027 activity domain-years. Consistency in reporting standards due to International Accounting Standards allows tracking activity domains on a year-by-year basis, consistently revealing changes in these domains.

Examining the role of activity domain context and characteristics contributes to the literature on modularity by emphasizing the module-characteristics (i.e., activity domain characteristics) to show that different levels of modularity have different effects on an activity domain's likelihood of recombination. This study also contributes to the examination of the coordination of multi-unit firms (Helfat & Eisenhardt, 2004; Martin & Eisenhardt, 2010) by arguing that firms can set the context for self-organization through recombinatory dynamics. Finally, this paper contributes to the strategic renewal literature by revisiting the role of power-distribution in organizations as a catalyst and inhibitor of change.

Figure 11: Distinguishing external and internal modularity in activity systems



4.2 Activity Domains: A Modular Perspective on Activity Systems

A firm's activity system encompasses its activity choices, such as which markets to operate in, which operations to perform and how. As implied by the term system, activity choices can and often are interdependent, i.e., the value and behavior of one activity influences the value and behavior of one or multiple other activities (Pfeffer & Salancik, 1978; Thompson, 1967). The interdependency characteristics for a given activity system determine the pay-off a chosen configuration receives in a given environment. Studies on activity systems conceptualize the environment as a fitness or performance landscape, a multidimensional mapping of all possible activity choices (Levinthal, 1997). In a simplistic way, one can understand this multidimensional mapping as a landscape with valleys and mountains of different heights. The peak of a mountain refers to a consistent configuration of activity choices with a positive performance. The height of a peak refers to different levels of performance – the higher the peak, the higher the pay-off (Kauffman, 1993).

Firms facing the same landscape often end up with very different activity system configurations. Even slightly different choices can affect the overall interdependency structure of an activity system (Rivkin & Siggelkow, 2003). For example, Porter and

Siggelkow (2008) show that interdependencies among choices are often altered by other "contextual" choices made by the firm. In addition, firms can make activity decisions that "thicken", i.e., increase the interdependency among certain activities (Siggelkow, 2002a); or they can make more independent choices that diffuse interdependencies throughout the system. These decisions define the occurrence of ***activity domains*** – core-themes — within the activity system (Ghemawat & Levinthal, 2008; Siggelkow, 2002a). Activity domains define what is "core" to a firm's strategy in terms of its strategic positioning and value proposition to the customer. Siggelkow (2002a) notes that what constitutes core to one company does not necessarily constitute core to another company. Put differently, while a certain activity choice might define an activity domain around a particular core choice, the same activity might be peripheral in another firm. For example, Switzerland's two largest banks, Credit Suisse and UBS, both have retail banking activities in place. However, the dominance and centrality of these activities differ remarkably. As of 2011, UBS had an activity domain called "Retail and Corporate" with notable centrality, as stated in the 2011 annual report:

> *"Retail & Corporate unit constitutes a central building block for the universal bank model of UBS Switzerland. Retail & Corporate supports our other business divisions by referring clients to them and assisting retail clients to build their wealth to a level at which we can transfer them to our Wealth Management unit" (UBS, 2011: 33).*

In contrast, Credit Suisse, as of 2011, defines no retail activity domain but refers to its retail operations as part of the "Private Banking" activity domain. In their annual report, they state:

> *Private Banking offers comprehensive advice and a broad range of wealth management solutions, including pension planning, life insurance products, tax planning and wealth and inheritance advice, which are tailored to the needs of high-net-worth and ultra-high-net-worth individuals (UHNWI) worldwide.* ***In Switzerland, Private Banking supplies banking products and services to individual clients, including affluent, high-net-worth and UHNWI clients, and***

> ***corporates and institutions*** *(Credit-Suisse, 2011: 234; bold added by the author).*

The above example shows that the configuration of a firm's activity domains is at the discretion of the firm. While UBS decided to have a strategic theme of retail banking, determining its activity domain and importance to the system as a whole, Credit Suisse included retail banking instead as a peripheral choice in support of its choice of activity domain theme: private banking. Hence, while both have included retail banking operations in their respective activity domains, the domain's themes differ tremendously.

This example further shows that an activity choice, such as retail banking operations, is considered part of an activity domain when it influences the higher-order domain-theme directly or indirectly, through interdependencies with other activities. As activity domains denote clusters of activity choices, they correspond to the ***modularity*** of the activity system, i.e., the decomposability in sub-systems with relatively few interdependencies among each other (Simon, 1962). That is, an activity domain constitutes a sub-set of activity choices with more interdependencies among each other than across the remaining activity choices that constitute the overall activity system.

Activity Domain Recombination

The mixing and matching of modules in a system is considered an important mechanism of strategic renewal (Ethiraj & Levinthal, 2004; Galunic & Eisenhardt, 2001; Karim, 2006; Martin & Eisenhardt, 2010; Sanchez & Mahoney, 1996). Some modules may mix with other modules to create an entirely new module. Other modules might absorb other modules, while still others may dissolve into several new or existing modules. In this paper, I am interested in the module characteristics that explain when a module stops existing in its current form – due to deletion, dissolving into the system, or merging into new or existing modules within the activity system. These mechanisms that lead to dissolution of a module are shared by literature that studies recombination (Galunic & Eisenhardt, 2001) and reconfiguration (Karim, 2006). Because reconfiguration also encompasses the strengthening of an existing module, I find the term recombination to be more suitable for this study. Recombination, in a classic sense, implies that the module recombines with other parts within the system. I extend this view by including the deletion of a module as the most extreme type of module recombination – i.e., exit from the system. This terminology is in line with modularity literature that argues that the recombinatory power of a modular system leads to the easier substitution and outsourcing of modules (Schilling & Steensma, 2001). Because modules can be separated from the rest of the activity system, the "deletion" of a module is possible, and the resources or services needed from this module can be sourced from elsewhere.

External Modularity of Activity Domains

Modularity denotes the decomposability of a system into separate identity-retaining sub-systems (Baldwin & Clark, 2000; Orton & Weick, 1990; Weick, 1976). Identity-retaining means that the delineation as a module of its own from the rest of the system makes it possible to assign this module a theme or purpose, and it functions somewhat independently from the rest. It does not mean, however, that a module may not constitute a crucial part of the overall system-survival because of some interdependency among modules and the pooled effect for the system as a whole (Kauffman, 1995; Thompson, 1967). A typical example is the immune system in the human body. Although it is interdependent with all organs and deeply embedded in the functioning of everyday activities, the immune system can be clearly delineated from the rest of the system and even deliberately targeted (e.g., through medication) without necessarily interacting with other parts of the body. The same is true for organizations: an activity domain is a set of interdependent activities that constitute an important part of the overall activity system, but it can be separated or even replaced as part of the system.

