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A theory of routinization of the firm's innovation activities

ABHANDLUNG

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Dr. sc.

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Eidgenössischen Technischen Hochschule Zürich

vorgelegt von Ursula Deplazes

MSc LSE, MSc HEC, HLH

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in Sumvitg, Graubünden, Schweiz

Angenommen auf Antrag von

Prof. Dr. Roman Boutellier, Referent

Prof. Dr. Fritz Fahrni, Korreferent

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Abstract

Diese Dissertation basiert auf zwei Haupteinsichten. Einerseits führen einige Theorien das ausserordentliche wirtschaftliche Wachstum in der freien Marktwirtschaft im Gegensatz zu anderen wirtschaftlichen Systemen auf das Phänomen der Routinisierung der Innovation zurück. Andererseits zeigen Studien auf, dass die grosse Mehrheit der Unternehmen nicht fähig ist, überdurchschnittlich profitables Wachstum langfristig zu generieren. Somit liegt es nahe, dass grosses Potential darin liegt, herauszufinden, wie Unternehmungen das Phänomen der Routinisierung der Innovation nutzen können, um langfristiges profitables Wachstum zu generieren. Diese Themenstellung wird in zwei Dissertationen analysiert, deren Inhalt folgendermassen aufgeteilt ist: diese Dissertation ist vor allem konzeptioneller Natur und entwickelt eine Theorie der Routinisierung der Innovation auf der allgemeinen Stufe der Innovationsaktivitäten des Unternehmens (R-IA). Die zweite Dissertation (Deplazes 2008a) stellt, basiert (u.a.) auf die Theorie der Routinisierung der Innovation, die in der ersten Dissertation entwickelt worden ist, einen Unternehmensdesign-Ansatz vor.

Während das Phänomen der Routinisierung der Innovation der Innovationsaktivitäten des Unternehmens wenig Aufmerksamkeit erfahren hat, gibt es eine ausführliche Literatur im Bereich der Routinisierung in verschiedenen Disziplinen. Diese Dissertation setzt sich zum Ziel, einen Beitrag zu leisten, die Routinisieurng der Innovationsaktivitäten im Unternehmen besser zu verstehen. Spezifisch will sie einen konzeptionellen Rahmen basiert auf transzendentalem Realismus entwickeln, um die Routinisierung zu analysieren. Zusätzlich entwickelt die Dissertation ein Konzept der Unternehmung und ihrer Innovationsaktivitäten basiert auf Annahmen der Prozessphilosophie, Systemtheorie and Theorie der Routinen. Die Dissertation schliesst mit einer Theorie der Routinisierung der Innovationsaktivitäten, die von der Rationalisierung getrieben wird. Daraus ergibt sich ein evolutionäres Muster aus alternierenden Zyklen von disruptiver und gradueller Routinisierung. Die Dissertation beschreibt dieses Muster basierend auf Analogien mit ökonomischen, sozialen und Produktionssystemen verbunden ergänzt durch Evidenz aus zusätzlichen empirischen Analysen.

Abstract

This dissertation builds on a dual insight. On the one hand, various economic theories associate the extraordinary growth in free-market as compared to other economic systems with the phenomenon of routinization of innovation. On the other hand, studies confirm that the majority of companies are not able to generate above-average profitable growth in the long-term. This dual insight suggests there is an opportunity to investigate how companies can capitalize on the phenomenon of routinization of innovation to secure profitable long-term growth. This opportunity is explored in a joint research effort combining two research projects: while this research project develops a theory of routinization at the generalized level of the firm's innovation activities, a fellow research project (Deplazes 2008a) develops an approach of organizational design based on routinization of innovation.

While routinization at the generalized level of the firm's innovation activities has received little attention, there is a burgeoning literature related to routinization in various contexts and disciplines. This research project aims at making a contribution to understanding the phenomenon of routinization at the level of the firm's innovation activities (R-IA). Specifically, it draws a conceptual framework for studying routinization based on foundations of transcendental realism. Further, it develops a concept of the firm and its innovation activities based on assumptions of process philosophy, systems theory and theories of routines. Based on these building blocks the proposed theory of R-IA is developed. The research project concludes that R-IA is driven by the underlying mechanism of rationalization. It follows an evolutionary pattern composed of alternate cycles of disruptive and gradual routinization. The dissertation describes this pattern based on analogy with the economic, social and production systems combined with evidence from further empirical research.

Acknowledgement

For years I have been interested in phenomena associated with the polarization between creativity and automatization. The role automatized behaviour plays in creating, for example, a piece of art has fascinated me. It was my brother, Wolfgang Deplazes, who spurred my interest to research this issue in the field of innovation management. This gave rise to our joint research effort to understand routinization of innovation and define implications for firms wishing to capitalize on this phenomenon.

Initially, our objective was to develop an approach of organizational design based on insights of routinization of innovation. Quickly we understood that this implied a double research question. First, we needed to understand what routinization of innovation really was and how it manifested itself at the level of the firm’s innovation activities. Second, we needed to draw implications from these insights to develop a theory of organizational design based on routinization of innovation. This research project deals with the first research question, while Wolfgang’s fellow research project deals with the second question (Deplazes 2008a). As a matter of course, the two research questions implied a great deal of common research, both in terms of case studies and review of theories in a variety of scientific fields. In line with his background in general management and business restructuring, Wolfgang adopted a perspective of the individual firm. My own multi-disciplinary background and interest led me to adopt a more generalized perspective.

I would like to thank Wolfgang for his initiative that gave rise to this exciting research project. Our joint undertaking has been both, challenging and rewarding. Wolfgang’s creativity, curiosity and perseverance in identifying unresolved questions and answering them have been of great value to the project, but also to me personally.

I would like to express my special thanks to the supervisor, prof. Dr. R. Boutellier, and the co-supervisor, prof. Dr. F. Fahrni, for accompanying me along the path traced by this research project. Additionally, I would like to thank the companies and the scientists who participated directly or indirectly in this research project. I am grateful to my family and friends for their inspiring support. Finally, I would also like to thank my colleagues at The Swiss Federal Institute of Technology for their kind support.

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List of abbreviations

DP
Design parameters, i.e. the key physical variable (or other equivalent terms in the case of design of software, organization, system, etc.) in the physical domain that characterize the design that satisfies the specified functional requirements.

FMCG
Fast-moving consumer goods, i.e. rather inexpensive products that people usually buy on a regular basis, such as toiletries, detergents, packaged food products and other non-durables such as paper products, plastic goods and batteries.

FR
Functional requirements, i.e. a minimum set of independent requirements that completely characterize the functional needs of the product (or software, organization, system, etc.) in the functional domain. By definition, each FR is independent of every other FR at the time the FRs are established.

I-ATELIER
Innovation Atelier, i.e. the explorative sub-system of the firm's innovation system.

I-FACTORY
Innovation Factory, i.e. the exploitative sub-system of the firm's innovation system.

I-INTEGRATION
Innovation Integration, i.e. the overarching management process whereby the firm's explorative and exploitative sub-systems are coupled.

I-SYSTEM
Innovation system, i.e. the firm's innovation activities.

R-IA
Routinization of the firm's innovation activities, i.e. the manifestation of rationalization in the context of the firm's innovation activities, for which this research project proposes a theory.

SCT.
Section, i.e. the dissertation is divided into sections that are composed of chapters.

VD-ARCHITECTURE
Value-delivery architecture, i.e. the modular representation of the firm's value-delivery system.

VD-SYSTEM
Value-delivery system, i.e. a dual construct consisting of the value a company proposes to the customer and the way it structures the value for delivery.

1 Introduction

Schumpeter was among the first economists to discuss in the 1940s routinization of innovation activities. This coincided with the rise of large corporations specializing in routine innovation activities. Routinization of innovation is understood as a process gradually turning innovation activities into "internal, bureaucratically controlled process(es)" (Baumol 2004b:11). As opposed to 'fortuitous innovation' by 'lonely geniuses', routinized innovation activities can be simply planned and calculated and thus executed by trained specialists following known and pre-determined standard procedures (Schumpeter 1950). In Baumol's (2004a, 2004b) view, the main source of the extraordinary growth of free-market economies is their ability to turn innovation into the primary competitive variable for firms and thus generate continuous flows of applied innovations. This "competitive innovation arms race" leads companies to allocate increasing amounts of resources to their innovation undertakings, thereby pushing the understanding of innovation activities and accelerating their routinization. Firms specializing in routine innovations "transform the breakthrough models into more easily usable, more powerful and more marketable products, raising them from infancy into mature products with substantial markets and massive outputs" (Baumol 2004a:8). Hereby, the incremental contributions of routinized innovation activities outperform the growth contribution of the original breakthrough ideas.

At the beginning of the 21st century routinization of innovation activities has become ubiquitous. In a business environment characterized by increasing innovation frequencies, accelerating technology speed and explosion of product variants, innovative capacity becomes a pre-requisite for a firm's survival rather than a differentiating competitive advantage. Companies can no longer rely on generating fortuitous innovations, but need to have the *capability to generate a predictable and continuous flow of innovative outputs.* Business organizations attempt to meet this challenge by implementing defined and recurrent innovation procedures. For example, the number of ISO 9001:2000-certified companies increased worldwide by more than 5 times from Dec 2002 to Dec 2006 (The ISO Survey of Certifications 2006:8). Structured and documented innovation procedures enhance the feasibility of planning and managing the firm's innovation activities. Investments in innovation become more transparent and comparable with other types of investments (e.g. in production equipment) based on standard investment evaluation methods (such as NPV). Fortuitous and uncertain innovation outputs generated by 'lonely geniuses' are progressively replaced by efficient and recurrent innovation routines. Innovation is thus gradually evolving from ‘art’ to ‘science’ with bureaucrats taking over a growing part of innovation creation. This evidences the phenomenon of routinization of the firm’s innovation activities (further referred to as R-IA).

A variety of studies show that the vast majority of companies was, over the past decades, not able to generate above-average growth rates in the mid- and long-term and developed more slowly than financial markets (among others Christensen and Raynor 2003b). Successful companies were associated with sustained organic growth and high market-to-book ratios. This reveals that these companies systematically accumulate valuable intangible assets (Devan et al. 2007) directly associated with the firm’s innovative capacity. As routinization of innovation has been associated with unprecedented growth in free-market economies, we intend to investigate which implications can be drawn from the phenomenon of routinization of innovation for the individual firm. Specifically, our research interest is with what routinization of innovation is and how companies can capitalize on this phenomenon.

In section 2, we formulate the fundamentals of our research project, i.e. the research gap and question addressed in this research project, and the overall research framework, approach and methodology. In section 3, we establish the fundamental concept of the firm adopted in the context of this research project. Based on the research framework we propose for studying the phenomenon of routinization (section 4), we draw findings in sections 5, 6 and 7 from our literature review on routinization in the contexts of economics, social sciences and production management. In section 8, we apply these findings to the firm’s innovation activities based on pivot points of analogy combined with findings from further empirical research. This gives rise to the proposed theory of R-IA. We summarize the key findings of our research and give an outlook for further research in section 9. In section 10, the references used in this dissertation are presented. Further, we summarize the key findings of our publications and specify further details of our empirical research in section 11. The publications that form an integral part of our research project are attached in section 12.

2 Research fundamentals

Routinization of innovation has been identified as a major driver of the unprecedented growth in free-market economies. However, companies don’t seem to be able to systematically reap the benefits associated with the routinization of innovation. Our literature review suggests that this is based on a dual gap: the lack of a theory of routinization of the firm’s innovation activities (chapter 2.1), and the lack of a comprehensive approach of organizational design based on routinization of innovation (chapter 2.2). After discussing this dual gap, we formulate the research question (chapter 2.3) and introduce the research framework and methodology adopted in this research project (chapter 2.4).

2.1 Theory of routinization of the firm's innovation activities

There is ample literature on the phenomenon of routinization in areas such as social sciences or production management. Our literature review also produced a large number of theories of routines in various domains. However, these theories ground on distinct (implicit or explicit) ontological and theoretical assumptions, and their subject-matter is either the unitary routine (among others Becker 2005a, 2005b; Hodgson 2003; Feldman 2000; Feldman and Pentland 2003) or routinization at a higher level of macro-/micro-economics or social systems (among others Schumpeter 1950, 1955; Baumol 1993; 2002, 2004a, 2004b; Weber 1947; Luhmann 2007). Our interest, however, is with the phenomenon of routinization at the level of the firm's innovation activities.

2.2 Design approach based on routinization of innovation

Routinization of innovation has been associated with the extraordinary growth of free-market economies. Companies are struggling to generate above-average growth due to their insufficient innovative capacity. Despite the burgeoning theories and methodologies aiming at enhancing the innovative capacity of the firm and despite "forty years of studying innovation in organizations, academic research has not produced compatible theories that can guide management practice" (Tidd 2001 in Damanpour and Wischnevsky 2006:270). Importantly, scientific literature does not provide a comprehensive approach of organizational design based on R-IA. Based on the proposed theory of R-IA, we will attempt to define a set of imperatives for a consistent theory of organizational design based on R-IA, which will be further developed in a fellow research project (Deplazes 2008a).

2.3 Research question

The dual research gap discussed in chapters 2.1 and 2.2 gives rise to the following main research questions:

- *How does routinization manifest itself at the level of the firm's innovation activities?*
- *How can firms capitalize on the phenomenon of routinization of innovation?*

The present research project addresses the first research question, while a fellow research project (Deplazes 2008a) explores the second research question. Specifically, we will propose a theory of R-IA in this research project and formulate some basic implications for organizational design based on R-IA. This gives rise to the following secondary research questions:

- *How can we generate consistent findings from the diverse literature related to routinization and apply them to the context of the firm's innovation activities?*
- *What is a generalized evolutionary pattern of routinization at the level of the firm's innovation activities?*
- *What are underlying mechanisms driving routinization?*

The subject-matter of this research project is the phenomenon of routinization as it manifests itself at the generalized level of the firm's innovation activities. At the core of our research interest is the cleavage between routine and non-routine innovation activities and how it is overcome. Hereby, we do not assume a strict dichotomy between non-routine and routine innovation activities, and view the transition between the two extremes as continuous and progressive. This is in line with theories by a variety of authors such as Schumpeter (1955) and the neo-Schumpeterian theory of the firm by Winter (2006).

2.4 Research framework and methodology

Our research project encompasses four main building blocks (Fig. 1): We start with the establishment of the fundamentals of this research project (I). Then, we establish a concept of the firm's innovation activities (II) and draw findings from the diverse literature on routinization in various scientific fields, such as economics, social sciences and production management (III). Subsequently, we apply these findings to the firm's innovation activities. This gives rise to our proposed theory of R-IA. It describes how routinization manifests itself at the generalized level of the firm's innovation activities (IV).

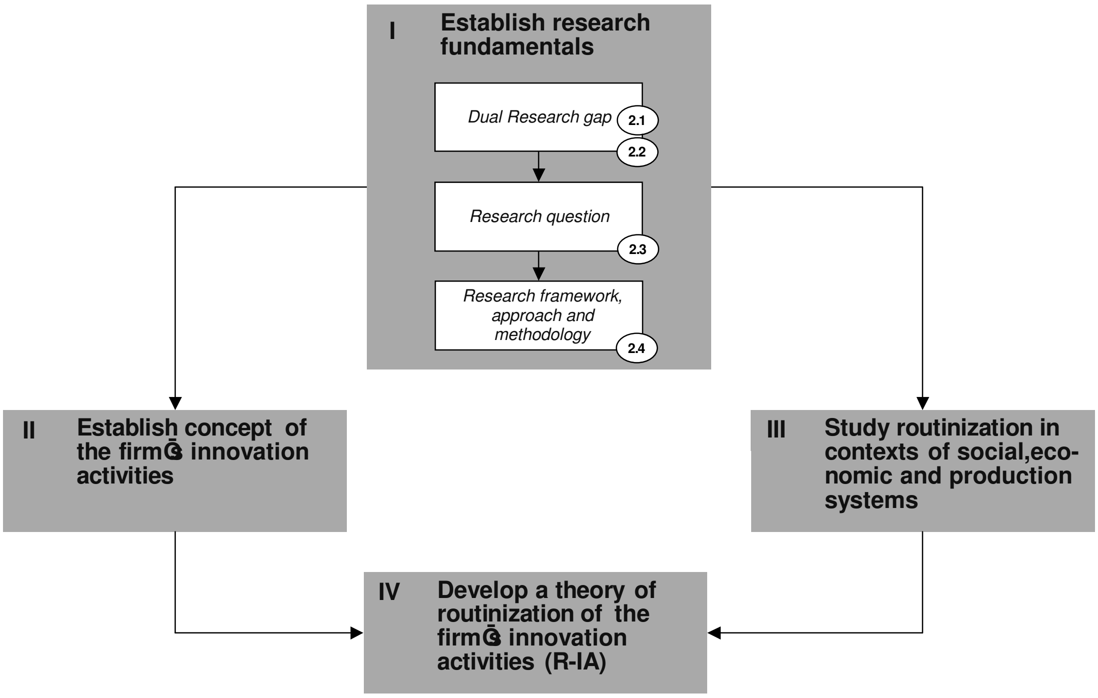


Fig. 1: Four building blocks of the research project

For each of the building blocks II, III and IV, we draw sub-research frameworks that call for specific research methodologies.

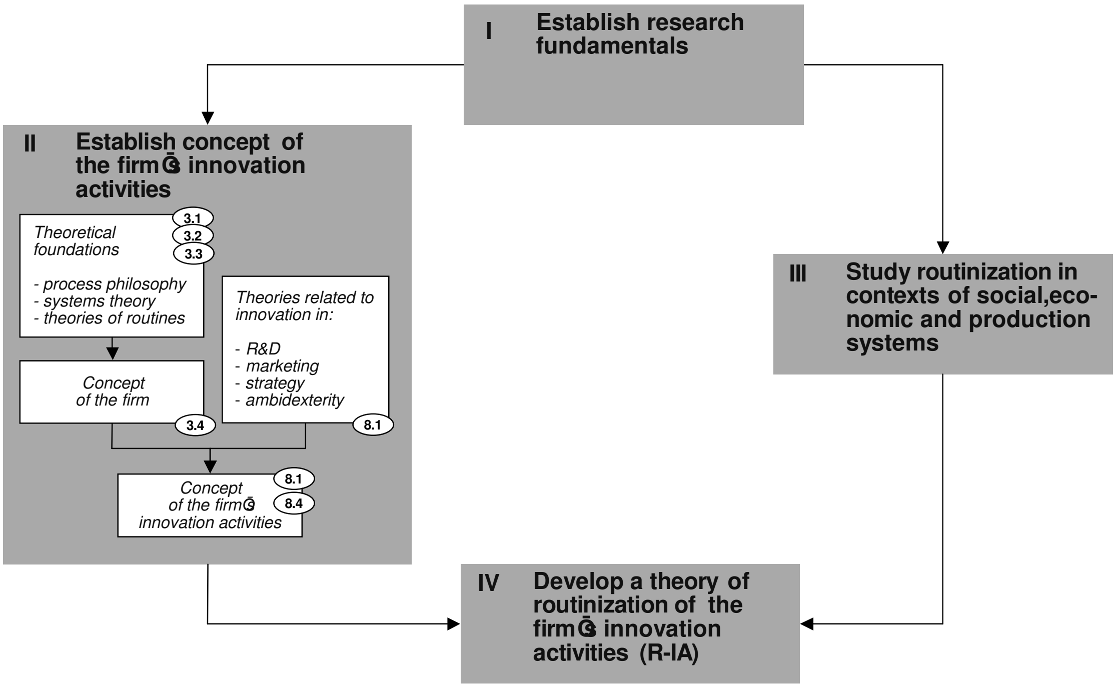


Fig. 2: Sub-research framework for building block II

In building block II, we establish the concept of the firm and its innovation activities adopted in this research project (Fig. 2). First, we select the theoretical foundations that reflect the fundamental understanding of the firm adopted in this research project, i.e. process philosophy, systems theory and theories of routines. Based on these foundations we draw a concept of the firm. Subsequently, we further specify the concept of the firm to account for the focus of this research project, i.e. the firm's innovation activities. Hereby, we apply findings from our review of literature related to innovation in the fields of R&D, marketing, strategy, and ambidexterity.