Modules are argued to adapt and innovate simultaneously to their own fitness landscape, which is less rugged and complex than the overall landscape of the activity system. In addition, modules are available as pools of resources for recombination with other modules in the system (Penrose, 1959). For example, Galunic & Eisenhardt (2001) find in their study of a large Fortune 100 multi-business firm that modularity *"generated diversity among the various divisions. This diversity originated with each division having its own unique product-market domain that demanded different kinds of skills and so encouraged divisions to develop them. […] Thus, as divisions […] pursued their different charters in largely independent fashion and evolved with their markets, they replenished Omni's corporate stock of diversity and generated a changing set of recombinant opportunities" (Galunic & Eisenhardt, 2001: 1243).*

A greater number of activity domains suggests variety in the sets of activities that otherwise would constitute a joint activity domain (Ashby, 1956; Galunic & Eisenhardt, 2001). Reordering the different core-themes of activity domains may result in newly defined themes that reposition the activity system. For example, a bank may decide to merge its previously separate activity domains “asset management & insurance” and “private banking”, repositioning these activities as “global wealth management” and “insurance”. Consequently, the number of activity domains a focal domain can recombine with, increases the combinatory alternatives for different evolutionary paths of the activity system (Baldwin & Clark, 2000; Brown & Eisenhardt, 1998; Pil & Cohen, 2006). With an increasing number of co-existing activity domains, the recombination of a module becomes less disruptive to the rest of the activity system. For example, let us assume that firm A has an activity system that encompasses eight activity domains, while firm B’s activity system encompasses four activity domains. If firm A recombines two domains, it affects 25% of its activity system. If firm B recombines two domains, it affects half of its activity system. Such a radical change in the system can have detrimental effects on the activity system, at least temporarily (Tushman & Romanelli, 1985). Hence, I argue that the availability of a greater number of activity domains in an activity system increases the chances of a focal domain to undergo recombination.

> *H1: An activity domain with greater external modularity is more likely to undergo recombination.*

Internal Modularity of Activity Domains

The literature has shown that the relative independence of a focal module from the rest of the system allows local search – i.e., adaptation within the module to be an effective mechanism of renewal (Ethiraj & Levinthal, 2004). Prior empirical research tends to stop at this level of analysis, neglecting lower levels of modularity, which may go beyond a mere aggregation effect and instead have different implications for higher level modules’ recombination. Simon (1962) notes that complex systems are hierarchic in the sense that they can be decomposed into sub-systems that again can be decomposed. He states: “in a hierarchic formal organization, each system consists of a “boss” and a set of subordinate subsystems. Each of the subsystems has a “boss” who is the immediate subordinate of the boss of the system". In addition, Simon notes that the modularity on each level can differ remarkably[14].

Distinguishing between different levels of modularity as separate variables is consistent with research on networks that argues that change is influenced by different levels of networks and needs to be viewed in its appropriate context. Brass, Galaskiewicz, Greve, and Tsai (2004: 808) show that the mechanisms for change are different on an interpersonal level and on an interunit level; therefore, they state that "[u]nderstanding network change requires understanding cross-level pressures".

In addition, distinguishing between internal and external modularity finds motivation in recent studies that distinguish between the hierarchy and the divisionalization of organizational structure. Zhou (2013: 5) argues that "*hierarchy relates to the organizational interconnections between divisions […] where the degree of divisionalization measures the extent of horizontal segmentation at the lowest level […] whereas the degree of hierarchy measures the extent of vertical coordination above the lowest level*". Translated to the terminology of this paper, activity sub-domains (internal modularity) are "coordinated" toward a common theme, the theme of the activity domain on the highest level.

For example, a multi-business firm can be examined at different system-levels. At the highest level, the firm's activity system demonstrates a certain modularity corresponding to the activity domains, e.g., operating business segments, such as investment banking and retail banking. On a business segment level, one would find that the segment might encompass sub-systems such as mortgage banking choices and consumer loan operations. The sub-level modularity depends on the activities that carry out the higher level module's task and can appear in different configurations. These activities, in turn, are deliberate activity choices made by the firm. In this respect, the internal modularity constitutes a deliberate design choice. In the terminology of activity systems, activity domains do not simply consist of an aggregation of lower level sub-domains, as the first level of modules – the domain – has a strategic theme that requires activities and/or sub-domains, respectively, to carry it out. A mere aggregation of sub-domains would require that the second-level modules (sub-domain) could be viewed with blanking out the first-level modules (the

[14] Simon (1962) illustrates this using the example of a diamond: "A diamond has a wide span at the crystal level, but not at the next level down, the molecular level". That is, a diamond consists of many sub-modules (the crystal level), but these modules consist only of carbon atoms (molecular level).

domains) and still convey the same strategy. This distinction implies that an activity domain varies in its sub-modularity, and thus the activity domain and the sub-domain level are two distinct variables of an activity system. Figure 11 illustrates the different levels and their respective terminology. Activity domains set the strategic-theme into place and thereby "coordinate" the sub-domains of activities. The sub-domains, in turn, partially carry out the strategic-theme and thereby implement the activity domain. If external modularity implies that an activity domain faces more combinatory opportunities, what are the implications of internal modularity? I argue that a higher degree of internal modularity decreases the likelihood of recombination of a given activity domain for two main reasons. First, high internal modularity enables the activity domain to take advantage of simultaneously performed local search within its multiple modules, which taken together on the activity domain level let the module evolve and renew continuously without recombination. This argument is consistent with studies on exploration and exploitation (Ethiraj & Levinthal, 2004; Ethiraj et al., 2008) and classic literature studying modular designs (Baldwin & Clark, 2000; Kauffman, 1995), arguing that intra-module adaptation motivates simultaneous and local search. Second, sub-modules within the activity domain constitute a heterogeneous sub-environment themselves and may allow recombination within the domain. This argument borrows from the requisite variety perspective (Ashby, 1956), suggesting that these "internal" modules pose a source of heterogeneous resources (Penrose, 1959). These heterogonous resources are closer and more likely to be available for recombination due to a common theme and existing interdependencies than "external" modules with more distant themes and choices. In addition, internal modularity allows the deletion, adding, and transferring of sub-domains more easily across domains, for example, in cases where a sub-domain does not fit the core-theme or would be of more use in a different activity domain. In these cases, the activity domain as a whole does not need to undergo recombination. Hence, activity domains with high internal modularity undergo strategic renewal themselves and are less likely to need to recombine with other activity domains.

> *H2: An activity domain with greater internal modularity is less likely to undergo recombination.*

Concentration of activity domains

When facing the same environment and the same set of choices to choose from, firms often exhibit different interdependency concentrations among their choices based on the actual choices made (Ganco & Agarwal, 2009). The choices may result in more or fewer clusters of activities serving shared core-themes, which constitute activity domains. The relative influence – or "weight" – of a domain on the entire activity system is a function of all other choices taken by the firm. Activity domains become more influential in the system if they create particular value to the firm in terms of resources and information (Pfeffer & Salancik, 1974). In addition, they are central to the overall system if their activities and changes in their choices influence many current and future choices throughout the system (Siggelkow, 2002a). The more influential an activity domain on the entire system in terms of, for example, value contribution, the more central it becomes because other domains start depending on the performance of the dominant domain (Thompson, 1967). Hence, I argue that an activity domain that is more central to the system is less likely to encounter recombination within the activity system. The asymmetric distribution of interdependencies in concentrated activity systems provides the activity domains with more power over the behavior of the rest of the system. Concentrated activity systems face a fitness landscape that is less rugged and appears to have one dominant peak centered on the core-domain (Rivkin & Siggelkow, 2007). Therefore, local search is rewarded, and the system is less likely to recombine the entire fitness landscape. Put differently, more powerful activity domains require other domains to comply with and reinforce the central themes. Higher-power activity domains are likely to resist recombination with other domains and to maintain their autonomy and status because of an imbalance in influence (Casciaro & Piskorski, 2005; Pfeffer & Salancik, 1974). Central activity domains often play a role in system recombination, however, in absorbing and dictating roles, incentivizing renewal that favors the elaboration of their "distinctive competence" (Levinthal & March, 1993).

> *H3: An activity domain is less likely to undergo recombination the more the activity system is concentrated toward it.*

Concentration refers to the relative position of an entire activity domain within the activity system. Similar to the distinction between external and internal modularity, it is useful to elaborate on the relative power not only on an activity domain level but also on a sub-domain level. In hypothesis 2, I have argued that internal modularity can inhibit activity domain recombination because sufficient variety exists among sub-domains within the same activity domain. However, the more powerful and central these sub-domains are to the overall activity system, the more they strive for autonomy and their own activity domain status (Burgelman, 1983b). Such power can increase the momentum for elevating sub-domain interests and breaking loose from the current activity domain. In addition, power struggles are more likely to occur, which leads to conflict over resources and future decisions. Conflicts have been shown to push systems and sub-systems out of equilibrium (Anderson, 1999) and stimulate the exploration of alternative configurations (Blackler, 1993; Brown & Eisenhardt, 1998; Plowman et al., 2007). That is, higher sub-domain power in the face of a larger number of sub-domains is more likely to increase power struggles and conflict within the activity domain, leading to its recombination.

> *H4: An activity domain with greater internal modularity will be more likely to undergo recombination the more the activity system is concentrated toward these internal modules.*

4.3 Methodology

Data collection

Collecting data on activity systems in general and activity domains in particular poses a challenge. Case studies on activity systems clearly demonstrate that activity choices can extend far beyond operating activities (Porter, 1996). To quantitatively test my hypotheses, I needed a research context that offers a diverse number of observable activity choices that can but need not result in activity domains. In addition, these observable activity choices need to be reported in a consistent manner across domains and firms. Finally, these activity choices need to be reflected in a measurable outcome that is comparable across firms.

I chose the European banking industry as a research sample that meets the three requirements. First, most European banks operate as multi-business firms (called universal banks), engaging into a diverse yet related set of activities, such as retail, corporate, and investment banking, which the firms can configure in different ways.

This set of activity choices is diverse enough to examine differences in configurations, yet manageable in its observability and comparison, as choices are mainly limited to the financial service industry and diversification into other industries is rather uncommon. The universal banking model has evolved to be the predominant business model among banks in Europe, as there have historically been no regulations that opposed this concept (e.g., in contrast to the USA, due to the former Glass-Steagall Act of 1933). Hence, a single industry analysis is adequate here, as it accounts for the emergence of an industry recipe (Spender, 1989) in the European market, facing similar laws, regulations, and accounting standards.

Second, listed European companies are subject to International Accounting Standards (IAS; IFRS), which require firms to report their business segments following a "management approach", meaning that a firm "[…] must look to its organisational structure and internal reporting system to identify reportable segments" [IAS 14.26][15]. Such reporting increases the reliability that activities clustered together in an activity domain share interdependencies and are managed according to this clustering. Even if a firm adjusts its segment reporting because of accounting standards, the measured outcome is valid for this study because it is reasonable that the responsibilities change with the redefined business segments. Accordingly, business segments represent activity choices that are useful to group in one domain (segment) because they share resources, customers, and risk profiles – i.e., they are interdependent.

Third, the business segments in banking represent the main and most important activity choices to be made by the firm. In contrast to manufacturing firms, banking does not have many non-revenue generating activities, such as research and development, procurement, and production. Activity choices in banking become measurable and visible in the form of revenues, profits, and assigned assets. Hence, the financial figures of a business segment accurately reflect the actual degree of activity engagement. In addition, the methodological approach chosen here responds to Siggelkow's (2002: 126) concern that the ex-ante specification of activity domains is

[15] The account rule IAS 14, defining the business segment regulations, was succeeded in 2009 by IFRS 8. The underlying rules important for this study are not affected by this change. Ernst & Young, as one of the four leading auditing firms, state in their IFRS 8 implementation guide: "IFRS 8 adopts the management reporting approach to identifying operating segments. It is likely that in many cases, the structure of operating segments will be the same under IFRS 8 as under IAS 14, because IAS 14, like IFRS 8, defines reporting segments as the organisational units for which information is reported to key management personnel for the purpose of performance assessment and future resource allocation. When an entity's internal structure and management reporting system are not based either on product lines or on geography, IAS 14 requires the entity to choose one as its primary segment reporting format. IFRS 8, however, does not impose this requirement to report segment information on a product or geographical basis and in some cases this may result in different segments being reported under IFRS 8 compared with IAS 14" (Ernst&Young, 2009: 4).

problematic as it “assumes that the same elements are equally central or core in all firms”. This paper’s approach mitigates this problem because the activity domains are measured through the reported business segments, which are defined by the firm and can differ tremendously across firms. Hence, I rely on a semi-ex ante specification, assuming that business segments are core to the activity system (ex ante specification) of European banks, but these segments can be defined and configured differently from bank to bank and year to year (ex post specification).