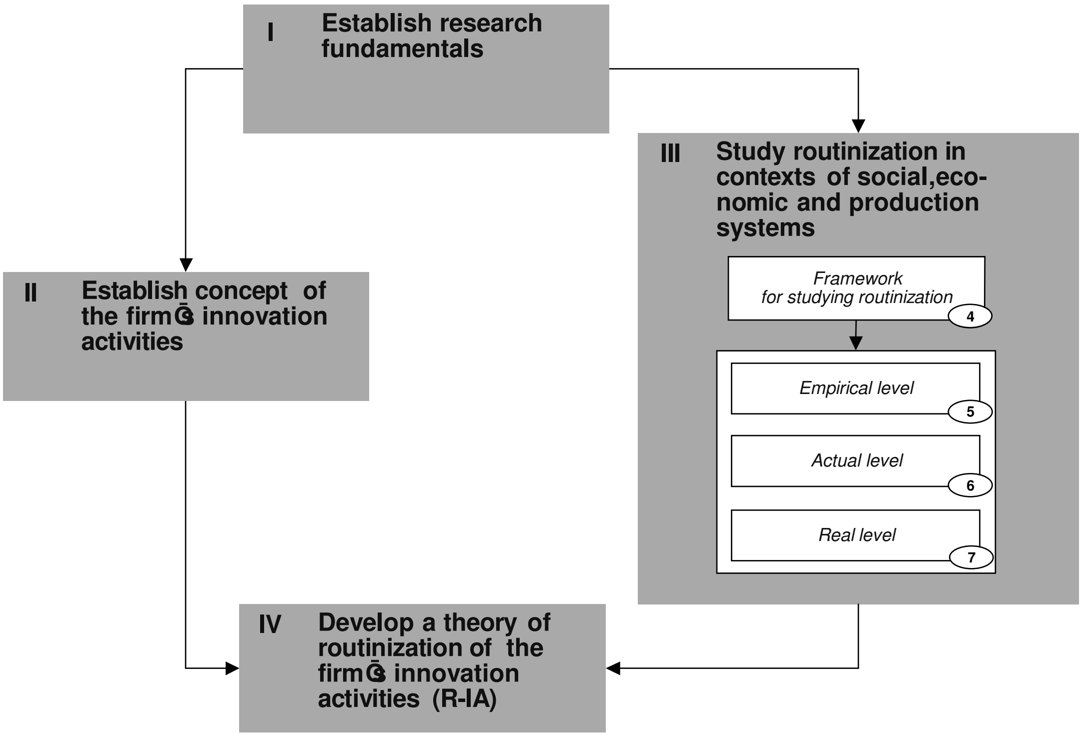


Fig. 3: Sub-research framework for building block III

Building block III: Our literature review produced a variety of theories of routinization and routines in various scientific fields. As these theories are based on diverging ontological assumptions, we need to establish a research framework that allows us to study these theories and draw consistent conclusions across various theories of routinization (Fig. 3). Based on theoretical foundations provided by transcendental realism and specifically Lawson's (1993) theory of nature and structure of reality, we draw a research framework for studying the diverse theories of routinization in the contexts of the social, economic and production systems. It is composed of three ontological levels, i.e. the empirical, actual and real ontological levels. Our research focus encompasses the actual and real levels. As these are irreducible and out-of-phase, they are connected by tendencies. The appropriate methodology to move from the actual to the real level is abduction (we further elaborate on the research framework and methodology adopted for studying routinization in section 4). After establishing the research framework for studying routinization, we review theories of routinization in the contexts of the economic, social and production systems according to the ontological levels. This allows us to draw consistent findings that can subsequently be applied by analogy to the firm's innovation activities (building block IV).

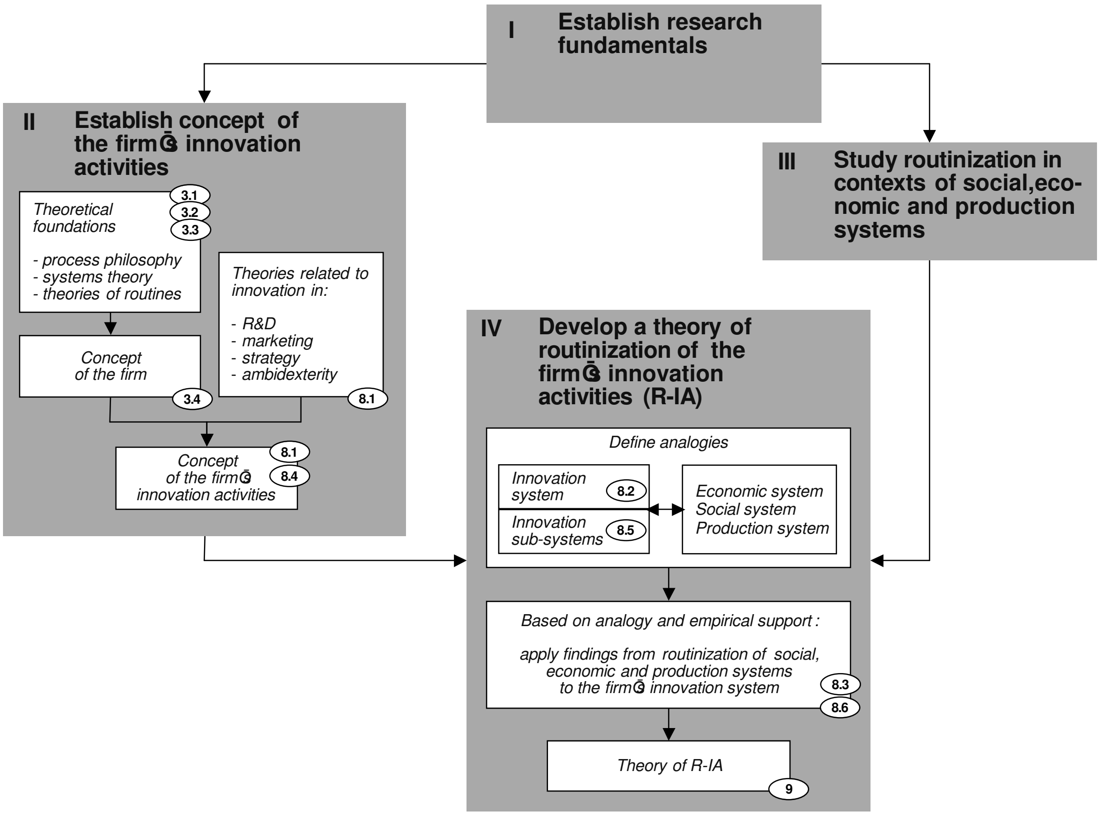


Fig. 4: Sub-research framework for building block IV

Building block IV: For developing the proposed theory of R-IA we proceed by analogy and empirical research (Fig. 4). Specifically, we establish pivot points of analogy between the firm's innovation system (and its sub-systems) and the economic, social and production systems. In combination with findings from further empirical research, this methodology allows us to apply findings from our study of routinization in the contexts of the economic, social and production systems to the firm's innovation system. The outcome of the building block IV is the proposed theory of R-IA that describes the manifestation of routinization at the generalized level of the firm's innovation activities. This theory allows us to draw some fundamental implications for organizational design based on R-IA and to propose a more general agenda for further research on R-IA.

3 Concept of the firm

In this section, we propose a concept of the firm based on theoretical foundations that accommodate for our research focus. Thus, we elaborate on the foundations of the proposed concept, i.e. process philosophy and systems theory in chapters 3.1 and 3.2 respectively. This gives rise to the adopted definition of the firm as a *system composed of routines*. It is based on two building blocks, i.e. ‘system’ and ‘routines’. While insights from the systems theory and its sub-theories apply to the first building block (i.e. system), our literature review for the second building block (i.e. routines) produced a multitude of theories associated with varying ontological assumptions. In chapter 3.3, we resort to an ontological review of these theories of routines to allow for consistent findings, based on which we establish the adopted definition of routines, their building blocks and characteristics. In chapter 3.4, the conclusions of the preceding chapters are consolidated to establish the concept of the firm used in the context our research project. This concept is further specified in chapters 8.1 and 8.4 to accommodate for our research focus, i.e. the firm’s innovation activities.

3.1 Process philosophy

Process philosophy belongs to the field of metaphysics. Process philosophy’s main concern is with what really exists in the world. Dynamic aspects of reality, i.e. processes, are prioritized over static equilibria. The main precepts of process philosophy refer to reality as a process, a continuous state of change. “(T)he whole world of reality is like an ever-flowing stream, and nothing is ever at rest for a moment” (Heraclitus in Burnet 1920:ch 3 part 65). Bergson, a prominent advocate of process philosophy, developed an evolutionary philosophy viewing life as “creative evolution”. “Chacun d’eux (i.e. des moments de notre vie) est une espèce de création” (Each moment of our life is a kind of creation) (Bergson 1957 :15). It is the source of novelty creating a future that cannot be predicted. Bergson introduced creativity as the driver of evolution. Whitehead (1990), another proponent of process philosophy, views the world as an ensemble of processes, which he calls ‘actual occasions’. Evolution is an additional process combining these ‘actual occasions’ to create new ‘actual occasions’, which are in turn new processes. Thus processes and change are the main reality in process philosophy. An ontology based on process philosophy therefore adopts a change-perspective of the subject-matter. This is in line with the unprecedented dynamics characterizing the business environment of the early 21st century, which cannot be accommodated for in static equilibrium-based models. In analogy with Steyaert’s (1997) work on entrepreneurship, we strive to avoid static equilibrium-based models and apply insights from process philosophy to define a conceptual foundation of the firm: "a process approach to entrepreneurship is seen more and more as an appropriate way to develop knowledge about entrepreneurship in that it allows me to address a changing and highly dynamic entrepreneurial reality more closely than I can using static and equilibrium-focused models" (Steyaert 1997:16).

Nelson and Winter view the organization as "a set of interdependent operational and administrative routines" (Zollo and Winter 1999:3). The firm's behaviour is determined by the organization's routines (Nelson and Winter 1982). The evolution of the firm can thus be conceptualized as changes of the firm's routines. Hereby, "routines are a unit of analysis that is processual in nature" (Becker 2004:649). They "provide a 'practice lens' for studying organizations, an analytical lens that helps understand how practices are influenced by (organizational) structures and how they constitute them in turn" (Giddens 1984 and Orlikowski 2002 as cited by Becker 2005b:819). Routines will be analysed from a situated action perspective (Suchman 1983, Hutchins 1991). Such a perspective considers "change as endemic to the practice of organizing and hence as enacted through the situated practices of organizational actors as they improvise, innovate, and adjust their work routines over time" (Orlikowski 1996 as cited by Becker 2005b:819). This evolutionary and behavioural approach to the firm is built on the firm's routines. This calls for a definition of a concept of 'routine' that will be provided in chapter 3.3.

Conclusion I / sct. 3:

- *A process approach (based on insights from process philosophy) is adopted toward the firm and its innovation activities. This is in line with the dynamic environment thereof.*
- *The firm is viewed as a set of interdependent routines. These are processual in nature and constitute the object of analysis.*

3.2 Systems theory

Whitehead, a proponent of process philosophy, can also be viewed as a precursor of systems theory. As Miller (1978) mentions, his thoughts in 'Science and the Modern World' are particularly close to the basic ideas of both, process philosophy and systems theory. Whitehead describes science as the 'study of organisms'. Each organism has a particular structure, which Whitehead refers to as the 'organic character'. From an ontological perspective, it is an organic process "that repeats in microcosm what the universe is in macrocosm" (Whitehead in 'Process and Reality' as cited by Frandberg

2005:374). Thus, there is a structure of organisms within organisms, each repeating on its own level similar processes. This is in line with the view adopted by systems theory, that complex systems have “parts-within-parts” structures. Specifically, they are “composed of subsystems that in turn have their own subsystems, and so on” (Simon 1996:184). This hierarchical structure is composed of sub-systems, each being decomposed into further sub-systems. The sub-systems are re-integrated to form a higher-rank system with irreducible emergent properties, i.e. properties at the system level that cannot be reduced to the sub-systems. The firm can thus be viewed as a complex system composed of sub-systems. We will discuss systems theory further in terms of evolution of complex systems (chapter 7.1.2) and modularity (chapter 7.2.1).

Conclusion II / sct. 3:

- *The firm is viewed as a complex adaptive system composed of sub-systems.*

Conclusion III / sct. 3:

- *Combining insights from process philosophy and systems theory, we view the firm as a complex adaptive system composed of routines. It can itself be viewed as a routine composed of sub-routines.*

3.3 Concept of routines

Nelson and Winter’s “An Evolutionary Theory of Economic Change” (1982) gave rise to burgeoning scientific research on routines and a multitude of theories of routines. However, Nelson and Winter’s concept of routines appears to be somewhat vague, particularly from an ontological perspective. Thus the theories of routines derived from their concept are quite distinct and often conflictual. While Winter views this multitude of definitions as a strength of the concept (Winter in Cohen et al. 1996:685), we agree with several authors (among others Becker 2004b, 2005a; Cohen and Badcayan 1994; Cohen et al. 1996; Reynaud 1998; Narduzzo et al. 2000) maintaining that scientific research based on a vague concept is prone to ambiguities and inconsistencies.

In this chapter, we are searching for a definition of routines to be adopted in the concept of the firm’s innovation activities. In order to counteract any potential ambiguities in the definition of routines, we first define the ontological level appropriate to our research focus (chapter 4.3.1). Then, we review theories of the relevant ontological level to establish the definition and typology of routines to be used in our research project (chapter 4.3.2). Subsequently, a routine’s building blocks and characteristics are defined, which allows for the operationalization of the rather generic concept of routines (chapter 4.3.3).

3.3.1 Ontological level of routines

We base our ontological discussion on the generic pheno- and genotype distinction and apply Becker's (2004b) categorization of theories of routines according to their ontological perspective of routines. The distinction between *genotype* and *phenotype* draws on studies of heredity and development of organisms. The phenotype describes the outward, physical manifestation of the organisms, while the genotype refers to the internal, genetic constitution. The phenotype is thought to be the result of the underlying genotype and environmental influences. From a phenotype perspective, routines are viewed as the actual behaviour that is manifested. From a genotype perspective, they are seen as the underlying 'genetic' material. Becker (2004b) builds on the pheno- and genotype distinction. He groups the numerous theories of routines into three categories, i.e. (i) behavioural patterns, (ii) rules and (iii) behavioural capabilities.

(i) *Routines viewed as behavioural patterns* relate to the level of activity, particularly aspects of behavioural regularities. At this level, routines are viewed as recurrent activity patterns. Authors viewing routines as behavioural patterns refer to the content of the pattern as 'actions', 'activities', 'behaviours', or 'interactions'. Becker (2004b) refers to these collectively as 'activities'. At the behavioural level, routines can thus be viewed as recurrent activity patterns. (ii) *Routines viewed as 'rules'* relate to the level of cognition and aspects of cognitive regularities. They are associated with the abstract representation of the activity pattern. This is in line with traditional streams in theory of computation, considering "routines to be synonymous with programs, i.e. a list of instructions in (artificial language)" (Egidi in Cohen et al. 1996:685). (iii) *Routines viewed as behavioural capabilities* relate to propensities, i.e. dispositions to express a certain behaviour or thought. Routines are thus viewed as "organizational dispositions to energise conditional patterns of behaviour within an organized group of individuals, involving sequential responses to cues" (Hodgson and Knudsen 2004:290). At this level, routines are to organizations what habits are to individuals. "(T)he building and replication of routines involves organizational learning and the transmission of knowledge" (Hodgson and Knudsen 2004:290). Hereby, routines can themselves be seen as "replicators (…), information-carrying entities that can be copied in some way in an evolving system" (Hodgson 2003:356).

Definition of routines	Authors (order according to publication year)
Behavioural action patterns	Levitt & March 1988; Cohen et al. 1996; Egidi 1996; Feldman 2000; Narduzzo, Rocco & Warglien 2000; Jarzbkowski & Wilson 2002; Becker, Lazaric, Nelson & Winter 2005; Becker, Knudsen & March 2006
Behavioural interaction patterns	Dosi et al. 1992; Pentland & Rueter 1995; Teece & Pisano 1995 ; Tranfield & Smith 1998 ; Zellmer-Bruhm 1999, Burns 2000 ; Costello 2000; Gittell 2002 ; Zellmer-Bruhm 2003 ; Becker 2005a, 2005b
Rules	Hall & Hitch 1939; Katona 1956; Simon 1957; March & Simon 1958; Cyert & March 1963; Simon 1967; Simon 1977; Cohen 1991; Egidi 1992; Delmestri 1998
Behavioural capabilities	Knudsen 2002; Hodgson 2003; Hodgson & Knudsen 2003

Table 1: Definitions of routines: A selective literature review (adapted from Becker 2005a)

The focus of our research project is with the performance implications of routines (and routinization) at the level of the firm's innovation activities. Specifically, we are interested in "how work tasks are accomplished, rather than just what tasks are to be accomplished" (Suchman 1983 in Becker 2005b:819). Among the three levels of the notion of organizational routines, the behavioural level is "the appropriate level of analysis for questions pertaining to performance" (Becker 2005b:818/819).

Conclusion IV / sct. 3:

- *Routines are viewed as 'recurrent activity patterns triggered by cues'. They are represented by rules and procedures and build on 'behavioural capacities' and 'organizational dispositions'.*

3.3.2 Typology of routines

Literature in organizational management documents a variety of theories viewing routines as recurrent activity patterns. From the perspective adopted in our research, these theories essentially characterize routines based on their (i) degree of automaticity, and (ii) scope of a routine's flexibility.

(i) Cohen et al. (1996) consider *automaticity* as the distinguishing factor between routines and other kinds of behaviour. Routines can be characterized by their degree of automaticity along a continuum opposing the two extremes of full choice and full automaticity. A high degree of automaticity is associated with narrow choices the actors can make when executing the routine. (ii) Nelson and Winter (1982) distinguish between routinized and partly routinized behaviour based on the *scope of a routine's flexibility*. Partly routinized behaviour is associated with a wider scope of flexibility, which gives rise to search routines. These "denote all those organizational activities which are associated with the evaluation of current routines and which may lead to their modification, to more drastic change, or to their replacement" (Nelson and Winter 1982:400). Search routines are associated with rather low degrees of routinization and are thus characterized by limited manageability and predictability. "When and whether a solution will be found may be quite uncertain, but the search itself follows a routine" (Nelson and Winter 1982:132).

The typology of routines adopted in our definition of the firm's innovation activities is based on the combined characteristics of automaticity and scope of flexibility. We will differentiate between two types of routines – specifically, (i) routines in the narrow sense and (ii) search routines.

(i) *Routines in the narrow sense* are "complex, highly automatic (...) behaviors that "function as a unit" and typically involve high levels of information processing that is largely repetitive over separate invocations of the routine" (Cohen et al. 1996:663). Such routines are rather specific and thus concede a low degree of discretion (in terms of search and flexibility) to their actors. (ii) *Search routine*s (Nelson and Winter 1982) are characterized by a low degree of automaticity and a wide scope of flexibility. They are rather broadly defined and concede a high degree of discretion to their actors. This involves rather demanding requirements as to the actors' skills, such as the ability to face uncertainty and the creativity needed for non-routinized problem-solving. The process of search is rather "disorderly" (Damanpour and Wischnevsky 2006:274). The outcomes of search routines cannot be entirely planned or predicted.

Conclusion V / sct. 3:

- *Routines are categorized in 'routines in the narrow sense' and 'search routines'.*
- *Both types of routines imply search activities. Search undertaken in 'routines in the narrow sense' is associated with high degrees of routinization and rather predictable outcome. Search associated with 'search routines' involves creative problem-solving and is associated with low degrees of routinization and a rather limited predictability of the outcome.*

3.3.3 Operationalization of routines

The proposed definition of 'routines' is general and thus difficult to operationalize in empirical research. Based on findings from theories of business process management and production and operations management, we enlarge the adopted definition of routines to accommodate for the firm's specific environment and ensure its operationalization in our empirical research. This gives rise to the definition of a routine's building blocks (chapter 3.3.3.a) and some key characteristics associated with routines (chapter 3.3.3.b).

3.3.3.a Building blocks of routines

Theories of production and operations management, view the production process as the transformation of inputs into outputs, which take the form of goods, services or information (among others Jewell 2003). Theories of business process management produced a variety of definitions of a process, including "a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer" (Hammer and Champy 1993:35); "a structured, measured set of activities designed to produce a specific output" and "a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs" (Davenport 1993:5); "a set of linked activities that take an input and transform it to create an output. Ideally, the transformation that occurs in the process should add value to the input and create an output that is more useful and effective to the recipient either upstream or downstream" (Johansson et al. 1993:57). Combining these definitions, a process in a business environment can be viewed as a structured and defined sequence of activities that is designed to transform pre-defined inputs to create pre-defined outputs that are of value to the customer.

By analogy, a routine can be viewed as a recurrent activity pattern processing inputs into outputs that lie within the range of the routine's pre-defined scope. The actual realization of a routine (i.e. occurrence) is enabled by organizational resources, such as specialized human resources, capabilities, and infrastructure. In the following we discuss the building blocks of a routine, i.e. (i) pattern of activities (or process), (ii) scope, and (iii) inputs and outputs (or interfaces). The argument is illustrated by an invoicing routine.

(i) *A pattern of activities* is a defined sequence of activities, also referred to as process. It is designed to allow for the recurrent transformation of inputs into outputs. (ii) *A routine's scope* defines the range of potential outputs associated with the routine. An occurrence, i.e. the actual execution of a routine, produces an output within the routine's scope. (iii) In an occurrence, *inputs* are combined to produce an *output*. A routine has two types of inputs: trigger-inputs and other inputs. A trigger-input is an output of a preceding, tightly coupled routine. It provides occurrence-specific information (e.g. customer-specific requirements, time) and triggers the execution of the routine. The other inputs are outputs of loosely coupled routines. Although they are necessary for the execution of a routine, they do not trigger it. Inputs and outputs constitute a routine's interfaces with other routines.

For a rudimentary invoicing routine the behavioural pattern might be described as a process consisting of the following operations: I - retrieve contract terms from database, II - balance delivery and contract terms, III - select appropriate invoice-standard, IV - establish invoice, V - print and dispatch invoice. The routine's scope is a range of potential outputs, i.e. standard-invoices S (S is the range of distinct standard-invoices) specifying customer information (customer name, address, contract terms and customer number N, whereby N is the range of all recorded customers), units delivered U (U is the range of deliverable quantities), and date of delivery D (D refers to the period from the start of the activity to the present). The routine's trigger-input for the actual occurrence X is the delivery note specifying units sold U_X, customer number N_X, and date of delivery D_X. This trigger-input stems from the tightly coupled routine of 'delivery to the customer'. The other inputs are delivered for stock by loosely coupled routines, e.g. customer information for customer N is stocked in a database upon conclusion of the contract in the sales process. The routine's output is an actual invoice S_X specifying customer information for customer N_X, units delivered U_X, and date of delivery D_X. The organizational resources dedicated to the routine include human resources, IT-system and infrastructure.

Conclusion VI / sct. 3:

- *A routine can be described based on its building blocks, i.e. scope, process, and interfaces (inputs and outputs).*

3.3.3.b Characteristics of routines

The routine's building blocks give rise to specific characteristics of a routine: (i) recurrence and feedback loop, (ii) conformity of scope and process, (iii) embeddedness and nestedness, and (iv) organizational requirements.

(i) *Recurrence and feedback loop:* a routine's scope and process jointly constitute a pivot point that makes similar occurrences possible. The output of a particular occurrence can be evaluated against the routine's scope and the occurrence-specific inputs. This gives rise to a systemic feedback loop: any mismatches are made transparent and lead to continuous adaptations, such as adjustments to the sequence of activities, the scope and interfaces, or the organizational resources. The routine's characteristics of recurrence and feedback loop enable an occurrence to profit from past learning and to add its own learning. This is at the core of the continuous learning associated with routines, also referred to as 'organizational learning' or 'capability development'. We will discuss the concept of feedback further in the context of progressive rationalization (chapter 7.1). Feedback loops are viewed as a major enabling and controlling factor for the dynamic evolution of a system and, in the view adopted here, of a routine. They constitute an important part of the underlying mechanisms giving rise to the phenomenon of R-IA.

Conclusion VII / sct. 3:

- *Routines are characterized by 'recurrence' and 'feedback loops'. These give rise to organizational learning and capability development. They can be described in terms of 'frequency of execution' and 'learning accumulation'. Feedback loops are viewed as a main part of the mechanism driving a system's evolution.*

(ii) *Consistency of scope and process:* a routine's scope and process are interrelated as they refer to different aspects of the same underlying reality (i.e. the routine). The scope refers to what work tasks are accomplished (research focus of routine theorists such as Perrow 1963). The process focuses on how work tasks are accomplished (research focus of routine theorists such as Suchman 1987 and Becker 2005a). Hereby, the process is defined in a way such that it combines inputs to deliver outputs in conformity with the routine's scope. Rather specific scopes (i.e. allowing for limited flexibility) are associated with narrowly defined processes (i.e. allowing for a high degree of automaticity). They jointly form 'routines in the narrow sense'. 'Search routines' are characterized by rather unspecific scopes associated with search processes. The illustrative invoicing routine is characterized by a highly specific scope (i.e. range of narrowly defined invoices) and a narrowly defined process (i.e. series of specific activities). In practice, such routines are commonly automatized. The distinction of scope and process we adopt in the concept of routines addresses the concern of several authors that "(t)he analytical distinction between work task and their accomplishment is important" (among others Becker 2005a). However, we do not give priority to either scope or process and consider both as interrelated and equally important building blocks of the underlying routine.

Conclusion VIII / sct. 3:

- *A routine's scope and process are considered as equally important building blocks of a routine. They are interrelated as they refer to the same reality, i.e. the underlying routine.*

- *'Routines in the narrow sense' are associated with rather specific scopes and narrowly defined processes. They allow for limited flexibility and high degrees of automaticity. 'Search routines' are associated with rather unspecific scopes and broadly defined processes. They allow for high flexibility and rather low degrees of automaticity.*

(iii) *Embeddedness* and *nestedness* represent the same view that a routine does not exist in isolation. By its interfaces, a routine is coupled with other routines. Their coupling gives rise to a routine of higher-rank (i.e. embeddedness) that can be situated within or beyond the firm's boundaries. This view is in line with the view adopted by Zollo and Winter (2002). A routine is itself composed of sub-routines (i.e. nestedness). Thus, the invoicing routine is triggered by the delivery notification (e.g. as recorded in the firm's ERP system). The output (i.e. actual invoice) triggers other routines within the firm's boundaries (e.g. record accounts receivable) or beyond them (e.g. payment of invoice by customer). The manufacturer's invoicing routine is thus embedded within the firm's boundaries in its higher-rank routine of 'purchasing, manufacturing and selling' and beyond the firm's boundaries in the customer's routine of 'purchasing and distributing'. Additionally, the invoicing routine is composed of sub-routines, such as the retrieval of data from the IT-system, printing, or dispatching.

Conclusion IX / sct. 3:

- *A routine is embedded in higher-rank routines within or beyond the firm's boundaries via their interfaces. This characteristic is referred to as embeddedness.*
- *A routine is composed of sub-routines that are coupled through their interfaces. This characteristic is referred to as nestedness.*

Conclusion X / sct. 3:

- *The characteristics of nestedness combined with 'conformity of scope and process' give rise to the routines' characteristic of double nestedness. A routine can thus be represented by a double architecture including: (i) a scope architecture (decomposing the routine's scope into sub-scopes) and (ii) a process architecture (decomposing the routine's process into sub-processes).*

(iv) *Organizational requirements*: For an occurrence to materialize, a routine relies on a series of organizational resources enabling the realization of an occurrence, such as capabilities, human resources, IT resources, budgets, and equipment. In the course of an occurrence, some of these resources are consumed (e.g. paper for the invoices, equipment), others develop further by accumulating learning (e.g. capabilities). The nature of these resources depends on the requirements of the routine, specifically its scope and process. Importantly, also the firm's organizational set-up (including the delimitations of areas of responsibility) is a key resource facilitating the execution of a routine. In line with findings from a variety of case studies of organizational design and with theorists of organizational design advocating for process-based organizational set-ups associated with fewer interfaces and reduced complexity (among others Hammer and Champy 1993), it can be concluded in favour of consistence between organizational set-up and the underlying routines.

Conclusion XI / sct. 3:

- *Organizational resources enabling the execution of a routine are conform to the organizational requirements deriving from the nature of the routine and specifically its scope and process.*

3.4 Conclusion concept of the firm

In the preceding chapters of section 3, we drew the proposed concept of the firm on the basis of theoretical foundations provided by process philosophy and systems theory. It was further specified by findings from our review of diverse theories of routines. These foundations give rise to the concept of the firm adopted in the context of this research project. It views the firm as an open complex system composed of two fundamental types of routines, i.e. 'search routines' and 'routines in the narrow sense'. We also discussed various implications of the proposed concept of the firm, essentially regarding its (i) representation, and (ii) operationalization.

(i) The firm can be *represented* as a multi-level hierarchy of (sub-)routines that decompose further into sub-routines (i.e. nestedness). The firm itself is viewed as a routine embedded in higher-rank routines beyond the firm's boundaries. Also the firm's sub-routines are embedded in higher-rank routines situated within and beyond the firm's boundaries (i.e. embeddedness). (ii) With regard to the *operationalization* of the proposed concept of the firm, we concluded that the firm and its sub-routines can be described based on their building blocks, i.e. scope, process, and interfaces. In addition to the characteristics of nestedness and embeddedness, they share the common characteristics of recurrence and feedback loop, and consistency among scope and process. Further, the organizational resources required for the actual execution of a routine need to conform to the organizational requirements deriving from the nature of the individual routine and specifically its scope and process.

In section 8, we further specify the proposed concept of the firm to accommodate for our research focus, i.e. the firm's innovation activities.

4 Framework and methodology for studying routinization

Our literature review produced a variety of theories related to routinization in various disciplines such as social sciences, economics and production management. However, these theories are based on distinct ontological assumptions and when combined do not allow for consistent conclusions. As we intend to use findings from these diverse theories to draw implications for R-IA, it is key to rely on explicit and consistent ontological foundations. This concern is at the core of the conceptual framework we propose for studying R-IA. In the following, we elaborate on the importance of ontology in the context of routinization (chapter 4.1) and discuss the ontological foundations of the proposed research framework, i.e. transcendental realism (chapter 4.2). Subsequently, we draw the conceptual framework for studying routinization based on Lawson's (1997) 'theory of nature and structure of reality' (chapter 4.3) and introduce the research approach and methodology we adopt for studying routinization (chapter 4.4).

4.1 Importance of ontology

Ontology is a key research area in philosophy of science. It deals with what there is, i.e. with the fundamental constituents of being. According to some, ontology identifies potential inconsistencies between the subject-matter of scientific investigation and the method of investigation chosen. Critical realists (among others Lawson 1997) adopt a broader view and maintain that ontology deals with "pre-scientific questions". Using a famous Lockean analogy, ontology 'clears the rubbish' from the 'construction site' *before* the 'edifice of science' is built. It is the '*under-labourer* of science'. The ontologist puts forward some general and "*unconditional* claims about the way the world is" (Guala 2005:3). However, Lawson (1997) advocates in line with other authors, that such ontological claims 'about the way the world is' are often implicitly assumed rather than justified by scientific research. He maintains that this may lead to conflicting ontological assumptions. An illustration of Lawson's argument for an explicit ontological framework, is his analysis of the state of contemporary economics (Lawson 1997). Lawson identifies at the core of the "persistent theory/practice inconsistencies (…) a widespread, rather uncritical, reliance by economists upon a questionable conception of science and explanation" (Lawson 1997:15). Lawson calls for a "rather fundamental, necessarily broadly methodological, enquiry" eventually necessitating "a quite radical transformation of the very nature of contemporary economics" (Lawson 1997:14).

Lawson's argument for an explicit ontological framework is also relevant for our research project. The explicit ontological framework we propose in this section, will allow us to draw implications from a variety of theories and empirical research based on inconsistent and often conflicting ontological assumptions. Hereby, we agree with the established view that any ontological exercise involves some reconstruction (a.o. Carrara and Varzi 2001). It is undisputed that "reconstruction means potential disagreement" (Guala 2005:3). Moreover, ontological theorizing goes hand in hand with the acceptance of epistemological relativism. This suggests that an idea cannot be known or represented in a neutral, culture-free manner. It implies "the possibility of a plethora of theories being produced and that none can be produced or represented in a 'cultural-free way'" (Lawson 2003:167).

4.2 Transcendental realism

Transcendental realism is a general philosophy of science where scientific investigation consists in understanding the underlying mechanisms of the particular phenomenon analyzed (Bhaskar 1997). It is associated with an "enquiry into the conditions of the possibility of some central, especially significant, or pervasive, feature of our experience" (Lawson 1997:49). This suggests that there is a mind-independent reality that can be perceived and experienced. The explanation of it is sought at a transcendental level, where deeper reasons for the existence of the actual facts are looked for. "Explanation (…) entails providing an account of those structures, powers and tendencies that have contributed to the production of, or facilitated, some already identified phenomenon of interest" (Lawson 1997:23). While empirical realism claims that reality is exhausted by atomistic events and their constant law-like conjunctions, the transcendental realist conception maintains that "the world is composed not only of events and states of affairs and our experiences or impressions, but also of underlying structures, powers, mechanisms and tendencies that exist, whether or not detected, and govern or facilitate actual events" (Lawson 1997:19).

4.3 Research framework for studying routinization

Transcendental realism gave rise to a variety of philosophical theories of science. We adopt Lawson's 'theory of nature and structure of reality' (Lawson 1997) as a foundation for our conceptual framework to study R-IA. For natural and social phenomena alike, Lawson distinguishes three ontological levels or domains of reality:

(i) the empirical level, i.e. experience and impression, (ii) the actual level, i.e. actual events and states of affairs, and (iii) the real level, i.e. structures, powers and mechanisms. These levels are ontologically distinct and irreducible to each other, i.e. they are out-of-phase or unsynchronized. Thus, they are not determined by each other in terms of causal relation. Lawson conceptualizes the links between the ontological levels as 'tendencies'. They are effects of underlying mechanisms that may or may not be materialized. "Because actual events or states of affairs may be co-determined by numerous, often countervailing mechanisms, the action of anyone mechanism, (…) may not be directly manifest or actualized" (Lawson 1997:23).

Based on insights from transcendental realism and specifically Lawson's 'theory of nature and structure of reality', we define the research framework we adopt for studying R-IA as composed of three ontological levels, i.e. (i) the empirical level, (ii) the actual level, and (iii) the real level. Our research interest lies in understanding a generalized pattern of evolution associated with R-IA and the underlying mechanisms driving R-IA. Thus, the core of the research project focuses on the actual and the real ontological levels, while the empirical level is only briefly discussed for further perspective.

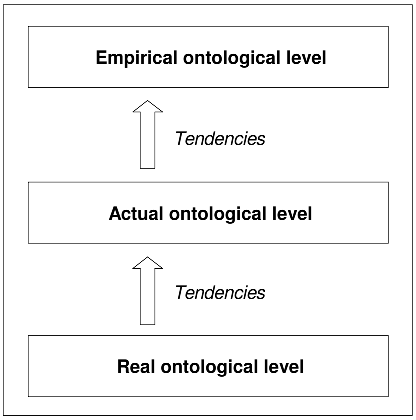


Fig. 5: Research framework for routinization composed of three ontological levels

(i) At *the empirical level,* experiences of the phenomenon are analyzed. They can vary greatly according to the observer and the time of experience. With regard to R-IA, the empirical level is associated with the accelerating flow of innovative outputs as evidenced by the increasing product variety and technological speed. (ii) At *the actual level,* routinization manifests itself in terms of progressive bureaucratization of innovation activities. Hereby, corporations progressively take over innovation activities and turn them into routines. The proposed theory of R-IA refers to the actual ontological level. (iii) *The real level* represents underlying mechanisms, powers and structures driving R-IA. Generalized mechanisms such as rationalization are analyzed at the real level including concepts of rationalization such as modularity.

- *The proposed conceptual framework for studying routinization is structured according to underlying ontological assumptions and includes the empirical, actual and real ontological levels. Although these are unsynchronized and irreducible, they are connected by 'tendencies'.*
- *With regard to routinization, experiences of routinization (such as the accelerating flow of innovative outputs) are situated at the empirical level, the manifestation of routinization at the actual level, and the underlying mechanisms driving routinization at the real level.*

4.4 Research methodology for studying routinization

In line with the research framework adopted, we review the diverse literature related to routinization from the perspectives of each ontological level. Our research focuses on the manifestation of routinization at the actual level and the underlying mechanisms at the real level. Thus, we briefly discuss findings related to the empirical level for illustrative purposes in section 5. In sections 6 and 7, we analyze theories of routinization in the contexts of the economic, social and production systems to draw findings that can subsequently be applied by analogy to the firm's innovation activities.

As the framework's ontological levels are irreducible and out-of-phase, the 'connection' between these levels cannot be established by methods of induction and deduction. These methods are appropriate to explain atomistic actual events under law-like conjunction, which contrasts with irreducible relations. Scientific enquiry based on foundations of transcendental realism is associated with methods of abduction (also referred to as 'retroduction'). Rather than attempting to cover a phenomenon under a generalisation, abduction transcends the level of actual events to find some deeper reality. Abductive methodology looks for the underlying mechanisms of some type of phenomenon analyzed. It "consists in the movement, on the basis of analogy and metaphor amongst other things, from a conception of some phenomenon of interest to a conception of some totally different type of thing, mechanism, structure or condition that, at least in part, is responsible for the given phenomenon" (Lawson 1997:23). "Abduction consists in studying the facts and devising a theory to explain them. Its only justification is that, if we are ever to understand things at all, it must be in this way" (Peirce 1867 in Becker 2005a:254). Abduction allows to cross from the actual level to the real ontological level. Questions such as ‘What does progressive routinization depend on?’ ‘Which underlying factors can be associated with routinization?’ lead to the identification of underlying mechanisms driving routinization. Thus, crossing from the actual to the real level takes place by means of abduction. It guides the search for underlying mechanisms driving routinization.

5 The empirical ontological level

Experiences at the empirical ontological level that can be associated with routinization have been object of wide empirical research in various contexts. In the field of innovation, increasing technology speed and increasing product variety have been established. Our research interest is to identify a generic pattern of evolution of routinization and underlying mechanisms driving routinization. As these are associated with the actual and real ontological levels of our research framework for studying routinization, the empirical ontological level is not at the core of our research project. Thus, we limit our argument to mentioning the finding from our literature review, that the effects of routinization of innovation can be ‘experienced’ in terms of changes at the level of (i) innovation input, and (ii) innovation output.

(i) *Indicators of innovation input* focus in general on innovation activity limited to R&D (such as BERD i.e. business expenditure on R&D, GERD i.e. gross domestic expenditure on R&D, and number of employees in R&D). They provide a rather limited view of innovation, as innovation activity encompasses various areas of the organization beyond R&D, such as strategic marketing. A survey on innovation in the United Kingdom conducted in 2005 concluded that only 41 percent of companies agree that “investment in R&D is the best indicator of innovation activity” (Mori 2005:5). It maintains further that R&D spending in innovation is a misleading indicator of innovation activity. Even though the traditional focus on R&D is starting to give way to a wider view of innovation management, there are few indicators of innovation input reflecting this wider view. According to Mori’s survey (2005), it can be assumed that actual business expenditure on innovation is about 6 times R&D expenditure and that 93% of UK companies invest on average 12% of their turnover in innovation activities.
(ii) *Indicators of innovation output* are for example the number of patents and technology speed. The number of patents has been increasing both in terms of patent applications and patent awards. Jaffe and Lerner (2004) found that US patent applications increased by more than three times in the second half of the 20th c., while patent awards in the US grew by just under 4 times in the same time frame. Similarly, Moore’s law maintains that the number of transistors that can be placed on an integrated

circuit is increasing exponentially (Moore 1965). Originally, it maintained a doubling thereof every year, which was subsequently adjusted to every two years. This law has proven its validity for the past fifty years and is expected to hold true for at least another ten years.

In general terms, various experiences of routinization of innovation are situated at the empirical ontological level, such as accelerating technology speed, increasing spending on innovation activities and increasing product variety. These can be associated with accelerating flows of innovative outputs and indicate that companies need to have the ability to generate continuous flows of innovative outputs.

6 The actual ontological level

The routinization of the firm's innovation activities at the actual ontological level has received little attention in literature. We thus proceed in this section with a review of theories in various scientific disciplines and draw conclusions that can subsequently be applied by analogy to the firm's innovation activities in section 8. Specifically, in addition to the bourgeoning literature on routines we reviewed in chapter 3.3, we draw conclusions from theories of routinization in economics (chapter 6.1), social sciences (chapter 6.2), and production management (chapter 6.3). As the theories we review ground on distinct ontological assumptions, findings thereof will be discussed according to the ontological levels defined in our research framework for studying routinization, i.e. the actual ontological level (section 6) and the real ontological level (section 7).

6.1 Theories of routinization in macro- and micro-economics

A variety of theories have been developed to explain the phenomenon of unprecedented economic growth in free-market economies, amongst which research streams considering innovation as a key force driving economic growth (further discussed in Deplazes et al. 2008a). In their theories of economic growth, Schumpeter (1950, 1955) and Baumol (1993, 2002, 2004a, 2004b) view "routinized innovation" and the "routinization of innovation" (Schumpeter 1955, Baumol 2004b) as a key driver of growth in free-market economies. As Baumol relies on Schumpeter's theory of routinization, we will briefly discuss some of his insights relevant to the actual ontological level (chapter 6.1.1) before discussing in depth Schumpeter's theory of routinization of innovation (chapter 6.1.2).

6.1.1 Routinization of innovation according to Baumol

Baumol views routinization of innovation as a significant driver of economic growth. Firms "have changed much of the economy's R&D into an internal, bureaucratically controlled process (...). They have routinized it" (Baumol 2004b:11). From the actual ontological perspective adopted here, Baumol's concept of routinization of innovation relies on Schumpeter's theory of routinization. We thus proceed with a detailed discussion of Schumpeter's theory to draw findings at the actual ontological level of the phenomenon.

6.1.2 Routinization of innovation according to Schumpeter

Schumpeter is among the most cited authors in various fields related to economics and political sciences. He coined a variety of established concepts such as creative destruction, the role of the entrepreneur, and routinization of innovation. Schumpeter's ideas appear as rather eclectic and there is no Schumpeterian school of economics with a consistent holistic framework. This gave rise to a variety of theories and empirical research that are not always compatible and in some cases even contradictory. In line with scientists such as Langlois (2007), and Becker and Knudsen (2003) we adopt the view that Schumpeter's innovation theories in his early works, such as "The Theory of Economic Development" (1955), and late works, such as "Capitalism, Socialism and Democracy" (1950), stress distinct aspects of a consistent innovation theory. This understanding contrasts with views associating for example the 'obsolescence theory' (of the entrepreneur) with Schumpeter (among others Tushman and Nelson 1990, Phillips 1971, Freeman 1982, Nelson 1977, Klein 1977 and Witt 2002).

Schumpeter is critical about 'classical' economic theories based on static, equilibrium-based models and viewing the sources of economic change as exogenous. He considered as "his mission to provide a theoretical approach that could account for the features of a self-transforming system, based on its internal dynamics rather than seeking change through external changes or stimuli" (Witt 2002:8). Schumpeter proposes a self-transforming system where innovation is an endogenous factor. His argument is based on the distinction between (i) 'development', and (ii) 'growth'.

(i) *Development* is viewed by Schumpeter as "a change from one vector norm to another in such a way that it cannot be decomposed into infinitesimal steps" (Schumpeter 1955). With regard to innovation, development is related to the generation of what Schumpeter calls 'novelty', i.e. knowledge that is qualitatively new to the system. (ii) *Growth,* however, is associated with incremental changes, i.e. with improvements along the same vector norm. Incremental changes capitalize on knowledge that is already in the system and exploit its innovation potential. Schumpeter views this exploitation of available knowledge according to pre-determined routines as the principle engine of capitalist growth. Schumpeter's distinctions of 'development vs. growth' and 'novelty vs. incremental changes' give rise to specialization in innovation and a division of labour with entrepreneurs generating novelty and large organizations dealing with routine innovation. Entrepreneur-style and corporate-style innovation jointly contribute to economic growth and form Schumpeter's self-transforming system.

Finding I / sct. 6:

- *Schumpeter views the 'economic system' as a 'self-transforming system' where innovation is an endogenous factor. It is composed of two interrelated sub-systems, i.e. the entrepreneurial and the corporate sub-systems. These are associated with development of novelty and growth by incremental changes respectively.*

Schumpeter adopts a dynamic perspective of his self-transforming system. Hereby, innovation is seen as an endogenous factor driving the system's evolution. Additionally, Schumpeter also adopts a dynamic perspective of the endogenous innovation. Hereby, the dynamics of innovation are driven by the underlying phenomenon of 'progressive rationalization of economic activity' (Schumpeter 1955), a concept based on Weber's (1947) theory of progressive rationalization (discussed in section 7, as it belongs to the underlying mechanisms driving R-IA).