Sample design

The final sample consists of ***1027 activity domain-year observations*** across 166 individual activity domains in 15 companies between the years 2000 and 2011. The 15 companies were chosen based on data convenience and availability from the largest 30 banks by total assets in 2000. To count as one of the 30 largest banks in 2000, the firms had to fulfill the following criteria: their primary activity had to be in banking, and they had to have been publicly listed for at least eight consecutive years to allow meaningful longitudinal analysis[16]. I provide an overview and several descriptions of the sample in the appendix. The data sources were the published annual reports and financial statements issued by the companies. Because the business segment reporting is strictly regulated by the International Accounting Standards Board (IASB), the reliability of the data on the activity domains is high. Additional variables are coded from the report information, which leaves some room for interpretation in how companies report this information. However, prior research suggests that annual reports can constitute a reliable source for firm strategy and organizational structures (Barr, Stimpert, & Huff, 1992; Klarner & Raisch, 2013; Lant, Milliken, & Batra, 1992). Further, the information collected in this study, such as the internal modularity of activity domains, is less likely to be subject to public relations-bias to advertise the company to the shareholders, as this information is not linked to performance or competitive advantage in any obvious way.

[16] To rule out potential sample selection biases that could influence the empirical analysis of this paper, I performed two-tailed t-test analyses to compare the selected 15 banks with the remaining 15 of the 30 largest banks. While the selected 15 banks are significantly larger in size, it is important whether these firms changed differently compared to other banks. Therefore, I performed t-tests to examine potential differences in firms’ growth/decline of profits and total assets for the years 2000 to 2005, 2000 to 2011, and 2005 to 2011. All two-tailed indicate that the difference in mean growth/decline between the selected sample and the non-selected banks is not different from zero. Hence, this study’s analysis is unlikely to suffer from selection-bias.

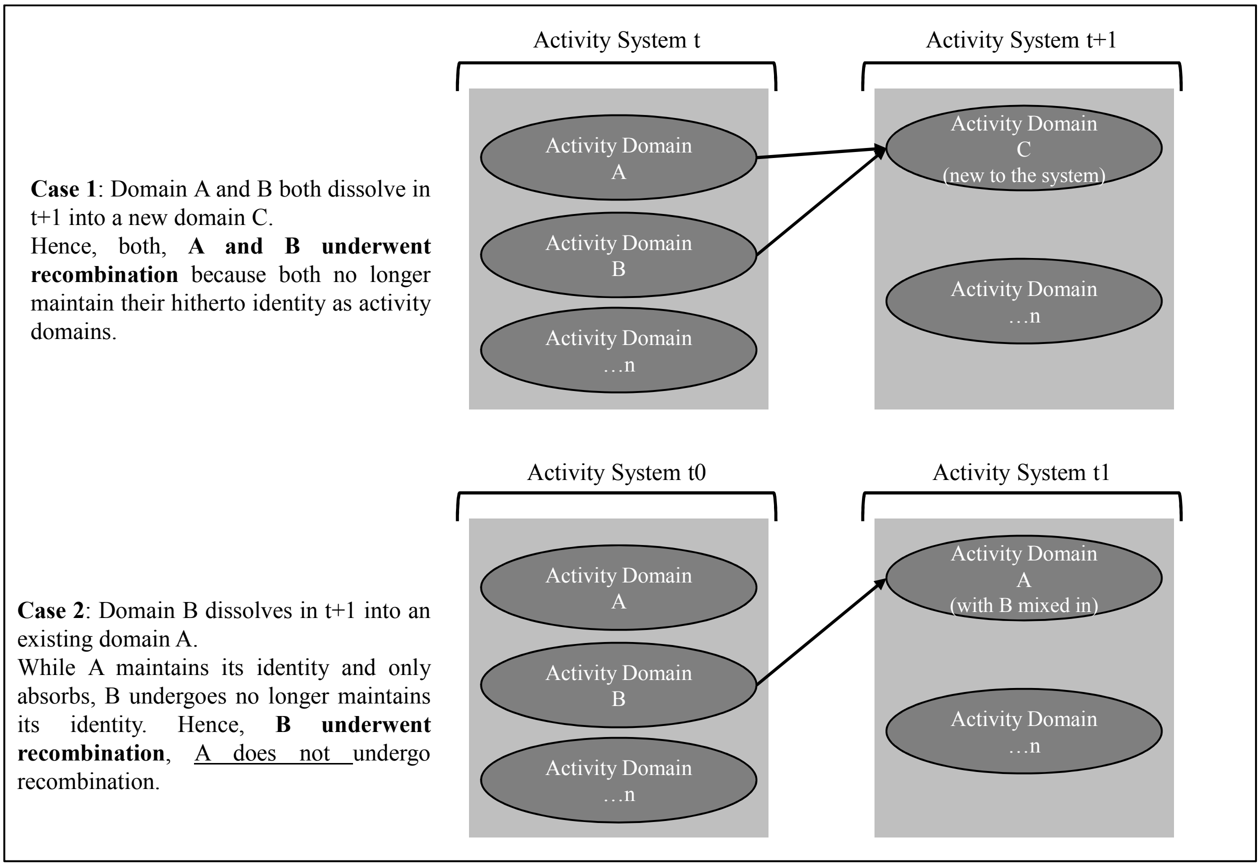
Level of Analysis

The level of analysis is the activity domain level in an activity system. That is, if a firm has three activity domains at a given point in time, each activity domain is treated as an own individual panel identity for the data analysis. All variables in this analysis are therefore activity domain characteristic variables as well as variables of context. Consequently, all predicted effects in this model need to be interpreted from a focal activity domain's perspective.

Dependent Variable

In this study, the dependent variable, ***recombination***, refers to the event when an activity domain dissolves into other existing, new activity domains, or is divested from the activity system. I operationalized recombination for a given activity domain by assigning the value 1 when it stopped existing in its current form. This case occurs if it dissolves into other domains or merges with other domains, leading to a new activity domain theme. To identify these cases, I followed a two-step approach. First, I compared the official segment reporting in the accounting statement of the current year with the previous. The segment reporting section in the annual accounts provides an overview of the firm's operating business segments and therefore allows a reliable identification of deviation from the segment definitions to the previous year. Second, once changes occurred in the segment reporting, I analyzed where the business segment operations from the previous year were assigned in the current year. I coded the previous existing business segment as recombined (assigning a "1") if it was divested, merged with at least one existing business segment and adopted the existing segment's "theme", or merged with one or multiple other segments or parts of segments, forming a new segment "theme". Figure 12 provides illustrations of recombination cases.