Finding II / sct. 6:

- *The underlying mechanism of progressive rationalization (situated at the real ontological level) gives rise to a dynamic evolution of innovation referred to as the progressive routinization of innovation activities.*
- *As innovation is an endogenous factor, its progressive routinization drives the evolution of Schumpeter's self-transforming system (and of its entrepreneurial and corporate sub-systems).*

Although Schumpeter uses the expressions of 'routine' and 'non-routine behaviour', he opposes a strict dichotomy between the two types of innovation. He rather views the transition between these two extremes as continuous. This view is also adopted in Winter's (2006) neo-Schumpeterian theory of the firm maintaining that "(t)here is (…) a quite continuous gradation from highly routine behaviour to highly innovative behaviour" (Winter 2006:32). As most innovation activities are situated somewhere between routine and non-routine behaviour, the progressive routinization of innovation activities means that their degree of routinization increases along a continuum from non-routine to routine behaviour. Hereby, innovation activities become increasingly rule-governed in order to better meet the requirements of the particular economic situation faced by the firm. The unknown can be increasingly calculated rationally, uncertainty is gradually replaced by plans and predictability, and intuition by bureaucratically controlled processes generating innovation. The underlying mechanism driving routinization is the progressive rationalization of economic activity.

Finding III / sct. 6:

- *Routinization of innovation activities develops along a continuum from non-routine to routine behaviour. Routinization is associated with increasing degrees of rule-governance, plannability, and predictability of innovation activities.*

The specialization of innovation activities based on the distinct types of knowledge and capabilities required by entrepreneur-style and corporate-style innovations defines the division of labour in Schumpeter's self-transforming system. Schumpeter (1950) views entrepreneur-style and corporate-style innovations as interrelated, as the former is a radically new innovation on which the latter is based. For Schumpeter, the entrepreneur (referred to as 'Unternehmergeist' in the original edition in German) is, as described by Baumol (2004b), the "*independent innovator,* (...) the bold and imaginative deviator from established business patterns and practices, who constantly seeks the opportunity to introduce new products and new procedures, to invade new markets, and to create new organizational forms" (Baumol 2004b:57). In this view, large corporations are dealing with innovation activities that have already been turned into routines. These can be executed by trained specialists according to pre-determined standard procedures. They aim at achieving increases of efficiency and predictable streams of innovation outputs.

Schumpeter also adopts a dynamic perspective of the division of labour between the entrepreneurial and the corporate sub-systems. He maintains that their relative roles are evolving as more and more innovation activities are seized in a routine and become bureaucratically controlled. Thus, routinization of innovation manifests itself in the increasing number of innovation activities being represented and executed as pre-determined sequences of activities, whereas they were formerly not executed in routines. Routinization of innovation refers to innovation activities becoming 'planned' and 'calculated' and being executed by 'trained specialists' following known and pre-determined standard procedures (Schumpeter 1950). It can be concluded that routinization leads to a change of the nature of innovation activities: innovation activities formerly undertaken in an entrepreneur-style manner are undertaken in a corporate-style manner. In fact, innovation activities progressively move from the entrepreneurial sub-system to the corporate sub-system. In this view, routinization manifests itself in a rather disruptive change of the nature of innovation activities. It can thus be referred to as 'disruptive routinization'. This argument can be illustrated by e.g. (i) Edison's innovation factory, (ii) the development of chocolate products, and more generally (iii) studies of businesses that innovate constantly.

(i) *Edison's innovation factory* (Marlo Park, New Jersey) is considered as the first dedicated R&D facility. Edison made innovation more of a science than an art. Innovation was no more driven by genius-type inventors, but by teams working together in a structured way to transform ideas into products. Genius-type fortuitousness was replaced by an organized innovation process systemized into defined, repeatable steps. Edison maintained that "(t)he real measure of success is the number of experiments that can be crowded into 24 hours" (Edison in Hargadon and Sutton 2000: 163). By establishing his innovation factory, Edison "demonstrated that a stream of promising ideas could be generated if a company was organized in the right way" (Hargadon and Sutton 2000:161). This allowed for the generation of more than 400 patents in six years and the fulfilment of Edison's promises of "a rapid and cheap development of an invention" and "a minor invention every ten days and a big thing every six months or so" (Hargadon and Sutton 2000:161). (ii) The development of *chocolate goods* went a long way since, in a convent of the 16th century, nuns discovered that cocoa could be refined with sugar and spices such as clove and cinnamon. In contrast with this fortuitous genius-type innovation, we describe the innovation factory of a manufacturer of branded packaged chocolate goods in our publication attached in chapter 12.3. Specifically, in the face of increased competition and price pressure the project-based NPD (i.e. new product development) process reached its limits and required a major organizational re-shuffle to allow the company to generate a continuous flow of product news. This gave rise to an innovation organization encompassing an innovation atelier (allowing for the systematic generation of rather disruptive innovative outputs) and an innovation factory (allowing for the generation of a predictable and manageable flow of incremental innovative outputs). Innovation in this context has little to do with the original fortuitous genius-type approach, and a lot to do with disciplined and routinized planning and executing. Rather than with the genius-type inventor, innovation in this context is associated with production operations. (iii) Among a multitude of *studies on firms' innovative capacity*, we mention Hargadon and Sutton (2000) who found in their five-year study of businesses that innovate constantly, that "the best of these innovators have systematized the generation and testing of new ideas - and the system they've devised can be replicated practically anywhere, because it has everything to do with organization and attitude and very little to do with nurturing solitary genius" (Hargadon and Sutton 2000: 157).

Finding IV / sct. 6:

- *Routinization progressively moves innovation activities from the entrepreneurial sub-system to the corporate sub-system. This implies a dynamic change in their relative roles and is associated with a step-change of the nature of innovation activities, i.e. innovation activities that were formerly not expressed in routines are turned into pre-determined sequences of activities.*

The disruptive change of the nature of innovation activities gives rise to routines executed based on standard procedures. In Schumpeter's view, these procedures are determined and implemented via a normative procedure applicable in an organization. This implies that the rise of routines requires an active intervention at the level of the individual firm, whereby the routine is specified and integrated in the bureaucratic processes of the organization. Thus, 'disruptive routinization' implies the active determination of the specific sequence of activities, and the bureaucratization of the sequence of activities at the level of the individual firm. Our fellow research project that deals with organizational design based on R-IA (Deplazes 2008a) associates the mission of organizational design with this understanding of routinization as an active intervention at the level of the individual firm.

Finding V / sct. 6:

- *At the level of the individual firm, disruptive routinization is materialized based on an active intervention that establishes routines. It refers to the determination and bureaucratization of specific sequences of activities.*

After innovation routines have been established, integrated and bureaucratized, they are still subject to routinization. In this view, routinization moves innovation activities further along the continuum from less routinized to more routinized activities. This evolution is rather gradual: The individual employee executing a routinized activity is required to make some decisions while following the established pattern of behaviour. This element of discretion, that Schumpeter associates with routines, gives rise to the introduction of small variations into the system. Hereby, "only small variations at the margins, such as every individual can accomplish by adapting himself, to changes in his economic environment, without materially deviating from familiar lines" (Schumpeter 1955:81) are possible while executing routinized activities. It can be concluded that routinization gives rise to further development of routines. A rather gradual evolution allows routines to adapt to low-scale environmental changes. This increasingly efficient exploitation of available knowledge according to pre-determined routines represents in Schumpeter's view the engine of capitalist growth. It produces growth (as opposed to 'development') associated with incremental changes, i.e. with improvements along the same vector norm (as opposed to 'novelty'). Incremental changes capitalize on knowledge that is already in the system and exploit its innovation potential.

Finding VI / sct. 6:

- *Gradual routinization refers to the continuous increase of the degree of routinization of innovation activities after their bureaucratization within large corporations. It is evidenced by the increasing elaborateness of procedures, i.e. by the increasingly narrow definition of the sequences of activities.*

Schumpeter bases his argument on Weber's theory of routinization in the domain of social sciences. This is discussed in the following chapter.

6.2 Theories of routinization in social sciences

Max Weber is among the most prominent authors who coined the expression of 'routinization' in social sciences. He first introduced it in his discussion of charisma in "Wirtschaft und Gesellschaft" (1980, originally published in 1921). The expression originally applied in German is 'Veralltäglichung des Charisma' (Weber 1980). Weber views routinization as the process of bureaucratization of charismatic authority, whereby a previously exceptional (i.e. 'ausseralltäglich', 'nicht jedem anderen zugänglich') characteristic of a particular person ('Führer'), is turned into an integral part of a system. The charismatic characteristic becomes rule-governed and thus durable, i.e. permanent and stable. Behaviour based on charismatic authority is progressively turned into a routine and governed by bureaucratic domination. In Weber's view, routinization of charisma is driven by the underlying mechanism of rationalization. This latter is a universal phenomenon of abstract nature, the manifestation of which is empirically contingent. Thus, in the empirical context of charisma it manifests itself as rationalization of charisma (Weber 1980). In what is seen as his social theory, Weber describes the manifestation of rationalization also in other empirical contexts in the field of social sciences. This gave rise to concepts such as 'rationalization of social actions', 'rationalization of dominance', and 'institutionalization'. Hereby, Weber's use of the term ‘rationalization’ appears as ontologically inconsistent. To avoid ambiguities in our conclusions from Weber’s theories, we differentiate between rationalization viewed as an underlying universal mechanism and rationalization as it manifests itself in a specific empirical context. We associate the former with the real ontological level (discussed in section 7) and the latter with the actual ontological level (discussed in this section).

Finding VII / sct. 6:

- *The underlying mechanism of ‘rationalization’ is situated at the real ontological level. It is empirically contingent and its manifestation at the actual ontological level has been described in a variety of empirical contexts as e.g. routinization, rationalization of a phenomenon (such as social actions, dominance and authority), and institutionalization.*

6.2.1 Rationalization of social actions according to Weber

Rationalization in the context of social systems is at the core of Weber’s social theory. In the following, we draw generalized conclusions from Weber’s theory of ‘rationalization of social actions’. These will be applied by analogy to the firm’s innovation activities to draw implications for a theory of R-IA in section 8.

Weber describes rationalization of social actions as a dynamic evolution of the nature of social actions from less rational to more rational along a quasi-continuum of degrees of rationalization. We proceed with a discussion of Weber’s typology of social actions (chapter 6.2.1.a) and an analysis of the evolutionary pattern of social actions subject to the phenomenon of rationalization (chapter 6.2.1.b). Subsequently, we give a perspective beyond rationalization (chapter 6.2.1.c) and mention further manifestations of rationalization (chapter 6.2.1.d). The two latter chapters are, however, not at the core of our research project.

6.2.1.a Typology of social actions

Weber studies social actions based on their ‘means’ and ‘ends’, which he both associates with varying degrees of rationality. This gives rise to his typology of social actions including the categories of (i) traditional, (ii) affectual, (iii) value rational (also referred to as ‘wertrational’), and (iv) instrumentally rational (also referred to as ‘zweckrational’) social actions.

(i) *‘Traditional actions’* are determined by the customary execution of some type of action. They are influenced by long practice, i.e. ingrained habituation. Their ends are not available in the consciousness. Thus, their means and ends are irrational in Weber’s understanding. (ii) *'Affectual actions'* are determined by the actor's specific affects and feeling states. Affective actions are mechanical, emotional and not available in the consciousness. Thus, their means and ends are viewed as irrational. (iii) *'Value rational actions'* are determined by a conscious belief in values, such as ethical, religious, aesthetic, or other forms of behaviour, independently of its prospects of success. Although irrational, such ends are 'definitely given and practical' and can be achieved based on the an ever more precise determination of appropriate means (Weber 1968). In value rational actions, the ends are known and the best means to achieve these are defined based on rational principles of choice. Thus, value rational actions are associated with conscious, but irrational ends that are attained based on rational means. (iv) *Instrumentally rational actions* are determined by what is expected in the environment and by other human beings (Weber 1968). Subjectivity is reduced to a minimum. There is clear awareness about the goals to be achieved and the corresponding means. This involves the making of rational choices for ends and means. Thus, rational ends and rational means are determined based on rational means-ends calculations.

Both, traditional and affectual actions are not available in the consciousness of self-interest. They are not determined by rational optimization principles (e.g. maximization of self-interest or utility) viewed by Weber as the basis of rationality. In contrast, value rational and instrumentally rational actions pursue ends that lie within the consciousness of self-interest. This allows for a rational definition of the best means to achieve the conscious ends. While ends are irrational in value rational actions, means to achieve the ends can be chosen based on rational optimization principles. Instrumentally rational actions are considered as of the highest degree of rationality with both, means and ends being chosen based on rational optimization principles.

Finding VIII / sct. 6:

- *Social actions are differentiated based on the degree of rationalization of their 'means' and 'ends'.*
- *Traditional and affectual actions are pursuing ends that are not situated within the conscious domain and are viewed as irrational in terms of means and ends. Value rational and instrumentally rational actions pursue ends within the consciousness of self-interest. Thus, either means are chosen rationally to achieve given irrational ends (i.e. value rational), or both, means and ends are chosen rationally (i.e. instrumentally rational) based on rational means-ends calculations.*

6.2.1.b Dynamics of rationalization of social actions

In the context of social actions, rationalization manifests itself in the increasing degree of rationalization of their means and ends. It gives rise to an evolutionary trajectory of social actions from irrational actions (in affectual and traditional social systems) towards value rational and instrumentally rational social actions (in value rational and instrumentally rational social systems respectively). It can be concluded that rationalization of social actions implies: (i) a rather disruptive development moving actions into the conscious domain, and (ii) a rather gradual evolution of conscious actions towards actions based on rational ends and means.

(i) *Rather disruptive rationalization of social actions* manifests itself in traditional and affectual social systems. Specifically, the rationalization of traditional actions is the substitution of the unthinking acceptance of ancient custom by deliberate and conscious adaptation to situations in terms of self-interest (Weber 1968). And the rationalization of affectual actions manifests itself in the transformation of existing material relationships into rationalizing norms (such as legal system). Thus, the rationalization of traditional and affectual social actions implies that they undergo a step-change of their nature and become available in the conscious domain. As the ends are made conscious, the means can be selected rationally based on their relative efficiency in reaching the ends. In this view, rationalization of social actions is associated with a dynamic, even revolutionary, social process that breaks down old institutional forms and lays the foundation for new ones (Weber 1968).

Finding IX / sct. 6:

- *Disruptive rationalization implies that social actions become conscious in terms of pursuing self-interest. As ends become conscious, means can be defined rationally based on their relative efficiency to achieve the conscious ends. This is referred to as rationalization based on rationality of means.*

(ii) The *rather gradual rationalization of social actions* manifests itself in the evolution of value rational social systems towards instrumentally rational systems. Specifically, irrational value-based ends are progressively converted into rational ends that are coherent with rational principles of optimization. Social systems subject to rationalization move from the value rational to the instrumentally rational type. Instrumentally rational actions are purely rational in the Weberian sense. Rational ends give rise to rational means-ends calculations. Thus, means and ends are not only conscious, but selected according to rational procedures.

Finding X / sct. 6:

- *Rationalization of social actions within the conscious domain gives rise to a gradual evolution of ends from value-based ends to ends selected according to rational procedures. Both, ends and means are selected based on rational means-ends calculations. This is referred to as rationalization based on rationality of ends.*

Conclusion I / sct. 6:

- *Combining findings IX and X/sct.6, it can be concluded that rationalization of social actions develops along a quasi-continuum encompassing (i) rationalization based on rationality of means, and (ii) rationalization based on rationality of ends.*

Action type	**Means**	**Ends**	**Quasi-continuum of rationalization**
Affective & traditional	unconscious-irrational	unconscious-irrational	becoming conscious
Value rational	rational	irrational	rationalization based on rationality of means
Instrumentally rational	rational	rational	rationalization based on rationality of ends

Table 2: Quasi-continuum of rationalization

6.2.1.c Perspective beyond rationalization

Weber also discusses an evolutionary dynamic where instrumentally rational social systems evolve into value rational systems that appear to be more stable. He maintains that, in instrumentally rational social systems, the rational orientation toward a set of rationally chosen individual ends gives rise to increasingly similar and uniform attitudes and actions by the actors. Hereby rational ends become conventional, i.e. pure rationality is replaced by conventional values. In this perspective beyond rationalization, the main concern is with how ‘what is generally done’ passes into convention and how ‘matters of taste’ become ‘matters of principle’ (Weber 1968).

Conclusion II / sct. 6:

- *Rationalization drives social actions towards the ‘instrumentally rational’ actions. Due to particularities of the social system, instrumentally rational systems tend to substitute their individual and purely rational ends for collective value-based ends and thus move towards value rational systems.*

The present research project is concerned with routinization of innovation as driven by the underlying mechanism of rationalization. What comes beyond rationalization is not at the core of the research project. In this context, our literature review produced findings from empirical research on the effects routines have on workers. In cosiological literature "(t)here is a high degree of consensus among analysts on how routinization affects workers: it oppresses them, it robs their work of interest and variety (…) it prevents them from deriving self-worth (…) (thus) alienating workers form their feelings, their faces, and their moods" (Leidner 1993:4). Braverman (1974) is a prominent advocate of this process of deskilling associated with work routinization. We also encountered more favourable accounts of the effects of work routinization. Thus, Leidner (1993) analyses routinization of interactive service work where employees are in direct contact with customers. She comes to the conclusion that routinization both degrades and benefits employees and customers. While we recognize the scientific and practical interest of this aspect of routinization, it lies beyond the scope of our research focus. The present research project is concerned with the analysis of routinization without making any qualitative judgement on its effects on the workers or discussing other socio-psychological aspects, such as their motivation. Human resources are viewed as organizational resources facilitating the execution of the routine and accumulating learning with each occurrence. They are selected and tailored according to the requirements of the routine. At another level, human resources are associated with the establishment of routines, i.e. the determination and bureaucratization of specific sequences of activities (conclusion VII/sct.6).

6.2.1.d Other manifestations of rationalization

Weber also described the manifestation of progressive rationalization in other contexts than social actions and referred to these as rationalization of domination and authority, institutionalization, and routinization of organizations. They all build on the same foundation that progressive rationalization is the underlying mechanism driving a system's evolution towards the instrumentally rational type. Hereby, the rationalization of the system moves along a quasi-continuum including rationalization based on assumptions of rationality of means followed by rationalization based on rationality of ends. To support this generalized conclusion, we will briefly elaborate on (i) the rationalization of domination and authority, and (ii) institutionalization and routinization of organizations.

(i) Weber's concepts of *domination and authority* are closely linked. Domination is "the source of legitimate authority in collective action" (Pluye et al. 2004:123). Weber's continuum of dominance reaches from the power- to the charisma-based dominance. Bureaucratic domination lies in between these two extremes. Rationalization tends to convert charisma-based dominance into bureaucratic dominance. "From a technical point of view, the most 'rational' type of domination is found in the bureaucracy simply because it aims to do nothing more than calculate the most precise and efficient means for the resolution of problems by ordering them under universal and abstract regulations" (Kalberg 1980:1158). It can be concluded that domination and authority are subject to the same underlying mechanism of rationalization. It drives the degree of rationalization along a quasi-continuum based on evolving assumptions of rationality of means and subsequently rationality of ends. Hereby, charisma-based dominance transits into bureaucratic dominance. (ii) The concepts of *institutionalization and routinization of organizations* are associated with the same underlying mechanism of rationalization. Institutionalization is a "process by which certain social relationships and actions come to be taken for granted, and a state of affairs in which shared cognition defines what has meaning and what actions are possible" (Powell and DiMaggio 1991 in Pluye et al. 2004:124). It thus implies the establishment of customs and norms within institutions (e.g. a political system). Routinization in Weber's understanding refers to the establishment of norms, rules and routines within organizations. Institutions and organizations are seen as interrelated. Laws and norms of society influence organizational routines and vice versa.

6.3 Routinization in production

In theories of production, routinization has been associated with increased efficiency particularly in changing environments. In the following, we discuss theories of production management and routinization of production to draw conclusions that can be applied by analogy to the firm's innovation activities and establish implications for R-IA in section 8. Specifically, we analyze routinization in production as it manifests itself in the transition from craft to mass production (chapter 6.3.1), and the advent of more flexible production routines (chapter 6.3.2).

6.3.1 Transition from craft to mass production

The concept of 'routinization' was derived from Taylor's "The principles of scientific management" (first published in 1911). Taylor defined principles and methods to cope with the new challenges in manufacturing at the beginning of the 20th century.

On the one hand, the social emancipation of workers increased the organization's vulnerability to skilled workers leaving or striking (Kraft 1977) or - in Taylor's terms - the generalized phenomenon of 'shirking' that jeopardizes production output. On the other hand, the appearance of large and relatively homogeneous populations of consumers gave rise to a stable demand for standardized products in large quantities at relatively low cost. In such an environment, routines of craft production associated with skilled workers producing unique outputs reached their limits. This gave rise to the introduction of routines of mass production. The disruptive evolution from craft production to mass production is referred to as routinization in Taylor's scientific management. The most prominent example is the production of Ford's Model T. However, similar disruptive routinization can be observed long before scientific management in situations where the advent of a stable market environment allowed for the production of large volumes of relatively homogeneous outputs. Literature alleges examples such as: (i) the production of the Chinese Emperor Qin's Terracotta Army (around 215 BC) in which separate body parts were manufactured by different workshops and subsequently assembled for completion; (ii) the building and equipping of galleys at the Venetian Arsenal (16th century) with standardized parts on an assembly-line basis; (iii) Brunel's block-production (early 19th century) for the Royal Navy based on a linear and continuous assembly line; (iv) American firearm manufacture in the early 19th century based on assemblies of interchangeable parts in a repeatable manner; (v) various industries in the Industrial Revolution improving materials handling, machining, and assembly in the 19th century, such as textiles, sewing machines, clocks and watches; and (vi) Old's Motor Vehicle Company viewed as the first company to mass-produce automobiles using its patented assembly line around 1900.

It can be concluded that there is a variety of instances in the history of production when the advent of a stable market environment allowed for stable, large volumes of homogeneous outputs, which required a new kind of production routines. Gradual improvements of conventional craft production routines reached their limits in the face of the new requirements for large volumes of homogeneous outputs. Companies tended to question conventional production routines and embraced 'disruptive routinization'. They re-designed their production systems to allow for the exploitation of the new potential offered by environmental changes. The failure to do so is illustrated by the disappearance of a variety of automobile manufacturers succumbing to 'inertia' in the early automobile industry. To better understand the mechanics of this 'disruptive routinization' in the context of production, we contrast (i) craft production routines with (ii) mass production routines by means of the routine's building blocks established in section 3 (conclusion VI/sct.3), i.e. their scope, process, and interfaces (inputs/outputs).

(i) *Craft production routines* are suited for producing unique outputs in low volumes. They involve a high degree of customization both in terms of output and process, as each part of a product is created individually before being assembled on the basis of skilful cut-and-try changes of the parts. Craft production routines with their wide scopes of heterogeneous outputs and broadly defined processes build on highly versatile resources, such as craftsmanship and flexible tools. Recurrence across several unique products is achieved at the high and unspecific level of the production system (i.e. the workshop). (ii) *Mass production routines* aim at producing a flow of homogeneous outputs in large volumes. They are associated with a narrow scope of homogeneous outputs and a narrowly defined process. In view of the stable and high volumes required, the narrow scope gives rise to interchangeable parts and the narrowly defined process to repeatable specific operations. Mass production routines can thus be decomposed into sub-routines (i.e. workbenches). These perform a narrowly defined sequence of operations using highly specialized resources (i.e. labour and machinery). Recurrence is achieved at the level of the sub-routines where it drives efficiency and specialization (and thus independence of skilled workers). The workbenches are tightly coupled along an assembly line to form a narrowly defined production routine producing a flow of outputs. Hereby, a partially completed product moves along the assembly line and undergoes defined sequences of narrowly specified operations until product completion.

'Disruptive routinization' thus refers to the re-design of the production system in the face of the new requirements by a changed market environment. In terms of systems theory, a complex system (i.e. the production system) is structured into sub-systems (i.e. sub-routines) in a way such as to allow for specialization at the level of the sub-routines and give rise to emergent properties at the level of the production system. Hereby, emergent properties are defined as irreducible properties, i.e. they cannot be reduced to the sub-systems. This implies the definition of new, homogeneous scopes and corresponding processes, which gives rise to routines of a higher degree of specificity than conventional routines. They can be decomposed into more specific sub-routines with dedicated sub-scopes, sub-processes, and resources (labour and machinery). Recurrence and feedback loops are relegated to lower levels of the production routine. This is associated with increased efficiency in terms of economies of scale and learning accumulation. The tight coupling of the sub-routines along the assembly line gives rise to the emergent properties of stability, scale and output homogeneity at the level of the production system.

Finding XI / sct. 6:

- *Disruptive routinization implies a re-design of the production system according to the new requirements of the changed environment. It allows for subsequent gradual routinization within the new set-up.*
- *Changes of the environment open up new potentials in the face of which production systems based on conventional routines reach their limits. Disruptive routinization aims at achieving the efficiency-leap required to reach new dynamic stability in the changed environment.*

6.3.2 Advent of specialized sub-routines

Post-industrial business environment is characterized by increasing *volatility* and *differentiation*: market segments are progressively fragmented; time is compressed, variable, and volatile (Blackburn 1991, Stalk and Hout 1990); change is frequent and fast-paced (Toffler 1970); firms must evaluate and act upon the high rate of technological innovation and expanded product offering that characterizes this environment (Huber 1984, McCutcheon and Raturi 1994, Nord and Tucker 1987). The appearance of volatility and differentiation gave rise to requirements of *adaptability* and *variety* in production. These cannot be met alone by routines of mass production designed to produce stable, large volumes of homogeneous outputs. The challenge in production is to achieve economies of scale and meet the requirements of output variety and adaptability. Based on our review of theories of production management, we conclude that rationalization drives routinization in production at two levels: (i) the increasing specialization of sub-routines in terms of scope and process, and (ii) the differentiated coupling of these sub-routines to ensure irreducible emergent properties at the level of the production system.

Theories of production management describe specialized production (sub-)routines including project production, jobbing production, batch production, line production, continuous flow production, as well as combinations and advancements thereof. We reviewed these specialized sub-routines based on the building blocks of a routine established in section 3 (conclusion VI/sct.3), i.e. scope, process, interfaces. In the following, we discuss their specialized scopes (chapter 6.3.2.a) and processes (chapter 6.3.2.b), and subsequently their interfaces, i.e. their coupling that gives rise to irreducible emergent properties (chapter 6.3.2.c).

6.3.2.a Specialized scopes

The scopes of the specialized routines described in production management can be categorized based on criteria such as type of product variety (i.e. unique products, distinct products requiring similar task-expertise, variants of a same basic product, standardized discrete products, and standardized continuous products), type of demand (i.e. make-to-order, make-for-stock, assemble-on-demand), and volumes required (i.e. one-off, small quantities, batches, large quantities, flow). Combining these criteria gives rise to a typology of scopes based on the underlying product structure, i.e (i) unique products, (ii) distinct products, (iii) product variants, (iv) standardized discrete products, and (v) standardized non-discrete products.

(i) *Unique products* are also referred to as projects. They are one-off products made-to-order such as oil tankers and civil engineering projects. Such unique projects are associated with project production routines used e.g. for the construction of a power plant and for auditing the accounts of a large company. (ii) '*Distinct' products* are products that have distinct product structures, but the production of which requires similar functional task-expertise, such as forging, casting, welding, joining, turning, or sandblasting. Such products are usually produced in small quantities and made-to-order in jobbing production routines. Examples for this type of products include made-to-measure suits and sailing boats. (iii) *Product variants* have the same underlying product structure that allows for a certain degree of variation. They are usually produced in batches and made-for-stock (e.g. baked products, sports shoes, pharmaceutical ingredients, inks paints, adhesives) in batch production routines. (iv) *Standardized discrete products* have a standardized product structure. They are usually made-for-stock in large quantities using line production routines. Examples include motor vehicles and electrical goods. (v) *Standardized non-discrete products* have a standardized product structure (or recipe). They are made-for-stock in routines of continuous flow production. Examples include oil refining, cement and chemical manufacture.

- *Routinization of production gives rise to specialized sub-routines, the scopes of which are differentiated based on the underlying product structure. This gives rise to a typology of outputs including unique products, 'distinct' product, product variants, and standardized products.*
- *'Product structure' is a differentiation criterion that combines several output characteristics, i.e. degree of variety, type of demand, and volumes required.*

6.3.2.b Specialized processes

In the context of rationality of ends based on rational means-ends calculations (Weber 1968), the typology of specialized scopes (i.e. ends) gives rise to an according typology of specialized processes (i.e. means). Processes are thus designed to allow for optimal recurrence associated with economies of scale and learning accumulation. In accordance with the typology of specialized scopes (or innovation outputs), production management describes a typology of specialized processes including (i) project production, (ii) jobbing production, (iii) batch production, (iv) line production, (vi) continuous flow production, as well as combinations and advancements thereof (such as cell production, and fractal factory).

(i) *Project production* is used in the realization of one-off unique products, usually referred to as projects. The process includes breaking down the project into manageable tasks and coordinating these for project completion. In the production of several one-off projects, recurrence (and thus efficiency and learning accumulation) is achieved in a broadly defined project management process covering how to structure projects into tasks and coordinate these for project completion. (ii) *Jobbing production* applies to the production of 'distinct' products. The process is based on the product-specific configuration of sub-routines. Each of these perform specialized functional tasks (e.g. forging, casting) on a stream of distinct products. In accordance with their heterogeneous scopes, the sub-routines are highly versatile and endowed with broadly defined sub-processes and versatile resources. Recurrence is achieved based on the combined volumes of distinct products requiring similar functional tasks and the versatility of the task-specialized sub-routines. (iii) *Batch production routines* are used in the production of variants of a same basic product. The process is designed according to the requirements of the basic product and is broad enough to accommodate for variants. Similar operations are grouped in sub-routines (i.e. workstations) with dedicated sub-processes and resources. Recurrence is achieved based on scale (i.e. product variants grouped in batches) and sufficient versatility of the sub-routines to allow for variants. (iv) *Line production routines* are used for mass-producing a standardized discrete product. The process is narrowly defined according to the requirements of the product. Same operations are grouped in sub-routines. These perform narrowly defined sequences of operations and require specialized labour and machinery. Recurrence is achieved based on the high volumes of identical outputs, the narrow definition of the sub-routines, and their tight coupling e.g. along assembly lines. (v) *Continuous flow production routines* are used for flow-producing a standardized non-discrete product in large volumes. The production process is narrowly defined to the requirements of the standardized product and the resources are highly specialized. Recurrence is achieved based on continuity of production (often 24/7) in narrowly defined routines tightly coupled in a production line.

Finding XIII / sct. 6:

- *The specialization of the scopes gives rise to specialized processes including processes of project production, jobbing production, batch production, line and continuous flow production.*
- *Specific scopes (i.e. product variants and standardized products) are associated with narrowly defined processes and specialized resources (i.e. batch, line and continuous flow production). Heterogeneous scopes (i.e. unique and 'distinct' products) are associated with broadly defined processes and versatile resources (i.e. project and jobbing production).*

Conclusion III / sct. 6:

- *Recurrence across product variety is achieved based on the grouping of similar products (i.e. object-orientation) or similar functional tasks (i.e. skill- or 'process'-orientation) in sub-routines.*

6.3.2.c Interfaces and coupling of specialized routines

In the preceding chapters, we discussed the specialization of the sub-routines in terms of their scopes and their processes. This chapter discusses the coupling of specialized sub-routines that gives rise to irreducible emergent properties at the level of the production system, e.g. adaptability and output variety. Our review of routines in production management produced four essential types of coupling, i.e. (i) tight coupling, (ii) loose coupling, (iii) de-coupling, and (iv) dynamic coupling.

(i) *Tight coupling* of sub-routines gives rise to narrowly defined production routines. These cannot be easily re-configured to allow for the production of different products. Tightly coupled sub-routines are associated with mass-production of standardized products, where flexibility in the production routine is not needed. Routines of line production and continuous flow production are composed of sub-routines that are tightly coupled (usually along an assembly line) based on pre-defined 'takt-times'. Managing the production process focuses on keeping the pace of the production flow to the pre-defined 'takt-times' to avoid stoppages and capacity under-utilization. While some conventional theories maintain that the pace of production flow should be below 'takt-time' to allow for safety margins, lean manufacturing advocates that the pace of production flow should equal 'takt-time'.

Finding XIV / sct. 6:

- *Sub-routines are tightly coupled based on pre-defined 'takt-times' according to which the pace of the production flow is managed. Tight coupling of sub-routines avoids unnecessary (and costly) flexibility in a production system.*

(ii) '*Loose coupling'* of sub-routines increases the flexibility of the production routine. It allows for the (re-)configuration of the sub-routines according to the technical requirements of the specific product. In jobbing production routines, task-specialized sub-routines can be re-configured to allow for the production of several 'distinct' products requiring similar functional tasks. Managing the production routine involves *scheduling*, i.e. the product-specific configuration of sub-routines and the specification of which tasks to perform, when, and in which quantities to achieve optimal capacity utilization. In batch production routines, the batches are scheduled for optimal capacity utilization and minimal changeover, in addition to keeping the pace of production flow within a batch to defined 'takt-times'.

Finding XV / sct. 6:

- *Loose coupling increases versatility of the production routine to allow for the production of 'distinct products' and varying batches. Loose coupling is associated with re-configuration, scheduling and buffers.*

(iii) The '*de-coupling of sub-routines'* is applied in production routines such as assembly-on-demand and cell-production. Hereby, sub-routines are time-decoupled and connected via stocks. Such time de-coupling of sub-routines accommodates for further specialization of sub-routines in terms of task characteristics (e.g. manufacture, assemble), product characteristics (e.g. modules, components), different volume requirements (e.g. optimal batch sizes), different demand requirements (e.g. make-to-order, make-for-sock) and/or different cycle times. Time de-coupling allows for increased recurrence at the level of the sub-routines and increased reactivity to demand at the level of the production routine. Thus, 'assembly-on-demand' routines are decomposed based on task characteristics into a 'manufacturing-routine' and an 'assembly-routine'. The first manufactures semi-finished products for stock and the second assembles these into finished products on demand. The manufacturing routine is further decomposed into sub-routines (based on the characteristics above). When these sub-routines are de-coupled, they each produce modules (or variants thereof) for stock according to their specific requirements (of volume, demand, functional tasks, or cycle times). They are thus not merely executed in parallel to reduce lead-times, but they are out-of-phase to optimize their efficiency pending on their specific requirements. Subsequently, these modules are assembled-on-demand into finished goods.

Finding XVI / sct. 6:

- *Time de-coupling of sub-routines allows for increased specialization and recurrence at the level of the sub-routines and increased reactivity to requirements of demand at the level of the production system. De-coupling is associated with an overarching management process and a combination of 'scheduling' and 'takt-times'.*

(iv) '*Dynamic coupling'* is applied in production routines associated with fractal factories. It aims at overcoming the static perspective of conventional routines. Dynamic coupling goes beyond the re-configurability (loose/tight coupling) and the advanced specialization (de-coupling based on stocks) of the sub-routines. It adopts a dynamic perspective of the sub-routines and their interfaces. Thus, sub-routines (referred to as 'fractals') are defined to allow for self-transformation and self-organization. This implies also a dynamic evolution of their interfaces. Hereby, fractals are defined based on characteristics of self-transformation including product characteristics, availability of resources, material flow, and requirements of learning and capability building.

Finding XVII / sct. 6:

- *Dynamic coupling allows for increased adaptability in dynamic environments by allowing for 'self-transformation' of the routines. The dynamic evolution of the scope and process of the routine gives rise to a dynamic evolution of its interfaces.*

7 The real ontological level

In section 6, we discussed the manifestation of rationalization in various empirical contexts. At the real ontological level discussed in this section, our interest lies beyond the empirical contingency of rationalization. We search for generalized assumptions of rationality underlying routinization and for generalized evolutionary patterns of complex systems subject to rationalization. In section 8, we combine these findings with findings from section 6 and from empirical research, and apply them to the firm's innovation activities to draw implications for R-IA.

In Baumol's (2004b) view, the mechanisms of free-market economy lead to an innovations arms race that gives rise to routinization of innovation. "(W)hat differentiates the prototype capitalist economy most sharply from all other economic systems is free-market pressures that force firms into a continuing process of innovation, *because it becomes a matter of life and death for many of them"* (Baumol 2004b:viii). In contrast with conventional economic models viewing price as the major competitive variable, Baumol maintains that innovation is the primary competitive variable. Business organizations are dragged into a competitive "innovation arms race" (Baumol 2004b:270), where large and growing resources are allocated to innovation activities. Thus, the innovation arms race gives rise to and is itself fuelled by increasing resources allocated to innovation. Besides a growing concern for efficiency in innovation management, this leads to an increasing understanding of innovation, which allows companies to integrate a growing proportion of innovation activities within the confines of the firm. Baumol's innovation arms race thus drives R-IA.

Conclusion I / sct. 7:

- *The competitive innovation arms race typical of free-market economies drives the amount of resources allocated to innovation activities. This pushes understanding of innovation and ultimately routinization of innovation.*

The main implication of the innovation arms race for the individual firm is, however, not related to resource allocation and efficiency. It lies deeper: as routinization of innovation develops at a level higher than the individual firm, the firm needs to find ways to capitalize on this phenomenon. This is at the core of our research project that aims at understanding R-IA. In this section, our concern is with understanding basic mechanisms driving routinization of innovation that go beyond increasing resources and the management thereof. Specifically, we search for generalized characteristics and a generalized pattern of rationalization that can subsequently be applied to the firm's innovation activities to draw, in combination with the findings in section 6, implications for R-IA in section 8.

In chapter 7.1, the underlying mechanism of rationalization is discussed independently of its empirical contingency. This allows to draw implications for a generalized dynamic pattern of rationalization. In chapter 7.2, general concepts of rationalization stemming from systems theory and theories of complexity are discussed. They include among others modularity, standardization, and axiomatic design.

7.1 Progressive rationalization

In Schumpeter's (1955) view, the underlying mechanism driving routinization of innovation activities is the "progressive rationalization of economic activity" (finding II/sct.6). It is an economic manifestation of the general evolution of rationalization of society in which capitalism is rationalizing the human mind (Schumpeter 1951). Schumpeter describes capitalism "as a 'rationalist civilization', with a tendency to weaken and even do away with extra- or non-rational, pre-capitalist sanctions and habits of mind" (Zafirovski 2007:29). Hereby, rationality is understood in terms of rational choices based on defined preferences. This builds on Weber's (1947) theory of rationalization viewing rationalization as 'the disenchantment of the world', i.e. "the disappearance of the supernatural and the metaphysical in favour of a hard-headed concern with the here-and-now" (Langlois 2007:15). Earlier, it was concluded that rationalization implies an increasing degree of rationalization of the system upon which it acts and gives rise to a dynamic evolution thereof (finding VIII/sct. 6). Hereby, rationalization is directed by the underlying assumptions of rationality (findings IX and X/sct.6). Rationalization develops along a quasi-continuum encompassing rationalization based on rationality of means, and rationalization based on rationality of ends (conclusion I/sct.6). Based on this, we reach the following conclusion:

Conclusion II / sct. 7:

- *Rationalization as it acts upon a system can be described based on the following building blocks: (i) the direction of rationalization based on underlying assumptions of rationality, and (ii) the evolutionary pattern of a system subject to rationalization.*

In the following, we discuss rationalization based on its building blocks, i.e. the types of rationality directing rationalization (chapter 7.1.1), and a generalized evolutionary pattern of a complex system subject to the phenomenon of rationalization (chapter 7.1.2).

7.1.1 Direction of rationalization

Rationalization is directed based on the underlying assumptions of rationality. To understand a generalized pattern of rationalization, it is necessary to understand which rationality directs rationalization in which context. In the following, we review typologies of rationality. Our literature review produced a multitude of theories of rationality in many scientific disciplines. Rationality is also attracting increasing attention by multi-disciplinary research in the fields of self-organization and self-transformation. As a thorough review of these theories would be a research project in its own right, we build here on the theoretical foundations of systems theory (in line with the theoretical foundations of our concept of the firm) and focus our discussions on rationality as understood in economics (chapter 7.1.1.a) and social sciences (chapter 7.1.1.b).

7.1.1.a Typology of rationalities in economics

Rationality is a central concept of economics. Zafirowski (2007) distinguishes three broad periods each with a different understanding of rationality, i.e. (i) classical political economics, (ii) early neoclassical economics, and (iii) late neoclassical economics.

(i) *Classical political economy* adopts an Enlightenment-based concept of rationality. It is defined as "a reasonable, logical or intelligent process involving thought and action" (Zafirowski 2007:7). It is strongly influenced by sociological liberalism and the notion of human reason. (ii) *Early neoclassical economics* and more specifically marginalism operates with a concept of rationality reduced to utility maximization. "Neoclassical 'rational utility-maximization' (Razeen 2002) concepts or models represent a sort of (mathematical) formalization of utilitarianism ('principle of utility')" (Zafirovski 2007:17). (iii) In *late neoclassical economics*, the understanding of rationality is restrained to "pure economic instrumentalism" (Zafirovski 2007:4). It can be concluded that rationality in economics is understood as the rational choice of scarce resources (i.e. means) to achieve certain ends. Schumpeter bases his understanding of rationality on choice theory where choices are driven by preferences and are assumed to be rational. He distinguishes between rationality of analytical procedure (i.e. means) and rationality of the result (i.e. ends). The absolute view of perfect rationality adopted in economic models of optimization is somewhat softened by Simon's (1996) notion of bounded rationality. It maintains that the objective of economic projects is not absolute rational optimization, but rather finding satisficing solutions.

Finding I / sct. 7:

- *In economics, rationality is understood as a combined construct including rationality of processes and rationality of outcomes. The first implies a rational choice of means and the latter a rational choice of ends.*

7.1.1.b Typology of rationalities in social sciences

In social sciences Weber proposes a theory of rationality distinguishing between four types of rationality, i.e. (i) practical, (ii) theoretical, (iii) substantive, and (iv) formal rationality.

(i) *Practical rationality* characterizes a way of life where given realities with all the problems they imply are accepted and the most rational means to solve the problems are calculated. “This type of rationality exists as a manifestation of man’s capacity for means-end rational action” (Kalberg 1980:1152). (ii) *Theoretical rationality* “involves a conscious mastery of reality through the construction of increasingly precise concepts” (Kalberg 1980:1152). It is driven by the urge of intellectuals to understand the meaning of the world. Reality and innovation ends formerly belonging to the unconscious are thus progressively made available in the conscious domain. (iii) *Substantive rationality* implies objectives that are determined based on the particular value system of the actor. Thus, central to substantive rationality is the actor’s “preference for certain ultimate values (…). These values acquire ‘rationality’ merely from their status as consistent value postulates” (Kalberg 1980:1156). Rationality of means is evidenced by the systematization of (the actor’s) action to conform to these values. (iv) *Formal rationality* is based on a “means-end rational calculation by reference back to universally applied rules, laws or regulations” (Kalberg 1980:1158). Formal rationality is specific to certain spheres of life, among which are the economic and more specifically the bureaucratic form of domination. Rationality manifests itself in the calculation of the most efficient means for the resolution of ‘problems’ (i.e. ends) based on universal and rational constructs (Weber 1968). These constructs are also referred to as universal concepts of rationalization (discussed in chapter 7.2).