Figure 12: Recombination cases



This figure is inspired by Karim's (2006: 805) illustration of recombination cases.

I excluded cases that were subject to a mere separation of disclosure (increasing transparency, often due to accounting requirements) – i.e., a pure split in the reporting without any indication of the re-ordering of segments. For example, Credit Agricole disclosed its French retail banking and specialized financial services activities results in the business segment only as an aggregated value under the heading "French Retail Banking" until 2002, then began reporting more fine-grained results for these segments.

Independent variables

The ***external modularity*** for a focal activity domain was operationalized as the number of co-existing activity domains in the same firm. For example, the activity system of the Swiss bank Credit Suisse encompassed three activity domains in 2010: investment banking, asset management, and private banking. That is, the number of co-existing activity domains for each of the three domains was two. Consequently, each of the three activity domains of Credit Suisse in 2010 was assigned an external modularity of two.

The ***internal modularity*** was coded as the number of distinct activity sub-domains within a reported business segment. Internal modules can but need not correspond to structurally separated domains within a business segment. The indicators for distinct sub-domains are separate reporting and explicit mention of the distinct management and/or operation of activities (see Table 4 for coding examples). The reporting structure constitutes a valid indicator because it indicates that the respective activities take individual responsibility for their performance. It can be argued that firms might not disclose all sub-modules. However, firms are likely to report the important sub-domains that correspond to respective management responsibilities in terms of size and strategic relevance. Reviewing the annual reports showed that the mention and structure of sub-domains was reported in a consistent manner over the years for each activity domain, indicating the relevance of this sub-structure.

The ***domain concentration*** was measured using two different measures. First, I calculated the proportion of the assigned total assets of an activity domain in relation to all activity domains within the same company at a given point in time. Resource accumulation is a good indicator in terms of the pooled interdependence effect on other domains (Thompson, 1967) and corresponds to budget allocation criteria in organizations (Pfeffer & Salancik, 1974). I used total asset values as reported in the annual report instead of obtaining database values to avoid incorrect values due to restated financials. Second, I coded the proportion of the number of executives in the executive committee representing a focal activity domain in relation to all activity domains within the same company at a given point in time. Board representation constitutes an important means of power distribution in a company's decision making and course of strategy (Finkelstein, 1992; Pfeffer & Salancik, 1978).

For the ***sub-domain concentration*** I used the absolute number of executives representing the sub-domains of a given activity domain in the executive board. Financial measures were not possible because sub-domains are not required to disclose their results.

Control variables

I also included a number of control variables that the literature suggests to influence recombination and that I expected to explain variance and to be necessary for constructing reliable statistical models. To control for fixed-effects, I included ***company dummy*** variables as well as a dummy variable indicating the ***core-theme*** of a focal activity domain. I include this variable to control for theme-differences that could enable or facilitate recombination. Based on all observations, I defined a list of possible core-themes as follows: asset management, corporate banking, investment banking, insurance, private banking, wealth management, retail banking, private equity, and central services, based on the reporting focus of the business segment. To test for other firm-wide effects, I included the profit before taxes generated by all activity domains of a company (***profit before tax (activity system)***) using annual report values. I also included a dummy variable indicating a firm's ***transition to IFRS*** from domestic accounting standards, in case they did not previously report according to these standards. Although the European accounting rules have been relatively similar across countries in terms of requiring a fair and transparent view of business operations, a change in accounting standards could affect the segment reporting structure. Activity domains that are new to the activity system – as part of a recombination or an acquisition – could be more or less likely to be subject to recombination. To control for such effects, I included the variable ***new activity domain***, which indicates that the domain was created in the previous year. I also included the ***profit before tax (activity domain)*** (in millions of Euros) to account for differences in activity domain performance, and the ***number of activities*** performed in a focal activity domain. A larger number of activities in the activity domain could indicate higher interdependency and complementarity and consequently inhibit recombination. I coded whether an activity domain was performing one or multiple of the following activities: retail banking, corporate banking, sales & trading, M&A advisory & underwriting, asset management, private banking, life insurance, non-life insurance, and corporate support functions.

Table 4: Coding examples of recombination and internal modularity

Variable	Coding Source	Coding
Recombination	*"As of January 1, 2003 the Group completed a realignment of PCAM. As a consequence of this change, the three previous corporate divisions – Asset Management, Private Banking, and Personal Banking – were realigned into two new corporate divisions: Asset and Wealth Management (AWM), and Private and Business Clients (PBC)"* (Deutsche-Bank, 2003: Notes 105)	The following three activity domains stopped existing at the end of 2002: - Asset Management - Personal Banking - Private Banking First appearance of the following two new activity domains in 2003: - Asset and Wealth Management - Private and Business Clients
Recombination	Implicit recombination: In 2010, Barclays reported the following two segments as own business segments: - "*Barclays Africa provides retail, corporate and credit card services across Africa and the Indian Ocean as well as tailored banking services (including mobile banking and Sharia-compliant products).* - *Absa provides a full range of retail banking services and insurance products through a variety of distribution channels. It also offers customised business solutions for commercial and large corporate customers*" (Barclays-PLC, 2010: 264) In 2011, Barclays reported the activities of these two former segments under new heading together: - "*Africa Retail and Business Banking (Africa RBB) provides retail, corporate and credit card services across Africa and the Indian Ocean. Africa RBB combines the operations previously reported as Barclays Africa and Absa*" (Barclays-PLC, 2011: 174)	The following business segments stopped existing in 2011: - Barclays Africa - Absa First appearance of the following business segment in 2011: - Africa Retail and Business Banking
Internal Modularity	The activities of AIB Capital Markets, with total assets of € 54.1 billion at December 31, 2006, comprise corporate banking, global treasury (with the exception of the International Banking Services in BZWBK) and investment banking, which includes the asset management and stockbroking activities of the Group. These activities are delivered through AIB Corporate Banking, Global Treasury, Investment Banking and Allied Irish America ("AIA")" (Allied-Irish-Banks, 2006: 14-15).	Allied Irish Banks's Business Segment "Capital Markets" was assigned in 2006 an internal modularity of 4 because the domain is decomposable into four separate areas.
Internal Modularity	BNP Paribas structured in 2002 its Corporate and Investment Banking Segment's activities into three sub-domains (1) Corporate & Financial Institutions: "The Corporate & Financial Institutions division was created to ensure full coverage of BNP Paribas' corporate and institutional clients. To this end, CFI covers 38 geographical areas, grouping the BNP Paribas teams specialised in Large Corporates, Financial Institutions and Corporate Banking departments, as well as the Paris-based Global Trade Services teams" (BNP-Paribas, 2002: 9). (2) Advisory and Capital Markets, which is further distinguished into Corporate Finance, Equity, and Fixed Income, (3) Specialised Financing: BNP Paribas' Structured Finance team designs and structures, on a worldwide basis, a broad range of complex and innovative financing arrangements, including syndicated loans, acquisition financing, LBO financing, Project Finance, optimisation and asset financing, media and telecommunications financing, marine financing and aircraft financing. This business unit is at the crossroads of lending and capital market activities. In addition, the Structured Finance division now oversees the structuring and monitoring of standard commercial banking transactions" (BNP-Paribas, 2002: 9).	BNP Paribas Business Segment "Corporate and Investment Banking" was assigned in 2002 an internal modularity value of 3 because the domain is decomposable into three separate areas.

Estimation Methods

This study examines the likelihood that an activity domain will undergo recombination within a firm's activity system. To test my hypotheses, I used Cox proportional hazard event history models (Cox, 1972, 1975). Cox models fit this study's data and research question particularly well because they account for right censoring in the dependent event variable. Right censoring is present when the event of interest may occur after the end of the observed time period, and thereby serves as a good estimator for rare events. That is, the chosen methodology takes into account that an activity domain can also be subject to recombination after 2011. In addition, due to using partial likelihood estimation, Cox models do not require the a priori specification of a baseline hazard rate function or the age of the unit to arrive at interpretable results (Winter, Szulanski, Ringov, & Jensen, 2012). Finally, Cox models are conceptualized for nonrepeating events testing time-varying covariates, which fits the dependent variable of an activity domain's recombination, after which the activity domain stops existing in its current form. The Cox proportional hazard rate is calculated as follows:

$$h_i(t) = h_0(t) \exp(\beta^1 x).$$

Hence, the hazard rate for the *i*th individual activity domain is estimated by the time-dependent baseline rate $h_0(t)$ and the regression parameters and covariates $\beta^1 x$ (Wowak, Hambrick, & Henderson, 2011).

All analyses were performed using *Stata 11.0* operating the *stcox* command. I classified the fiscal reporting year as a time variable and the individual activity domain as a potential multiple record variable (Cleves, Gould, Gutierrez, & Marchenko, 2010). In line with prior studies (e.g., Kapoor & Lee, 2013; Winter et al., 2012), I calculated all models using robust standard errors (Lin & Wei, 1989) clustered at the activity domain level (Stata option *vce(robust)*). In addition, I calculated all models using the more robust Efron method to account for ties (when two or more activity domains recombined at the same time) instead of using the simpler Breslow approximation (Cleves et al., 2010; Eggers & Kaplan, 2009; Kapoor & Lee, 2013).The hazard in this study is an activity domain's recombination, which leads to the dissolution of its current status and identity. The covariates measuring hypotheses 1-4 express how this hazard is affected.

4.4 Results

Hypothesis testing

Table 5 provides the mean, standard deviation, and correlation statistics of this study's variables. All correlations between variables used to test my hypotheses show no correlation higher than .30, indicating that multicollinearity is not a concern. The highest correlations among control variables are, unsurprisingly, between the profit on the domain-level and on the activity system level (.47). Table 6 reports the Cox hazard rate models. Model 0 is the controls-only model, which predicts that an activity domain is less likely to experience recombination the better the performance of the overall system. This effect, however, is very weak, close to zero, indicating that changes in company performance will only marginally alter the hazard for a focal activity domain to undergo recombination. In contrast, activity domains that are new (due to recombination or acquired) to the system are less likely to undergo recombination. These effects are consistent across all models. The transition to IFRS, not significant in the controls-only model, becomes significant in the models 2-7 (mainly at the 10% level). This result partially confirms, as predicted, that a change in the accounting standards increases the likelihood of recombination.

Models 1, 2, 4, and 6 are intermediate statistics to test each hypothesis independently. In Models 3 and 5, I successively include the respective variables of the prior hypothesis, and in Model 7, I include all variables.

In Hypothesis 1, I predicted that higher external modularity, in terms of the number of co-existing activity domains in the same activity system (the company), will increase the likelihood that an activity domain will undergo recombination. This hypothesis is supported by a direct and positive effect on the likelihood of recombination for the intermediate (Model 1) and for all aggregated Models (3, 5, and 7) with a p value < 0.001. In the most conservative model (Model 7), an increase in an activity domain's external modularity by one additional domain would increase the hazard to undergo recombination by 128% (the risk can be obtained by calculating exp (βx), i.e., exponentiating the product of the coefficient and the variable x; here: $\exp(0.822*1) = 2.28$).

In Hypothesis 2, I predicted that activity domains with higher levels of internal modularity, i.e., more sub-domains of activities, will be less likely to be subject to recombination. This hypothesis also finds support in the intermediate Model 2 (p <

.01) and the aggregated models (Models 3,5, 6, and 7). Model 7 suggests that an increase in an activity domain's internal modularity by one sub-domain decreases the hazard of recombination by 23%.

In Hypothesis 3, I predicted that the more concentrated an activity system toward a focal activity domain, the less likely that this domain will be subject to recombination. I tested this hypothesis by including the total assets of activity domain and the number of executives representing this domain in the executive committee, both measured in relation to the overall activity system. The coefficient for this effect is, as predicted, negative and significant for both measures in the intermediate Model 4 ($p < .05$ and $< .01$, respectively). The total assets measure, however, becomes insignificant for Models 5 and 7. Based on Model 4, an increase of one standard deviation in the relative total assets decreases the hazard of recombination by 42%. One standard deviation increase in the relative executive representation decreases the hazard by 40% (Model 7).

In Hypothesis 4, I predicted that the effect of internal modularity is reversed when an activity domain's sub-modules are more central to the overall activity system. Models 6 and 7 lend support to this prediction, indicating positive and significant coefficients for the interaction effect ($p < .01$ and $p < .05$ for Model 6 and 7, respectively). I also included the sub-domain concentration measure as a main effect, as suggested by Aiken and West (1991). The main effect is significant and negative, suggesting that sub-domain concentration decreases the likelihood of an activity domain to undergo recombination, if other factors are held constant.