Weber views these types of rationality as universal, i.e. they are not limited to certain societies or cultures. Weber’s typology of rationality is based on different degrees of rationality in terms of ends and means. All four types of rationality “become manifest in a multiplicity of rationalization processes orchestrated at all levels of societal and civilizational process” (Kalberg 1980:1145). In section 6, the rationalization process in the social domain was discussed. It gives rise to a dynamic evolution of the social system from the traditional/affectual type to the value rational and the instrumentally rational type. Hereby the system’s degree of rationalization increases along a quasi continuum based on evolving assumptions of rationality. From this, an evolving pattern of underlying rationality can be identified, i.e. from the becoming conscious of ends giving rise to rationality of means (in value rational systems) and subsequent rationality of ends giving rise to rational means-ends calculations (in instrumentally rational systems).

Finding II / sct. 7:

- *Rationalization of systems implies a progressive increase of their degree of rationalization along a quasi-continuum based on evolving underlying assumptions of rationality, i.e. from making conscious of ends giving rise to rationality of means, and subsequently rationality of ends giving rise to rational means-ends calculations.*

7.1.2 Generalized pattern of evolution

We resort to the theory of natural selection for an explanation of the evolutionary dynamics of complex systems subject to rationalization. It is based on the Darwinian concepts of variation, replication and selection first introduced in Darwin's 'Origin of Species' (1859). These concepts gave rise to burgeoning research on evolving systems in a variety of fields. The application of theory of natural selection in the context of evolution of complex systems is in line with the theoretical foundations of systems theory we used for the concept of the firm established in section 3. More specifically, Simon's (1962) argument for a hierarchical architecture of complex systems is based on a variation-and-selection view of natural (and artificial) evolution. The application of the theory of natural selection is also in line with the established view that "Darwinian principles provide a general explanatory framework into which particular explanations have to be placed" (Hodgson and Knudsen 2004:285) and that the theory of natural selection "can be simply generalized to any kind of systemic evolution" (Heylighen 1989:25). This is evidenced in theoretical and empirical research in the context of dynamic evolution in a variety of scientific disciplines, most prominently biology.

Theory of natural selection maintains that a system evolves based on a "generalized variation-and-selection dynamics" (Heylighen 1989:24). From the perspective of systems theory, a system undergoes variation in an environment exerting a "selective pressure" on the system. In this view, "only those configurations of the system will maintain (or grow) which are 'fit' or adapted to the environment" (Heylighen 1989:24). In the face of environmental variance, the evolving system "can be likened to a problem-solver" (Heylighen 1989:24): it strives to adapt to the environment by generating possible solutions by trial (i.e. variation), which subsequently undergo selection by the environment. Internal variation thus gives rise to negative or positive feedback based on the selection by the environment. Both, the generalized pattern of variation-and-selection and the characteristic of systemic feedback apply to complex systems, such as the economic and social systems and the firm's production system and

I-system discussed in this research project. In the following we further analyze implications of negative and positive feedback (chapter 7.1.2.a), and the generalized evolutionary pattern in the context of complex systems (chapter 7.2.3.b).

Finding III / sct. 7:

- *A system exposed to rationalization embarks on a dynamic evolutionary path that can be reduced to a generalized pattern of variation-and-selection.*

7.1.2.a Systemic feedback loops

In the face of environmental variance, complex systems adapt to the environment based on a generalized behavioural pattern of variation-and-selection. Hereby, it generates by trial possible solutions (i.e. variation), which subsequently undergo selection by the environment. A generalized evolutionary pattern based on variation-and-selection implies that the system interacts with its environment in a way that makes fit or misfit transparent and initiates internal variation accordingly. This interaction is based on the interfaces coupling the system with its environment. Inputs from the environment confront the system with the external variance, to which the system attempts to adapt by internal variations. The system's outputs are subject to the selection by the environment. Hereby, information about the result is fed back to the input of the system in the form of input data. This gives rise to a closed feedback loop. The evolution of complex systems depends on the feedback mechanism. It is essential for a system to maintain itself in the course of time. Feedback systems are rather closed systems and contrast with feed-forward systems that are open systems and do not rely on feedback loops for the control of the system.

Rosenblueth et al. (1943) proposed in their paper "Behaviour, Purpose and Teleology" that behaviour controlled by negative feedback, whether in animal, human or machine, was a determinative, directive principle in nature and human relations. This kind of feedback is studied in cybernetics and control theory. Wiener (1948) first advocated for a broad applicability of the concept of feedback loop. Ever since, the concept of feedback has been used in research on complex systems in a variety of scientific disciplines, such as biology, social sciences, economics, engineering, and thermodynamics.

Our literature review produced a distinction between (i) negative and (ii) positive feedback. Hereby, the effect of feedback is not necessarily 'negative' or 'positive' in the sense of being desirable. 'Negative' and 'positive' refers to the nature of change of the system rather than the desirability of the outcome.

(i) *Negative feedback* tends to slow down the initiated internal variation and is associated with stabilization of the system. It leads to adaptive behaviour of the system towards equilibrium. In engineering, mathematics, physics and biology negative feedback gives rise to the system's gravitating around equilibrium points also referred to as attractors, stable states, setpoints, or eigenstates and eigenfunctions. Systems based on unchecked negative feedback loops will come to a standstill as evidenced by examples such as bankruptcy and economic depression. (ii) *Positive feedback* accelerates the evolution of the system in the direction of the initiated variation. Positive feedback loops have a cumulative effect that is also referred to as 'cumulative causation'. Unchecked positive feedback loops have a destabilizing effect on the system and lead to either exponential growth (also referred to as indefinite expansion and explosion) or exponential decline (also referred to as total blocking of activities and collapse). Such snowball effects are evidenced in phenomena such as chain reactions, population explosion, inflation, and compounded interest.

With regard to the focus of this research project, it has been established that routines have the characteristic of systemic feedback loops (conclusion VII/sct.3). These allow for the operation of both, positive and negative feedback, which gives rise to a 'controlled' evolution of the routines. Such control based on 'checked' mechanisms allowing for positive and negative feedback is essential for a system (i.e. a routine) to maintain itself and avoid indefinite expansion or total blocking of activities associated with unchecked positive feedback loops and standstill associated with unchecked negative feedback. Thus, the underlying mechanism associated with feedback loops accommodating for both, negative and positive feedback, gives rise to a routine's 'controlled' evolution based variation-and-selection. Hereby, negative feedback has a stabilizing effect on the routine and positive feedback accelerates the transformation of the routine.

Finding IV / sct. 7:

- *Systemic feedback loops accommodate for both, negative and positive feedback. They give rise to a 'controlled' evolution of the system based on variation-and-selection. Hereby, negative feedback has a stabilizing effect on the system (or routine) and positive feedback accelerates the transformation thereof.*

7.1.2.b Evolutionary pattern of complex systems

Unlike conventional problem-solving, a dynamic view (in line with our theoretical foundations of process philosophy) suggests that there is no final solution. A system is never optimally adapted to its environment: the system's evolutionary process is driven by continuous external variance that calls for continuous adaptation of the system. Natural selection, as exemplified by the models of Simon and the self-organization theorists, suggests that a rational approach proceeds in intermediate steps, i.e. "relatively easy-to-find problem states or configurations, which are no final solution" (Heylighen 1989), but closer to the goal than initial configurations. Simon (1996) refers to them as satisficing solutions. This search for intermediate solutions is essentially what happens during natural selection, as applied by the models of Simon and prominent theories of self-organization.

Finding V / sct. 7:

- *A system follows an evolutionary path from one intermediate solution to the next based on a generalized variation-and-selection pattern.*

In line with the theoretical foundations of systems theory adopted for the proposed concept of the firm (conclusions II and III/sct.3), complex systems (such as the firm's I-system) are viewed as hierarchical multi-level structures of sub-systems. Hereby, the coupling of sub-systems gives rise to higher-rank systems with emergent properties, i.e. properties that are irreducible to the sub-systems (Simon 1996). The higher-rank systems and the sub-systems, each follow the generalized evolutionary pattern of variation-and-selection. It can be concluded that a complex system follows a pattern of evolution based on internal and external variation as well as internal and external selection. *Internal variation* may be defined as a process in which inner parts of a system (i.e. its sub-systems) are changed. *External variation* refers to changes of the relation between the system and its environment. *Internal selection* leads to intrinsic stability as the internal structure of a system must be stable for the system to survive. This is associated with the phenomenon of self-organization. *External selection* gives rise to adaptation at the level of the system. In a *multi-level complex system*, the same applies also to the sub-systems. In a relatively closed system internal variation and selection refers to the parts of a sub-system, and external variation and selection to a sub-system's environment within the system. Thus, complex systems follow an evolutionary pattern that is in general parallel or distributed (Heylighen 1989).

Finding VI / sct. 7:

- *Complex adaptive systems have multi-level structures. They evolve along a multi-level pattern of internal and external variation-and-selection.*

In relatively open complex systems, such as the firm's I-system, each sub-system is not only part of the system as defined by the firm's boundaries, but also interacts with its environment to give rise to other higher-rank systems beyond the firm's boundaries. There is thus not just one system and its environment, but a multitude of sub-systems in continuous interaction with their environment within and beyond the firm's boundaries. Hereby, each higher-rank system follows an evolutionary path based on internal/external variation-and-selection. Thus, sub-systems evolve partly autonomously from its primary higher-rank system (e.g. the firm or the firm's I-system) and its fellow sub-systems and partly in interaction with them. This 'network' structure of evolutionary processes implies that there is no absolute distinction between internal and external, i.e. between a system and its environment. Conventional perspectives viewing the firm as a rather closed system defined by the firm's boundaries appear in this context as insufficient to account for the dynamics of a complex system. What is conventionally viewed as external to a system (e.g. to the firm's I-system) is in fact internal to other systems that include also sub-systems of the first. "Any external selection can be reduced to internal selection by considering a larger, more global system. Adaptation is then reduced to the existence of a stable relation between one sub-system (the original system) and another sub-system (the original environment)" (Heylighen 1989:26). This more holistic view of a complex system and its sub-systems, reduces external variation and selection to internal variation and selection. This opens a broader potential for self-organization. In organizational studies this phenomenon is referred to as fractal organizations. Also the firm's I-system can be viewed as a relatively open complex system. In section 8, we discuss implications of this in terms of interface standardization and dominant design.

Conclusion III / sct. 7:

- *In open complex systems, sub-systems are coupled with fellow sub-systems within and beyond the firm's boundaries. This gives rise to a 'network' structure of evolutionary processes based on a generalized pattern of internal and external variation-and-selection.*
- *Such evolution of sub-systems is partly autonomous from the primary higher-rank system, i.e. the firm of the firm's I-system, and thus subject to the internal/external variation-and-selection based evolution of higher-rank systems beyond the firm's boundaries. The evolution of sub-systems is also partly in interaction with the primary system and thus subject to the internal/external variation-and-selection based evolution of the system (e.g. as defined by the firm's boundaries).*

7.2 General concepts of rationalization

Weber also describes rationalization as a progressive mastery of reality based on increasingly precise and abstract concepts. Such abstract concepts of rationalization are concepts of means-ends calculations applicable to contexts of rationalization directed by underlying assumptions of rationality of means and rationality of ends. Reality (e.g. complex systems) is represented based on these concepts of rationalization (e.g. modularity). The phenomenon of rationalization gives rise to an increasingly precise representation of reality (e.g. modularization) leading to a more advanced understanding thereof. Hereby, a higher degree of rationalization is associated with a more precise representation and a more advanced understanding of reality.

In line with the theoretical foundations of this research project and our focus on contexts subject to rationalization directed by rationality of means and rationality of ends, we further elaborate on concepts of rationalization provided by systems theory and theories of complexity. Specifically, we discuss modularity and its dynamics, i.e. modularization (chapter 7.2.1), complementary concepts stemming from theories of complexity (chapter 7.2.2), standardization (chapter 7.2.3) and other concepts of rationalization (chapter 7.2.4).

7.2.1 Modularity

In Simon's (1996) view, human beings with bounded rationality are not able to assess complex phenomena, as mere observation and understanding might be too limited. Systems theory views complex phenomena as complex systems. These are artefacts (i.e. man-made as opposed to natural) moulded by goals to environments in which they live (Simon 1996). Even though Simon does not propose a formal definition of complex systems, his notion of complexity used in the context of complex social systems is structural and more specifically hierarchical in nature. To make complex phenomena understandable, systems theory resorts to the basic concept of rationalization referred to as 'modularity'. Modularity is a basic concept of rationalization allowing for some degree of theoretical mastery of complex phenomena. Hereby, complex systems are decomposed into simpler sub-systems that are easier to manage. This gives rise to 'parts-within-parts structures' that can be represented by hierarchical architectures composed of various levels of sub-systems (Simon 1996), i.e. components, or modules. As "hierarchies have the properties of near decomposability" (Simon 1996:204), interactions within sub-systems are strong and interactions among sub-systems are weak. Structuring systems based on the concept of modularity is therefore about "separating the high-frequency dynamics of hierarchy – involving the internal structure of the components – from the low-frequency dynamics – involving interaction among components" (Simon 1996:204).

Baldwin and Clark (2000) refer to modularity as the building of a complex system from smaller sub-systems that can be designed independently yet function together as a whole. Specialized sub-systems are coupled to give rise to emergent properties, i.e. properties at the level of the system that cannot be reduced to its sub-systems (Simon 1996). Pending on the objectives associated with the system, its sub-systems can be coupled rather loosely or rather tightly. Systems based on tightly coupled sub-systems are rather inflexible and slow at adapting to a changing environment. Loosely coupled sub-systems allow for emerging properties of adaptability. Hereby, the full value of specialization at the level of the sub-systems is unlocked and emerging adaptability at the level of the system is ensured.

Finding VII / sct. 7:

- *Modularity creates specialization at the level of the sub-systems (i.e. components, modules). The coupling thereof gives rise to emergent properties, i.e. properties at the level of the system that cannot be reduced to its sub-systems (Simon 1996, Heylighen 1989).*
- *Based on the intensity of interaction of its parts, a complex system is de-composed into modular sub-systems. Modular complex systems can be represented by hierarchical architectures of sub-systems.*

It was established that complex systems subject to rationalization move along an evolutionary path that can be reduced to a basic internal/external variation-and-selection pattern at all levels of the system. (findings III and VI/sct. 6). In the context of complex systems structured based on the concept of modularity, this is manifested in the increasing degree of modularization of the system. Hereby, increasingly specialized sub-systems are (re-)coupled to give rise to emerging properties according to the underlying assumptions of rationality applied in a given context (i.e. objectives associated with the system). Further, it was established that rationalization moves along a quasi-continuum of rationalization based on rationality of means and rationalization based on rationality of ends (findings IX, X/sct.6 and II/sct.7).

From this it can be concluded that modularity, and the dynamic modularization, are relative to the objectives associated with the system. They are oriented based on the underlying assumptions of rationality applied in a given context. A context of rationality of means gives rise to 'means-oriented' modularity. Hereby, rational means are structured into modular sub-means. Thus, routines of project production (used e.g. in the production of large oil tanks or civil engineering projects) and jobbing production (used e.g. in the production of made-to-measure suits) are based on means-modular architectures composed of modular sub-tasks. Similarly, routines of project management structure projects into project architectures composed of modular sub-tasks. A context of rationality of ends gives rise to 'ends-oriented' modularity. Rational ends are structured into modular sub-ends. Ends-modularity is applied e.g. in the design of product architectures underlying routines of batch and line production. These architectures are composed of modular parts, e.g. components and modules. They are used in the production of e.g. motor vehicles, electrical goods, fast-moving consumer goods. In the context of flow production the equivalent of the product architecture is commonly referred to as recipe (e.g. production of cement and chemicals).

Finding VIII / sct. 7:

- *Modularity is relative to the objectives associated with a system. Pending on the assumptions of rationality applicable in a given context, modularity is either 'means-oriented' or 'ends-oriented'. Similarly, modularization is directed either by assumptions of rationality of means or rationality of ends.*

We would like to highlight some additional insights regarding the concept of modularity stemming from our literature review, i.e. (i) the applicability of modularity, (ii) performance limits of modular architectures, and (iii) the modularity trap and the importance of systems integration.

(i) *Applicability of modularity:* Baldwin and Clark (2000) state that technology tends to pass from a more integrated towards a more modular state. And the same applies to organizations. (ii) *Performance limits of modular architectures:* Modularization is progressive until it reaches the performance limits of the modular structure. This gives rise to a new architecture. "Every technical architecture has inherent performance limits. (...) In order for the system to advance, a new architecture must be found" (Chesbrough 2005:175). Thus a system undergoes a two-fold evolution: a given system architecture becomes increasingly modular till it reaches a performance limit. Then it is replaced by a new system architecture that is also subject to progressive modularization. System innovation takes place *within* and *beyond* a given architecture. There is ample empirical evidence supporting the increasing modularity of systems (among others Sanchez 1995, Christensen and Chesbrough 1999). Based on our literature review, we agree with Chesbrough maintaining that "the process of advancing to a new, better architecture (...)

needs much more analysis" (Chesbrough 2005:175). His dynamic, cyclical model of modularity is a contribution toward explaining how the limits of a given architecture are overcome by establishing a new architecture. (iii) *Modularity trap and systems integration:* An important hurdle the company has to overcome when passing from a highly modular architecture to a new architecture is referred to as the "modularity trap" (Chesbrough and Kusunoki 2001 in Chesbrough 2005:181). It is grounded in the fact that modular architectures foster specialist knowledge at the module level, which often happens at the expense of system-wide knowledge. The system integration knowledge necessary to make a system's architecture evolve beyond its performance limits tends to get lost. However, as the firm is an open complex system, it evolves based on internal/external variation-and-selection stemming from beyond the firm's boundaries (conclusion III/sct.7). Chesbrough proposes a cyclical model of evolution of modular systems, where "the pattern of industry evolution shifts, from its well elaborated modular state back to an interdependent state" (Chesbrough 2005:182). He observed that "(o)nly in the interdependent state can the broad systems architecture be revisited, and re-architected" (Chesbrough 2005:182). In the face of modular structures evolving beyond the firm's boundaries, a firm caught in the 'modularity trap' sticks to a given and known architecture associated with limited potential rather than embracing a new architecture adapted to new requirements of a changed environment. Gallagher (2007) maintains that this eventually leads to the firm's lock-out. In organizational studies, a similar phenomenon is referred to as the challenge to overcome inertia. Behind this, the importance of the systems integrator in the transition from a modular to an interdependent (or integral) system becomes evident. Such an integrator holds the system-wide knowledge necessary to overcome a given architecture. Further, Chesbrough suggests that a business organization cannot expect to recover any value from their systems integration capabilities. He thus stresses the importance of theories of alliance formation, competition between alliances, and credible commitments to third parties as a solution to the crucial contribution of systems integration to the evolution of complex systems. Von Hayek (2001) adopts a more differentiated view of systems integration and maintains that the market offers the coordination mechanism necessary and sufficient to a modular architecture and its evolution.

Finding IX / sct. 7:

- *Modular system architectures follow a generalized pattern of evolution encompassing alternate phases of (i) incremental evolution whereby modularity of the system increases till a performance limit is reached, and (ii) disruptive evolution* *whereby a new architecture is established (with this latter being most likely integral).*

7.2.2 Concepts of rationalization based on theories of complexity

The application of modularity alone is not sufficient to tackle the complexity of reality. In fact, some complexity problems will still arise, in spite of the implementation of modular structures (Blecker and Abdelkafi 2006). Such inherent complexity limits the system's performance in terms of achieving its objectives. The process-based view adopted in this research project, suggests to consider the evolution of such inherent complexity that modularity cannot account for. Various theories explain the mechanics that give rise to an enhancement of complexity, among others the intelligent design theory, the inherent teleology theory, and the chance-plus-self-perpetuation theory. The self-potentiation theory states that complexity is self-propagating (Rescher 1998). This evidences the relevance of better understanding complexity, as self-potentiation suggests that the more there is, the more powerful the force to produce yet more complexity (Rescher 1998).

Theories of complexity developed basic concepts of rationalization that go beyond modularity. A literature review did not produce an established and generally accepted theory of complexity, but a multitude of theories based on varying assumptions and research interests. In the following, we will discuss various understandings (chapter 7.2.2.a) and typologies of complexity (chapter 7.2.2.b). Subsequently, we draw implications for generalized concepts of rationalization stemming from theories of complexity (chapter 7.2.2.c).

7.2.2.a Understandings of complexity

A literature review produced a multitude of understandings of the phenomenon of complexity. On the one hand, the understandings of complexity vary based on the scientific discipline they relate to. For instance, Whitesides and Ismagilov (1999) describe aspects of the phenomenon in chemistry; Weng, Bhalla and Iyengar (1999) discuss complexity in the context of biology, specifically, biological signalling systems; Koch and Laurent (1999) refer to neurosciences.

Author	**Approach to complexity**
Shannon (1948)	System entropy
Ashby (1958)	System variety (i.e. the number of different states the system can assume)
Von Hayek (1972; 1975)	Number of parts and their interactions Diversity of relationships between the parts
Patzak (1982)	Number and diversity of the parts as well as of the relationships between the parts

Chaitin (1987)	Algorithmic complexity
Bennett (1988)	Logical depth
Simon (1988, 1996)	Structure based on nested sub-systems
Gomez, Malik and Oeller (1975); Gomez (1978; 1981); Gomez and Probst (1997)	Descriptiveness of the system Number of parts and their interactions
Suh (2005; 2006)	Degree of uncertainty in achieving a set of design goals
Bryan and Joyce (2007)	Extent of contribution to increasing the value of the company

Table 3: Understandings of complexity (adapted from Blecker & Abdelkafi 2006 and Stüttgen 2003)

On the other hand, a review of a selection of authors in fields relevant to organizational studies (Table 3) shows that the authors' understandings of complexity are mostly driven by their specific research interests. For instance, Simon (1988) focuses on the structure of complex systems without determining in detail how complexity should be measured. Suh (2005) views complexity in the context of designing systems to achieve a certain goal. Complexity refers to the extent to which a system does not satisfy the goals it was designed to achieve. It is a measure of a system's inefficacy.

7.2.2.b Typologies of complexity

Based on his review of approaches to complexity adopted by scientists up to the 1990s, Rescher (1998) develops a typology of complexity based on its epistemic, ontological and functional characteristics (Table 4).

Types of Complexity (C)			**Description**
Epistemic Characteristics	Formulaic C	1. Descriptive C	Length of the account that must be given to provide an adequate description of the system at issue.
		2. Generative C	Length of the set of instructions that must be given to provide a recipe for producing the system at issue.
		3. Computational C	Amount of time and effort involved in resolving a problem.
Ontological Characteristics	Compositional C	1. Constitutional C	Number of constituent elements or components.
		2. Taxonomical C (Heterogeneity)	Variety of constituent elements: number of different kinds of components in their physical configurations.
	Structural C	3. Organizational C	Variety of different possible ways of arranging components in different modes of interrelationship.
		4. Hierarchical C	Elaborateness of subordination relationships in the modes of inclusion and subsumption. Organizational disaggregation into sub-systems.
Functional C		5. Operational C	Variety of modes of operation or types of functioning.
		6. Nomic C	Elaborateness and intricacy of the laws governing the phenomena at issue.

Table 4: Typology of complexity based on approaches up to the 1990s (adapted from Rescher 1998)

Approaches up to the 1990s typically view complexity in 'absolute' terms. It is for instance measured by the amount of components of a system (constitutional complexity), the length of the description (descriptive complexity), or the variety of constituents (taxonomical complexity). Suh (2005) refers to this search for an 'absolute measure' of complexity as the common characteristic of these earlier approaches.

7.2.2.c Concepts of rationalization based on theories of complexity

However, in the context of rationalization, the absolute concepts of complexity adopted up to the 1990s appear as too simplistic. Rationality of means and rationality of ends suggest that there is a 'teleological' dimension to the structuring of a system. In this view, a complex system is structured in relation to the objectives that it is designed to achieve. Inherent complexity is thus understood with regard to the value it generates towards achieving the objectives associated with the system. This gives rise to a relative (or teleological) understanding of complexity. In the following, we will further elaborate on (i) the relative understanding of complexity as adopted by Suh (1990, 2005) and Bryan and Joyce (2007), and (ii) present a prominent concept or rationalization based on this understanding of complexity, i.e. Suh's theory of design.

(i) Among others, Suh (2005) advocates in his theory of complexity for "a definition of complexity as a relative quantity" (Suh 2005:4). In his view, "(c)omplexity is defined as a measure of uncertainty in achieving the specified FRs (functional requirements)" (2005:293). In line with axiomatic design, functional requirements (FRs) refer to 'what it is we want to achieve'. They are defined as "a minimum set of independent requirements that completely characterize the functional needs of the product (or software, organization, system, etc.) in the functional domain" (Suh 2005:5). FRs are satisfied by means of design parameters (DPs) or physical parameters. These latter refer to 'how we are going to satisfy the FR'. For example, the FR 'measure the time within a billionth of a second' might be satisfied by the DPs 'the frequency/period of cesium laser' or 'the period of a pendulum'. As many DPs potentially satisfy the FR, a designer's main task is "to choose the DP that is the best" (Suh 2005:5). Design thus "involves a continuous interplay between *what we want to achieve* and *how we want to achieve it*" (Suh 1990: 25). However, "(w)hen we try to fulfil the FR, there is uncertainty, thus complexity, of satisfying it within the specified accuracy or tolerance. When a given DP is chosen to satisfy the FR, the uncertainty is characterized by the system's ability to satisfy the FR within its design range" (Suh 2005:5). Thus, "(w)hen our goal is always achieved using selected physical implements, the task would not be regarded a being complex. When we cannot achieve the function (…), the task would appear to be very complex" (Suh 2005:4). In this understanding, a system may be more complex than another in terms of constitutional complexity, but less complex in terms of relative complexity. More recently, Bryan and Joyce (2007) also adopted a relative perspective on complexity. They differentiate 'productive' from 'unproductive' complexity based on its contribution to the value of the company. Hereby, complexity is considered as productive when it produces value. Rational design of complex systems aims at removing unproductive and fostering productive complexity.

(ii) Suh proposed a concept of rationalization based on axiomatic design. Hereby, a complex system is designed (i.e. structured) across four domains of the design world linking customer attributes to functional requirements, to design parameters, and to product variables. Each of these design worlds is structured into a hierarchy of higher- and lower-level attributes in line with strategies of modularity. However, the design worlds are not seen as closed complex systems structured merely based on high/low frequency dynamics among its parts (such as with the rationalization concept of modularity). In fact, adjacent design worlds are structured in interaction at all their levels based on techniques of 'mapping' and 'zigzagging' (Suh 2005). This ensures a systematic (and iterative) link between the structuring of a complex system (e.g. product) and its 'teleological' dimension (e.g. customer attributes) or company objectives. A variety of theories of design adopt principles of axiomatic design (such as propagated in Suh's theory of complexity) as a complementary strategy to modularity. For an illustration of the application of modularity and advancements thereof as proposed by Suh's theory of design, we refer to our publications attached in chapters 12.3, 12.6, 12.8, and 12.9.

Finding X / sct. 7:

- *Theories of complexity propose advancements of the concept of modularity to better capture the complexity of complex systems. Hereby, the concepts of means- and ends-oriented modularity are expanded by a 'teleological' modularity that is based on mapping across different design worlds.*

7.2.3 Standardization

Standardization refers to the fact that rather open complex systems interact with their environment simultaneously at all their hierarchical levels (conclusion III/sct.7). It implies the establishment of standards, which allow for connectivity of a system with its environments at the system-level and at the level of its sub-systems. The notion of standardization refers to the extent to which organizational environmental issues are governed by rules, policies, and procedures (Brunsson and Jacobsson 2000). It is about ensuring compliance with known routines, importantly also beyond the firm's boundaries (e.g. within networks and entire industries). Adopting this perspective of standardization, our literature review produced essentially three different types of standards: (i) interface standards, (ii) component standards, and (iii) dominant designs.

(i) *Interface standards* are interface protocols defining the compatibility between modules of a single product, between different products and/or their complements. The key issue is interconnectivity. Interface standards can be internal (i.e. applicable within a single firm or a network of firms) or external (i.e. applicable at the level of the industry). Network markets or standard-based industries are created by interface standards enabling the development of complementary products at reduced transaction costs. “The importance of standards is driven by the actual or expected role of network effects” (Gallagher 2007:373). In accordance with Gallagher (2007) we differentiate various degrees of impact that industry standards may have on the industry. Specifically, the degrees might vary from there being no standard at all to the existence of core standards, where industry standards are to be adopted in order for the product to function. (ii) *Component standards* allow for “the use of the same component in multiple products and is closely linked to product variety” (Ulrich 2003:132). It can be internal (i.e. occurring within a single firm) or external (occurring across multiple firms). Ulrich (2003) underlines two conditions for standardization: “a component implements commonly useful functions; and the interface to the component is identical across more than one different product” (Ulrich 2003:132). This has effects on cost and performance. Standardization can also be inertial for the business organization. It might prevent the firm from adopting better components if they are not compatible with the defined standards. (iii) *Dominant designs* represent architectures at the industry level. “The key indicator of dominant design is the durability or persistence of its architecture” (Gallagher 2007:372). They emerge in general after a radical technological innovation has been brought to the market and different design approaches have been competing with each other. The establishment of dominant designs has been associated with a lock-out effect, i.e. firms not adhering to the dominant design are automatically excluded from the industry.

7.2.4 Other concepts of rationalization

Rationalization of complex systems in the context of rationality of means and rationality of ends, gives rise to a variety of other concepts of rationalization, including (i) miniaturization, (ii) democratization, (iii) commoditization. As these concepts are not at the core of this research project, we limit the discussion to a brief outline thereof.

(i) *Miniaturization*: Miniaturization manifests itself in decreasing sizes of components and products and in increased unitary performance. It is driven by rationality of means aiming at increasing efficiency of means to achieve certain ends. For example, Tuomi (in Kurzweil 2003) refers to the semi-conductor industry and maintains that, from 1960 to 1975, "miniaturization of component dimensions has (...) evolved at roughly exponential pace. This miniaturization had lead to about 32-fold increase in component density in 15 years" (Tuomi in Kurzweil 2003). Miniaturization reduces the resource limitations (such as product size) imposed on innovators and thus opens up new areas of innovation. Hereby, it enlarges the potential exploration and exploitation areas of routine activities and thus of R-IA. Texas Instruments Principal Fellow Gene Frantz maintained that "(y)ou can almost say that we are on the path to the vanishing product where the product will be so small and insignificant in size but so significant in capability that we really don't know where we have it; we just know we have it" (Wright 2006). Miniaturization is further discussed in our publication attached in chapter 12.2. (ii) *Democratization* is a concept described among others in von Hippel's "Democratizing innovation" (2005). "When researchers say that innovation is being democratized, we mean that users of products and services – both firms and individuals consumers – are increasingly able to innovate for themselves" (von Hippel 2005:64). Innovation is not the realm of specialized firms any more. The user of the innovation becomes the innovator himself. Thus, in a context of rationalization based on rationality of means and rationality of ends, democratization of innovation suggests that part of the innovation activities are pushed out of the firm's boundaries and left in the domain of the users themselves. In fact, routines are transferred from the firm's I-system to the users. (iii) Another concept that can be associated with rationalization is the *commoditization of innovation* (also referred to as 'commodification of innovation'). "Commoditization (...) means (that) competition converges on cost" (Kusunoki 2006:49). Costs remain the sole differentiating factor and margins are increasingly reduced. "The speed at which products and services become commodities has dramatically increased in recent years" (Kusunoki 2006:49).

In this section, we discussed rationalization as the main underlying mechanism driving routinization. It can be concluded that the routinization of a system is characterized by the direction of rationalization and by the system's evolutionary pattern. The direction of rationalization varies pending on the context that is either driven by what is referred to in economics as rationality of processes (i.e. rationality of means) or rationality of outcomes (i.e. rationality of ends). The system's evolutionary pattern is based on variation-selection mechanisms whereby the system's degree of rationalization increases. Complex adaptive systems have multi-level structures. The selection-variation mechanism thus occurs at the different levels of the structure. Modularity is one of the general concepts rationalization draws upon to structure complex and multi-level systems. It allows for specialization at the module level and the tight- and lose-coupling of innovation activities. Modularity alone is not sufficient to deal with the almost exploding complexity in most business environments. Thus, a deeper understanding of complexity is required. In line with theories of complexity, we adopt a relative notion of complexity whereby the strategy adopted is to eliminate unproductive complexity while fostering productive complexity.

8 Theory of routinization of innovation activities

In section 6 and 7, we drew findings from a variety of theories of routinization. In this section, we apply these findings to the firm's innovation activities and draw implications for R-IA.

In line with our concept of the firm established in section 3, we view the firm's innovation activities as a multi-level complex system composed of sub-systems. Thus, we develop our argument at two levels, i.e. (i) the level of the firm's innovation system, and (ii) the level of its sub-system.

(i) *At the level of the firm's innovation system* (further referred to as I-system), we further elaborate on its constituents (chapter 8.1). Then, we establish pivot points of analogy between the I-system and the economic and social systems (chapter 8.2). Based on these pivot points of analogy - combined with our findings from further empirical research - we apply our findings from theories of routinization to the firm's I-system and draw implications for R-IA at this level (chapter 8.3). (ii) Similarly, *at the level of the sub-systems*, we further specify their constituents (chapter 8.4) and establish pivot points of analogy (chapter 8.5), which allows us to apply our findings from theories of routinization and draw implications for R-IA at the level of the sub-systems of the firm's I-system (chapter 8.6).

8.1 The firm's I-system - static perspective

The firm's I-system is a complex adaptive system composed of routines and can itself be viewed as a routine (in line with conclusion III/sct.3). It can thus be described based on the building blocks of a routine (conclusion VI/sct.3), i.e. scope (chapter 8.1.1), process (chapter 8.1.2), and interfaces (chapter 8.1.3).

8.1.1 Scope of the firm's innovation system

Our literature review of innovation theories in fields of management science such as R&D, marketing, business strategy, and organizational management showed that the view of the scope of the firm's I-system has been broadening over the past decades. We also observed, that the perspectives of separate disciplines are converging towards a more holistic view (see Deplazes et al. 2008b). To define the scope of the firm's I-system, we review theories related to innovation in R&D (chapter 8.1.1.a), strategic marketing (chapter 8.1.1.b), business strategy (chapter 8.1.1.c), and organizational management (chapter 8.1.1.d). Based on these findings we adopt a typology of 'exploitative' and 'explorative' innovative outputs pending on whether they refer to innovations within or beyond the firm's VD-System (chapter 8.1.1.e).

8.1.1.a Perspective of R&D

From the perspective of R&D management, a literature review (Mitterdorfer 2001) illustrates the broadening understanding of innovation from a narrow and fragmented focus on products, technologies, and processes to a wider focus on 'company performance' including aspects of effectiveness, profitability, and customer satisfaction. In parallel, the understanding of the scope of the I-system has been broadening from a focus on innovative products, technologies and processes to include any innovations driving company performance (i.e. effectiveness, profitability, and customer satisfaction). More recent definitions see innovation as the first-time and successful economic use of a novelty (Mitterdorfer 2001). In this understanding, the scope of the I-system is a range of innovative outputs that are new to the firm, and have been successfully and profitably introduced in the market.

Finding I / sct. 8:

- *In R&D, the scope of the firm's I-system is viewed as a range of innovative outputs including: (i) products, technologies and processes, (ii) outputs driving company performance, and (iii) outputs new to the firm.*

In a variety of industries, successful market introductions are increasingly associated with innovations beyond the narrow scope of the physical product (composed of components, functionalities, technologies, and processes). They include innovative outputs in areas such as primary services, after-sales services, distribution, branding, and promotion. In practice, it can be observed that this shift of focus sets in latest when the differentiation potential of the physical product innovation is exhausted and thus less relevant from a market perspective. This contrasts with the core of organizational research in R&D that is mainly concerned with innovation aspects related to the physical product. It is, however, in line with typologies of innovation outputs such as 'product vs. process innovations' (Utterback and Abernathy 1975), 'technical vs. administrative innovations' (Daft 1987), and 'continuous vs. discontinuous technological innovations' (Porter 1986).

Finding II / sct. 8:

- *The scope of the firm's I-system is viewed as a range of innovative outputs including: (i) physical aspects, i.e. products with their components, functionalities, technologies, and processes, and (ii) non-physical aspects, i.e. primary services, after-sales services, branding, distribution, promotion.*

8.1.1.b Perspective of strategic marketing

Also in strategic marketing the perspective of innovation has been broadening over the past decades. This evolution is illustrated by Webster (2002) and Anterasian and Phillips (1988). It went a long way from Drucker's 'marketing concept' (Drucker 1993) advocating that the fundamental purpose of the firm is to create a satisfied customer. Drucker's concept gave rise to the introduction of concepts such as market segmentation, targeting, and positioning. In this early understanding, the scope of the firm's I-System is seen as *a range of innovative outputs driving customer satisfaction in a variety of market segments*. Subsequently, the marketing concept and strategic planning were integrated into a common concept of long-range planning. The first of a series of approaches to combine market needs with the company's capabilities was Kaldor's (1971) concept of 'imbricative marketing'. In this view, the scope of the I-System is *a range of innovative outputs driving (i) customer satisfaction, (ii) capability enhancement, and (iii) the match of needs and capabilities*. In the late 1970s/early 1980s, strategic planning was dominated by financial management viewing return on investment and profit as the objective of business activity. This was done at the expense of creating satisfied customers. The I-system's scope is thus viewed as *a range of innovative outputs driving profitability*.

In the mid-1980s the rediscovery of the marketing concepts was driven by severe market in-roads by Asian competitors who appeared to be better able to capitalize on the tastes, preferences, and buying habits of customers. The concept of 'total quality' was equalled to 'customer orientation'. *From this perspective, the scope of the firm's I-System is a range of innovative outputs driving customer orientation*. More recent authors propose the concept of 'value to the customer' as the strategic force driving company performance. Sources of value, and thus also sources of innovation, are associated with product and service, customer intimacy, and operational excellence (Treacy and Wiersema 1995). Webster (2002) defines the marketing concept as the process of defining, developing, and delivering customer value in the modern business environment. Anterasian and Phillips (1988) maintain in their 'value delivery theory of competitive advantage' that "sustainable competitive advantage is rooted in the abilities of a business to deliver superior value to customers at a profitable cost (…). This skill-based advantage may manifest itself in one or more areas of a business' value delivery system, i.e. its abilities to choose, provide, and communicate a superior value proposition to target customers. Skill(s) may reside in individual workers, functions, or may even become institutionalized and possessed by the business unit as a whole. Once institutionalized, these skill-based advantages become difficult for competitors to easily replicate, forming the basis for truly sustainable advantage" (Anterasian and Phillips 1988). In this understanding, the scope of the I-system covers the firm's value delivery system (further referred to as 'VD-system').

Finding III / sct. 8:

- *In strategic marketing, the scope of the I-System is viewed as a range of innovative outputs driving 'value delivered to the customer'. This range includes all elements of the firm's VD-system, i.e. the value a company proposes to the customer and the way it is structured for delivery.*

8.1.1.c Perspective of business strategy

Traditional approaches of business strategy aim at optimizing the company's fit with its existing (or imminent) environment. Pre-dominant strategy schools of the 1980s/90s identify sources of competitive advantage based on market positioning ('strategic positioning') or the firm's resources and capabilities ('resource-based view'). The former school adopts an 'outside-in' view and strives to align the company's organization and resources to the existing industry structure and market requirements. The latter school adopts an 'inside-out' view seeking market opportunities to be matched by the company's resources and capabilities. Both approaches (and their combinations) aim at continuously optimizing the fit between the organization and its environment.

Finding IV / sct. 8:

- *The scope of the firm's I-system is viewed as a range of innovative outputs that (i) increase the alignment of the organization and resources to the existing industry structure and market requirements, or (ii) match market opportunities with the company's resources and capabilities, or (iii) represent a combination of both.*

However, in the business environment of the early 21st century characterized by discontinuity unprecedented in terms of scale, pace, complexity and uncertainty (among others Tushman and Anderson 1986, Tapscott 1997, Hamel 2002, Gibbert et al. 2002, Voelpel et al. 2006, Christensen and Raynor 2003a and 2003b), companies are required to widen their strategic perspective beyond continuity to include opportunities of higher degrees of uncertainty. This appears to contradict the conventional continuity-based approaches to business strategy. Courtney et al. (1997) warn that “underestimating uncertainty can lead to strategies that neither defend a company against the threats nor take advantage of the opportunities that higher levels of uncertainty may provide” (Courney et al. 1997:68). Driven by the disruptive business environment companies need to widen their strategic perspective beyond continuity and include opportunities offered by higher levels of uncertainty. Applied to the scope of the firm’s I-system, this ‘continuity/uncertainty’ duality gives rise to sub-scopes we refer to as (i) continuity-based, and (ii) uncertainty-based sub-scopes.

(i) The *‘continuity’-based sub-scope* is a range of innovative outputs within a relatively specific ‘continuity’-based strategic framework. Such innovative outputs serve to exploit a rather specific strategic framework of opportunities defined based on conventional approaches to strategy development. The underlying assumption is that the environment develops along a fairly predictable continuity. (ii) The *‘uncertainty’-based sub-scope* is a range of innovative outputs within a rather unspecific ‘discontinuity’-based strategic framework of potential developments and levels of preparedness. Such innovative outputs ensure the necessary rate of creative destruction in a disruptive business environment. They are based on the exploration of this unspecific framework defined by uncertainty-based approaches of strategy development (among others Courtney et al. 1997).

Finding V / sct. 8:

- *The generalized scope of the firm’s I-system is dual and refers to the ‘continuity-based’ and the ‘uncertainty-based’ strategic frameworks of the firms. However, individual firms can choose to adopt a unitary focus on one of these dimensions.*

8.1.1.d Theory of ambidexterity

Approaches of organizational management belonging to the stream of ‘ambidexterity’ (among others Duncan 1976, O’Reilly and Tushman 2000) build on the ‘continuity/uncertainty’ duality of strategy. They advocate for a generic duality of the firm’s innovation strategy: in order to secure present and future strategic positions, companies need to generate parallel streams of ‘incremental’ and ‘more disruptive’ innovative outputs. The first is associated with ‘exploitation’ and the latter with ‘exploration’. These concepts are established by a variety of research streams adopting perspectives such as organizational learning and strategy (Levinthal and March 1993, Vera and Crossnan 2004), innovation (Daneels 2002, Rothaermel and Deeds 2004), and entrepreneurship (Shane and Venkataraman 2000).

Finding VI / sct. 8:

- *From the perspective of ambidexterity, the scope of the firm's I-system is a heterogeneous range of 'incremental' and 'more disruptive' innovative outputs associated with 'exploitation' and 'exploration' respectively.*

8.1.1.e Typology of innovative outputs based on the firm's value delivery system

The typology 'incremental vs. disruptive' innovative outputs does not qualify the degree of newness in absolute terms. It is contingent on the specific organizational context of the individual firm. This also applies to other typologies of innovative outputs building on the concepts of 'exploitation' and 'exploration' including 'incremental vs. radical' innovations (Abernathy 1979), 'continuous vs. discontinuous' technological innovations (Porter 1986), 'incremental vs. breakthrough' innovations, 'competence enhancing vs. competence-destroying' innovations (Tushman and Andersen 1986), and 'conservative vs. revolutionary' innovations (Abernathy and Clark 1985). Separately, studies confirm significant differentiation levels when considering individual theories of innovation types. However, Damanpour and Gopalakrishnan (2001) report that studies combining several theories of innovation types did not confirm any significant differentiation among the innovation types.