Robustness Tests

In addition to the Cox models presented in Table 6, I performed several robustness tests for the final model (Model 7). First, to determine whether the results were driven by certain industry events, I included dummy variables controlling for the years 2005 and 2008. In 2005, all European listed companies were required to fully comply with the IFRS regulation. The year 2008 constitutes the peak of the global financial crisis with the Lehman bankruptcy. Some banks reorganized their activities in 2008 due to large losses, especially in investment banking. The two-year dummies become positive and significant (year 2005 at the 10% level and year 2008 at the 1% level), indicating an increased hazard of recombination during these years. The main results of Model 7 remain robust in quality and magnitude. Second, to better account for potential differences in the reporting detail of companies, I classified the sample into two groups, large firms and small firms. I defined small firms as firms that started 2000 with total assets one or more standard deviations below the mean. I then stratified the Cox regression using the *strata* command in *Stata*. The results remained consistent and even partially improved in quality. Third, even though company fixed effects were included in the Cox regressions, using dummy variables, to correct for firm nested effects and potential heteroskedasticity, I additionally clustered the standard errors at the company level instead of the segment level. The quality of the predicted effects remains robust overall, with changes in the significance levels; the interaction effect becomes significant only at the 10% level. Finally, because three companies experienced no recombination within the observation period, I excluded them from additional tests, which did not affect the quality of the model.

Table 5: Means, standard deviations, and correlations

	Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10
1	Recombination	0.09	0.29										
2	Company performance (mn EUR)	4833.02	4748.03	-0.02									
3	Transition to IFRS	0.06	0.24	0.03	0.05								
4	New activity domain	0.1	0.3	-0.02	0.05	-0.09							
5	Profit before Tax (mn EUR)	875.14	1796.83	0.00	0.47	0.02	-0.01						
6	Number activities	2.36	1.51	-0.02	0.11	0.01	0.01	0.23					
7	External modularity	5.73	1.59	0.13	0.35	-0.01	0.14	-0.01	-0.38				
8	Internal modularity	2.2	1.7	-0.06	-0.07	0.05	-0.07	0.12	0.36	-0.30			
9	Domain concentration (total assets)	0.19	0.21	-0.08	-0.07	0.01	-0.08	0.19	0.25	-0.25	0.27		
10	Domain concentration (executives)	0.18	0.16	-0.05	-0.01	0.00	-0.04	0.07	0.20	-0.26	0.14	0.12	
11	Sub-domain concentration	0.21	0.7	-0.09	-0.02	-0.03	-0.02	0.10	0.09	-0.13	0.22	0.18	-0.21

Notes. N=855.
Correlations with absolute value 0.07 and greater are significant at the 5 percent level.

Table 6: Cox hazard rate model of activity domain recombination

	Model 0	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
External modularity		0.890^{***}		0.879^{***}		0.870^{***}		0.822^{***}
		(0.195)		(0.198)		(0.213)		(0.204)
Internal modularity			-0.301^{**}	-0.244^{**}		-0.199^{*}	-0.288^{**}	-0.206^{*}
			(0.102)	(0.089)		(0.096)	(0.097)	(0.100)
Domain concentration (total assets)					-2.576^{*}	-1.571		-1.032
					(1.133)	(1.125)		(1.180)
Domain concentration (executives)					-2.543^{**}	-1.741^{*}		-3.175^{**}
					(0.857)	(0.804)		(0.984)
Sub-domain concentration							-1.978^{**}	-2.635^{*}
							(0.733)	(1.176)
Internal modularity X sub-domain concentration							0.214^{**}	0.205^{*}
							(0.074)	(0.092)
Company dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Core-theme dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Profit before Tax (x1000) (Activity system)	-0.074^{*}	-0.123^{**}	-0.081^{*}	-0.131^{**}	-0.085^{**}	-0.137^{***}	-0.083^{**}	-0.074^{*}
	(0.034)	(0.042)	(0.033)	(0.041)	(0.032)	(0.040)	(0.032)	(0.034)
Transition to IFRS	1.994	2.588	1.978^{+}	2.549^{+}	2.005^{+}	2.462^{+}	2.007^{+}	2.480^{*}
	(1.261)	(1.578)	(1.200)	(1.488)	(1.119)	(1.333)	(1.180)	(1.254)
New activity domain	-2.344^{***}	-2.543^{***}	-2.402^{***}	-2.605^{***}	-2.457^{***}	-2.726^{***}	-2.440^{***}	-2.825^{***}
	(0.422)	(0.555)	(0.417)	(0.545)	(0.434)	(0.554)	(0.426)	(0.552)
Profit before Tax (x1000) (Activity domain)	0.016	0.033	0.027	0.039	0.050	0.064	0.032	0.016
	(0.067)	(0.075)	(0.077)	(0.084)	(0.126)	(0.133)	(0.079)	(0.067)
Number activities	-0.191^{+}	-0.084	-0.185	-0.060	-0.062	0.003	-0.184	-0.032
	(0.112)	(0.112)	(0.115)	(0.116)	(0.118)	(0.120)	(0.118)	(0.132)
Observations	835	835	835	835	816	816	835	816
Log likelihood	-313.627	-293.883	-308.664	-290.372	-288.444	-273.316	-304.214	-266.621

Notes. All independent variables (except Transition to IFRS) are lagged by one year.
Robust standard errors in parentheses.
The coefficients of profit before tax on activity system level and activity domain level are multiplied by 1000 to allow better interpretation.
Hazard ratios can be calculated for each variable by exponentiating the reported coefficients.
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.5 Discussion

In this study, I examined activity domain characteristics in activity systems to understand when the recombination of a particular domain is more likely to occur. Applying a modularity perspective to activity systems, the focus has been on internal and external modularity mechanisms and the concentration of power among these modules. The longitudinal analysis of 1027 activity domain years across 166 activity domains in 15 of the largest banks in Europe between 2000 and 2011 suggests that a modular system-environment (external modularity) renders the recombination of a focal activity domain more likely. The decomposability of the activity domain itself, into distinct sub-domains that fulfill the strategic theme of the domain they belong to, decreases the likelihood of recombination. In addition, the concentration of the activity system towards one activity domain renders this domain less prone to recombination. However, the more concentrated the activity system toward sub-domains within a focal activity domain, the more likely this domain is to recombine. The theory developed in this paper and the empirical findings reported contribute to the literature on modularity in activity systems, coordination in multi-business firms, and strategic renewal.

This study contributes to modularity research by taking a module-level perspective and theorizing about the relationship between different hierarchical levels of modularity. Prior studies have recently started to examine the limits of modularity, building on the trade-offs between efficiency and novelty that firms try to balance when choosing between integrated and modular structures (Ethiraj & Levinthal, 2004; Ethiraj et al., 2008; Sanchez & Mahoney, 1996). Ethiraj et al. (2008) find that the benefits of increasing modularity come at the cost of imitability, implying that more modular structures require innovation and more frequent recombination. Galunic and Eisenhardt (2001) state that "modularity enhances innovation and adaptation at both the subsystem and system levels", implying that this enhancement is independent of the nature, the context, and the hierarchical level of the respective modules. I engaged in a journey of examining different hierarchical levels of modularity and their respective implications for recombination. With the emphasis on activity domain recombination – the dissolution of a given domain – this study embraces modularity on (1) an activity system level, by taking into account all activity domains, and (2) the activity domain level, by taking into account second-level sub-domains. I show that recombination that affects the activity system as a whole is enabled by first-level modularity and inhibited by second-level modularity. This result extends the debate of contradictory findings in modularity studies (Brusoni & Prencipe, 2006; Ethiraj et al., 2008) suggesting that module context and characteristics (Karim, 2006) are important variables in understanding the mechanisms of recombination among modules. In particular, the effects of modularity on a system level can be undermined or enhanced depending on how the system is configured on the next lower level. Higher degrees of internal modularity slow down the dynamics of recombination on a higher level unless the lower level modules are relatively central to the overall system. In addition, I find that the relative "weight" and influence of a module can also slow down recombination. That is, two systems with the same number of modules in a similar context can face different outcomes and consequences following from these modules, because different mechanisms are enabled and used.

In addition, I contribute to the literature on multi-business firms and their coordination mechanisms. Recent studies have emphasized the advantages of self-organization among business units and the power of strategic renewal that results from it (Helfat & Eisenhardt, 2004; Martin & Eisenhardt, 2010). I add to this literature by bringing out design characteristics and the context conditions required to guide the evolution of the activity system. Firms that want to ensure that even fast growing and power-generating domains remain subject to recombination may be advised to endorse decisions that foster internal modularity and allow these sub-domains to develop their own identities and influence on the rest of the system. Hence, instead of "fighting" the dominance of a given business division through other divisions in the firm, the division might endorse recombination as a source from within, eventually leading to activity system-wide effects. In addition, suppressing recombination can be beneficial in the evolution of multi-business firms if autonomous units are expected instead to compete and develop completely independently. Accordingly, this study suggests the design of units with the "requisite variety" (Ashby, 1956) of sub-divisions and/or departments that bear the potential to be a rich source of strategic renewal, rendering more disruptive system recombination obsolete or at least less frequent.

Finally, this paper contributes to the strategic renewal literature (Floyd & Lane, 2000; Huff et al., 1992) by challenging the role of the distribution of power in organizations.

Prior literature has suggested that relative standing and power over resources and information rewards activities that reinforce the existing practices and strategy (Burgelman, 2002; Pfeffer & Salancik, 1974, 1978). Similarly, the centrality of choices influences the developmental path of large parts of the system and is often strengthened over time (Siggelkow, 2002a). However, I show in this study that the concentration of activities and the relative influence on the overall system can both inhibit and enable a deviation from the current state. I extend the idea of power (or influence) distribution in organizations by emphasizing different levels where power can be manifested. The twist with these different levels is that they explain the same "pool" of power that can be distributed. This concept suggests that the competition over power is not a simple matter of same-level competitors (e.g., business divisions) but also of multiple-level competitors, i.e., divisions compete with the sub-units of another division for power and resources.

Limitations

This study has a few limitations that need to be mentioned and that pose opportunities for future research. First, the methodological approach assumes a dualism, where strategy follows structure and structure follows strategy (Chandler, 1962). I argue that activity choices and the interdependencies among them define the resulting modularity pattern. These patterns are in theory but not in practice completely detached from an organization's structure. In turn, I argue that deliberate structural choices can increase or increase interdependency among activities. However, some of this study's data rely on or are related to structural demarcations of activity sub-domains. While the effect on the coding is in itself not an issue because activity domains are likely to be organized into corresponding structures, the actual limitation following from this coding approach is that there might be unobservable (to the coder) interdependencies among domains that might interfere with the accuracy of structure as a proxy.

Second, the sample size appears to be relatively large in activity domain year observations, but the higher level observations are relatively small, with 166 individual activity domains and 15 activity systems on the highest level in one industry. Hence, the results of this study are limited to a small number of relatively large firms in the banking industry.

Third, while I provide an understanding of which activity domain-characteristics drive and inhibit recombination, it will be necessary to test whether and to what extent these effects translate into the opposite direction of strategic renewal, namely, the reinforcement of the domain. For example, I argue that concentration inhibits recombination because of its relative influence on the rest of the system to comply with the current dominant competences (Levinthal & March, 1993). This inhibition should lead to the absorption of other domains and reinforcing (thickening) of its own configuration. This relationship has not been tested in this paper and needs further validation to advance this paper's framework.

4.6 Conclusion

This study directs attention to the role of the constituting activity domains in activity system recombination. Applying a modularity perspective, I have argued and shown that modularity can have opposing effects on the dissolution of activity domains depending on which level one considers. In addition, the power centrality of activity domains and sub-domains is shown to have different effects on different levels. I hope that this paper's focus on module characteristics encourages scholars to further investigate how the building blocks of an activity system account for the dynamics on the level of the entire system.

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Appendix

Company name	Country of headquarters	Total assets in 2000 in million Euros	Years of observation	Individual activity domains (sum of all years of observation)	Number of individual activity domain recombinations
Deutsche Bank AG	Germany	925,792	2000-2011	57	7
UBS AG	Switzerland	713,380	2000-2011	52	3
BNP Paribas	France	692,325	2000-2011	54	7
Credit Suisse Group AG	Switzerland	643,620	2000-2011	53	7
Credit Agricole AG	France	534,634	2001-2011	56	0
Royal Bank of Scotland Group PLC	Great Britain	509,155	2000-2011	89	12
Barclays PLC	England	503,078	2000-2011	77	9
Société Generale	France	455,881	2000-2011	59	2
Commerzbank AG	Germany	454,873	2000-2011	64	7
Banco Santander SA	Spain	347,973	2000-2011	42	4
Banco Bilbao Vizcaya Argentaria SA	Spain	296,118	2002-2011	37	4
Danske Bank A/S	Denmark	171,695	2000-2011	55	4
Deutsche Postbank AG	Germany	133,515	2000-2011	51	0
SE Banken	Sweden	126,748	2000-2011	64	9
Allied Irish Banks PLC	Ireland	79,511	2000-2011	45	5

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