In line with findings from theories of contingency on organizations (among others Thompson 2003), we searched for a typology of innovative outputs that accounts for the specific context of the individual firm. Hereby, we build on the findings stemming from our review of innovation theories and adopt the concept of 'value-delivery system' (further referred to as VD-system) borrowed from Anterasian and Phillips' (1988) 'value delivery theory of competitive advantage'. The VD-system is defined as a dual construct consisting of the value a company proposes to the customer and the way it structures the value for delivery.

The 'exploitative' innovative outputs can be associated with the incremental changes within the firm's VD-system, and 'explorative' innovative outputs with the more disruptive changes of and beyond the firm's VD-system (finding VI/sct.8). This typology is also confirmed by the pragmatic view shared by many R&D practitioners: they differentiate innovation activities based on whether they refer to changes within the product architecture or changes of and beyond the architecture. Besides accommodating for the duality 'exploitation vs. exploration' and 'continuity vs. uncertainty', the concept of VD-system is highly contingent upon the firm's individual context and represents the very essence of what the individual firm is about. Importantly, it also allows for a holistic view of the firm's innovation scope by integrating all aspects of the firm's value delivery, such as products and services (including their components, functionalities, technologies), branding, distribution, and promotion (findings I, II, III, IV/sct.8). This gives rise to a typology of innovation outputs based on the concept of VD-system: 'exploitative' outputs stem from innovation within the firm's VD-system and 'explorative' outputs stem from innovation of and beyond the firm's VD-system.

Conclusion I / sct. 8:

- *The scope of the firm's I-system is defined as a range of heterogeneous innovative outputs including 'exploitative' outputs (i.e. associated with incremental changes within the firm's VD-system) and 'explorative' outputs (i.e. associated with more disruptive changes of and beyond the firm's VD-system).*

8.1.2 Innovation processes

Our literature review produced a multitude of conventional models of innovation processes shown in Table 5. These adopt a broad and unitary perspective of the entire innovation cycle from the decision to begin research on recognized or potential problems, to development, commercialization, diffusion, decision to adopt, implementation, and consequences (Rogers 1995). For a detailed review of models of innovation processes, we refer to Damanpour and Wischnevsky (2006).

Study	**Model of innovation process**
Klein & Sorra (1996)	Research → development → testing → manufacturing → packaging → dissemination → awareness → selection → adoption → implementation → routinization
Rogers I (1995)	Needs/problems → research (basic and applied) → development → commercialization → diffusion and adoption
Rogers II (1995)	Agenda-setting → matching → redefining/restructuring → clarifying → routinizing
Kanter (1988)	Idea generation → coalition building → idea realization → transfer or diffusion
Roberts (1988)	Recognition of opportunity → idea formulation → problem solving → prototype solution → commercial development → technology utilization and/or diffusion
Rothwell & Robertson (1973)	Idea generation → project definition → problem solving → design and development → production → marketing
Tornatzky & Fleischer (1973)	Research → development → deployment → adoption → implementation → routinization
Zaltmann et al. (1973)	Knowledge awareness → attitudes formation → (adoption) decision → initial implementation → continued-sustained implementation

Table 5: Models of innovation processes (adapted from Damanpour and Wischnevsky 2006)

However, these conventional models adopt a static problem-solving perspective and view innovation outputs in an undifferentiated way. This is not in line with the theoretical perspective of process philosophy we adopted for our research project (conclusion I/sct.3). Additionally, these models do not account for the specialized innovation scopes associated with requirements of exploration and exploitation, nor for the evolution of the I-system based on internal/external variation-and-selection in a context of rationalization (finding VI/sct.7).

	I-Factory (exploitative processes)	**I-Atelier (explorative processes)**
Objectives	Generate continuous flow of 'exploitative innovations' within the company's current VD-system.	Generate and complete 'exploitative innovations' of the company's current VD-system.
Strategies	Routinizable problem-solving and information-processing	Creative problem-solving, creation of new ideas and outputs
	Generation of continuous flow of innovative outputs	Completion of single-projects (or clusters of projects)
Mgmt focus	Increasing the efficiency of the flow generation from the perspective of the entire I-Factory.	Increasing the efficiency of the project completion at the level of either single-projects or portfolios of projects.
Process	Process is "relatively orderly, more like a periodic and sequential progression of phases" (Cheng and Van de Ven 1996)	Process is "relatively disorderly, more like a random process of chance and chaotic events" (Damanpour/Wischnevsky 2006: 274)
Output	Flow of outputs with a high degree of similarity.	Highly differentiated single-outputs or categories of outputs.
Repetitiveness	A given set of clearly defined activities is repeated regularly with a high similarity between successive cases.	A given set of broadly defined activities is completed at relatively low frequency with a low similarity between successive cases (single-projects or portfolios of projects).
Orientation (process vs object)	Process-orientation: continuous, highly repetitive process delivering a sustained flow of outputs.	Object-orientation: Tasks with distinct beginning, end and deliverable.
Driver of novelty	Process-orientation: the exploitative process is itself the source of continuous novelty.	Object-orientation: the completed project is the source of novelty.
Routinization	High degree of routinization (exploitation processes)	Low degree of routinization (project management processes)
Organizational Design	Process-orientation	Project-orientation
Fragmentation *(decomposition Simon 1962)*	I-Factory is structured based on process typologies.	I-Atelier is structured based on project typologies.
	Structure exploitative sub-system into modular sub-processes for scope and scale economies	Structure explorative sub-system into groups of projects, then groups of tasks for efficient coordination.
Integration *(recomposition Simon 1962)*	Integration of specialized sub-processes based on 'VD- architecture' underlying the I-Factory	Integration of tasks based on project or portfolio architecture underlying the single-project or the portfolio of projects
	Secure the integration of specialized sub-processes at the level of the I-Factory.	Secure the integration of project tasks at the level of single-project or portfolio of projects.

Table 6: Overview contrasting explorative and exploitative processes

In accordance with the dual scope of the firm's I-system, the objective of the innovation processes is to generate simultaneous streams of exploitative and explorative innovative outputs. The exploitative and explorative scopes differ as to their degree of specification and call for processes of distinct nature (conclusion VIII/sct.3). In conformity with the typology of 'exploitative' and 'explorative' innovation outputs (conclusion I/sct.8), these processes are referred to as 'exploitative' and 'explorative' processes respectively. This view is in line with organizational theories of ambidexterity (among others Duncan 1976, O'Reilly and Tushman 2000) maintaining that 'exploitation' and 'exploration' activities are distinct with regard to their scopes, processes, and organizational requirements. Various authors of theories of ambidexterity (among others Tushman and O'Reilly 1996, Benner and Tushman 2003) argue from an organizational perspective, that explorative and exploitative activities be undertaken in distinct organizational units. Benner and Tushman (2003) maintain that units engaging in explorative innovation pursue new knowledge and develop new products and services for emerging customers or markets. Units pursuing exploitative innovation build on existing knowledge and extend existing products and services for existing customers (Benner and Tushman 2003).

In line with other authors (among which Damanpour and Wischnevsky 2006), it can be concluded that 'exploration' and 'exploitation' differ considerably from a process-perspective. Essentially, they innovate in distinct ways: 'Exploration' is more emergent and characterized by variation, search, experimentation, and discovery, whereas 'exploitation' is more planned and characterized by selection, refinement, choice, and execution (Damanpour and Wischnevsky 2006). In consistence with the nature of their respective scopes, exploitative processes are 'narrowly defined' processes and explorative processes are broadly defined 'search-type' processes (conclusion V/sct.3). Table 6 shows a non-exhaustive overview contrasting characteristics of exploitative and explorative innovation processes. We compiled this overview based on literature research, interviews with R&D managers and case studies. Further, in our publication attached in chapter 12.3 we maintain that exploitative and explorative processes differ significantly and conclude from a perspective of organizational design, that innovation processes need to be tailored contingent upon the characteristics of the innovation scopes they are associated with.

Conclusion II / sct. 8:

- *Innovation processes can be differentiated based on their degree of specification into search-type 'explorative' processes and narrowly defined 'exploitative' processes.*

8.1.3 Coupling of the firm's innovation routines (interfaces)

Combining conclusions I and II/sct.8 allows for the conclusion that the firm's I-system is composed of explorative and exploitative routines. Essentially, exploitative routines belong to the category of 'routines in the narrow sense' and are associated with rather specific scopes, narrowly defined processes, and high degrees of routinization (in line with conclusion V/sct.3). Explorative routines belong to the 'search routines' characterized by rather unspecific scopes, broadly defined processes, and low degrees of routinization (in line with conclusion V/sct.3). When applying Schumpeter's terminology (finding I/sct.6), it can be concluded that the explorative sub-system drives novelty-based development, and the exploitative sub-system drives growth based on incremental changes. We refer to the firm's explorative sub-system as the 'innovation atelier' (I-Atelier) and to its exploitative sub-system as the 'innovation factory' (I-Factory).

Conclusion III / sct. 8:

- *The firm's I-system is composed of the I-Atelier and the I-Factory. The first is the explorative sub-system associated with innovation of and beyond the firm's VD-system. The latter is the exploitative sub-system associated with innovation within the firm's VD-system*

The 'division of labour' between I-Atelier and I-Factory is based on whether innovation refers to changes within or beyond the firm's VD-system (conclusion I/sct.8). These routines are coupled to form the firm's I-system. In analogy with Baumol (2004a) this interface can be described as the transformation of "the breakthrough models into more easily usable, more powerful and more marketable products, raising them from infancy into mature products with substantial markets and massive outputs" (Baumol 2004a:8). This reveals that the firm's I-Atelier and I-Factory are time-decoupled. Our review of theories of production routines produced the finding that the interface between time-decoupled routines are coordinated based on an overarching management process (finding XVI/sct.6). We refer to this process of coordination among the I-Atelier and the I-Factory as 'innovation integration' (I-Integration). As the division of labour between the I-Atelier and I-Factory is based on the underlying VD-system (conclusion III/sct.8), managing the interface between them implies the integration of explorative outputs (i.e. stemming from innovation beyond the actual VD-system) into the firm's VD-system. This is also confirmed by our findings from case studies and interviews with R&D managers. They suggest that disruptive innovations stemming from exploration are subsequently made subject to exploitation for further incremental innovations. Usually, this transfer happens at the stage of 'proof-of-concept'.

Conclusion IV / sct. 8:

- *I-Integration is the overarching management process that couples the firm's I-Atelier and I-Factory. It consists in integrating explorative outputs into the firm's VD-system.*

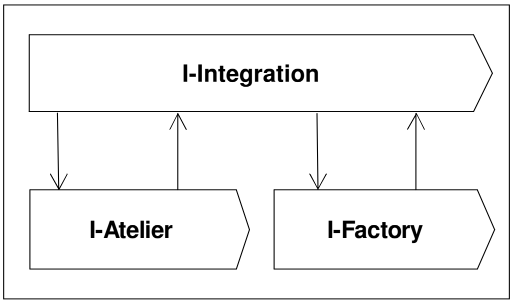


Fig. 6: The firm's I-system

8.2 Analogies at the level of the firm's I-system

In this chapter, we establish pivot points of analogy, which allows using the findings in sections 6 and 7 to draw implications for R-IA at the level of the firm's I-system. Specifically, we establish analogies between the I-system and (i) Schumpeter's self-transforming system and (ii) Weber's social system.

(i) Schumpeter's 'self-transforming system' is composed of the 'entrepreneurial' and the corporate sub-systems. The first is associated with novelty-based development and the second with growth based on incremental changes (finding I/sct.6). Similarly, the I-Atelier is associated with innovation beyond the firm's VD-system and the I-Factory with incremental innovation within the VD-system. Schumpeter's genius-type innovation is associated with irrational ends and means and is thus situated outside the conscious domain, i.e. outside the continuity- and uncertainty-based strategic frameworks of the firm.

Conclusion V / sct. 8:

- *Based on their similar nature, we draw an analogy between 'self-transforming system' and I-system, 'entrepreneurial sub-system' and I-Atelier, as well as 'corporate sub-system' and I-Factory.*

(ii) Weber views the social system as a system of social actions. Based on the degree of rationality of their means and ends these can be differentiated in affectual, traditional, value rational and instrumentally rational social actions (finding VIII/sct.6). In the following, we define an analogy between (a) the I-Atelier and Weber's value rational system, and (b) the I-Factory and Weber's instrumentally rational system. Further, (c) we give an additional perspective on the traditional and affectual actions, which are not within the scope of our research interest.

(a) *The I-Atelier* is associated with innovative undertakings within the uncertainty-based strategic framework of the firm, where innovation ends are made conscious based on a strategic stance of the firm in the face of uncertainty (finding V/sct.8). However, they are not defined based on a universal procedure of rational maximization and can thus not be viewed as rational in Weber's understanding. In this context of rationality of means, conscious ends allow for a rational choice of means to achieve the ends (finding IX/sct.6). Similarly, Weber's value rational system is situated in a context of rationality of means, where means are chosen rationally to achieve given irrational (i.e. value rational) ends. This choice of means is based on a rational methodology. For the I-Atelier, rational means are associated with procedures to structure projects into tasks and coordinate these for project completion.

Conclusion VI / sct. 8:

- *Based on their similar context of rationality of means, we draw an analogy between Weber's value rational system and the I-Atelier.*

(b) The I-Factory is associated with innovative outputs within the defined VD-system. These outputs stem from strategy development within a framework of close-to-certainty and can thus be associated with rational optimization in Weber's understanding (finding VIII/sct.6). This context of rationality of ends allows for rational 'means-ends calculations' of which value the company decides to propose to the customer (i.e. ends) and the way it decides to deliver this value to the customer (i.e. means). Similarly, Weber's instrumentally rational social actions are situated in a context of rationality of ends that allows for a rational maximization based on 'objective' criteria.

Conclusion VII / sct. 8:

- *Based on their similar context of rationality of ends, we draw an analogy between Weber's instrumentally rational system and the I-Factory.*

(c) Traditional and affectual actions pursue ends that stem from tradition or affect. They are not situated within the conscious domain and are thus viewed by Weber as irrational in terms of their means and ends. The affectual and traditional-type systems are not within the scope of our research interest. In our further argument, we draw implications based on the analogies between I-Atelier/I-Factory and value/instrumentally rational actions, as they all pursue ends within the consciousness of self-interest.

Conclusion VIII / sct. 8:

- *The traditional and affectual social actions pursue ends that are not within the conscious domain and are thus viewed as irrational in terms of their means and ends. They are not within the scope of our research interest.*

8.3 R-IA at the level of the firm's I-system

Based on the pivot points of analogy established in chapter 8.2, we proceed by analogy and use the findings in sections 6 and 7 to draw implications for routinization at the level of the firm's I-system. Progressive rationalization drives routinization, both in Schumpeter's (finding II/sct.6) and Weber's (finding VII/sct.6) views. Hereby, rationalization moves along a quasi-continuum of rationalization based on rationality of means (finding IX/sct.6) and rationalization based on rationality of ends (finding X/sct.6). Thus, in the following, we discuss R-IA in the context of rationality of means (chapter 8.3.1) and in the context of rationality of ends (chapter 8.3.2).

8.3.1 R-IA in the context of rationality of means

Schumpeter maintains that driven by the underlying progressive rationalization of economic activities, formerly genius-type innovation is increasingly subject to routinization (finding IV/sct.6). Weber maintains that rationalization drives the increasing consciousness of ends, whereby conscious ends - even though irrational - give rise to rational means. Rationalization thus drives the making conscious of ends, which gives rise to rationality of means (finding IX/sct.6). Weber associates this with the transition from a traditional/affectual system to a value rational system (finding VIII/sct.6). By analogy, we maintain that R-IA at the level of the firm's I-system gives rise to a progressive expansion of its scope (chapter 8.3.1.a) and discuss implications of this conclusion for organizational design based on R-IA (chapter 8.3.2.b).

8.3.1.a Expanding scope of the firm's I-system

With regard to R-IA at the level of the I-system, it can be concluded that innovation activities move from the affectual/traditional-type towards the value rational type. Thus, rationalization manifests itself in the continuous expansion of the scope of the I-system. Hereby, innovation ends in an uncertain and disruptively changing environment are progressively made available in the conscious domain. Such ends cannot be determined based on rational extrapolation of the actual situation, they require a firm to take a strategic stance in the face of uncertainty. This stance is based on the firm's vision of the future environment rather than on pure rational maximization (in Weber's understanding). In this context, innovation ends formerly belonging to the unconscious progressively become conscious. Rationality of means suggests that the means to achieve these conscious, but 'irrational' ends (in the Weberian sense) can be determined rationally (finding IX/sct.6). Formerly unconscious innovation is thus included in the scope of the 'bureaucratized firm' (Weber 1968) and becomes subject to routinization. This continuous expansion of the scope of the firm's I-system is also confirmed by the broadening view of innovation in the fields of R&D (findings I and II/sct.8), strategic marketing (finding III/sct.8), and business strategy (finding IV/sct.8) over the past decades. Further, theories of strategy development are being proposed, which capture ever expanding strategic horizons beyond certainty (finding V/sct.8).

Conclusion IX / sct. 8:

- *R-IA at the level of the I-system manifests itself in the progressive expansion of the scope of the I-system. Hereby, formerly unconscious innovation opportunities become conscious, which allows for the rational determination of means to achieve the ends.*

8.3.1.b Implications for organizational design based on R-IA

To capitalize on the phenomenon of R-IA at the level of their I-system, firms need to continuously broaden their strategic perspective and take a strategic stance in the face of uncertainty. It is about exploring innovation opportunities beyond a continuity-based strategic framework that can be determined based on rational (in Weber's understanding) extrapolation of the known situation. Thus, companies need to design their I-Ateliers to allow for the exploration of these broadening strategic frameworks for innovation opportunities, define projects and manage these for completion. The means of exploration of the uncertainty-based strategic framework of the firm can be determined rationally. This gives rise to routinization at the level of the I-Atelier.

8.3.2 R-IA in the context of rationality of ends

Schumpeter maintains that routinization gives rise to a dynamic evolution of the relative division of labour between the entrepreneurial and corporate sub-systems (finding IV/sct.6). Weber maintains that rationalization based on rationality of ends implies the progressive conversion of conscious ends into rational ends (finding X/sct.6). Hereby, social actions transit from value-based systems towards instrumentally rational systems. Both, means and ends are not only conscious, but rational (in Weber's understanding) they can be selected according to rational procedures of means-ends calculations. By analogy, we maintain that R-IA gives rise to a dynamic expansion of the VD-system (chapter 8.3.2.a). Subsequently, we discuss implications of this conclusion for organizational design based on R-IA (chapter 8.3.2.b).

8.3.2.a Expansion of the VD-system

With regard to R-IA at the level of the 'division of labour' between I-Atelier and I-Factory, it can be concluded that rationalization based on assumptions of rationality of ends manifests itself in the progressive conversion of conscious (i.e. value-based) ends into rational ends. As these ends can be determined by rational extrapolation of the actual situation and can be viewed as rational in Weber's understanding. In this context, innovation activities can be defined based on rational means-ends calculations and thus transit from the value rational system towards the instrumentally rational system, i.e. from the I-Atelier to the I-Factory.

In analogy with Baumol (2004a) the interface between I-Atelier and I-Factory can be described as the transformation of "the breakthrough models into more easily usable, more powerful and more marketable products, raising them from infancy into mature products with substantial markets and massive outputs" (Baumol 2004a:8). Hereby, innovation activities that were formerly associated with novelty-based development (finding I/sct.6) and were thus part of the (value rational) I-Atelier are incorporated into the (instrumentally rational) I-Factory that drives growth based on incremental changes (finding I/sct. 6). R-IA thus gives rise to a dynamic division of labour between I-Atelier and I-Factory. As the division of labour between I-Atelier and I-Factory is based on the underlying VD-system (conclusion III/sct.8), it can be concluded that innovation activities are progressively integrated into the firm's VD-system. R-IA thus gives rise to a progressive expansion of the VD-system.

Conclusion X / sct. 8:

- *R-IA manifests itself in the progressive transition of innovation activities from the I-Atelier to the I-Factory. This gives rise to a progressive expansion of the VD-system, i.e. the scope of the I-Factory. The division of labour between the I-Atelier and I-Factory is dynamic.*

8.3.2.b Implications for organizational design

To capitalize on R-IA at this level, firms need to allow for the systematic transfer of innovation activities from the I-Atelier to the I-Factory. We referred to this as the overarching I-Integration, by which explorative 'novelties' are inserted into the firm's

VD-system and thus made subject to exploitative innovation by incremental changes (conclusion IV/sct.8).

8.4 The firm's I-Atelier and I-Factory - static perspective

The firm's I-system is composed of its exploitative and explorative sub-systems (i.e. I-Factory and I-Atelier). These are differentiated based on whether they refer to innovation within or beyond the firm's VD-system (conclusion III/sct.8). We proceed with a discussion of the I-Factory (chapter 8.4.1) and the I-Atelier (chapter 8.4.2).

8.4.1 I-Factory

Organizational theories use the concept of 'product architecture' as a base for structuring R&D activities. This architecture is documented by literature in the fields of engineering and R&D (among others Oostermann 2001, Riepe 2003). In section 6, it was established that a product-based perspective of innovation is not sufficient to account for all exploitative innovation opportunities (findings II, III, and IV/sct.8), particularly in industries driven by innovation in areas not exclusively related to the physical product (i.e. its components, functionalities, and technologies). Based on findings from theories of strategic marketing (finding III/sct.8), the VD-system was introduced as a more appropriate concept to define the scope of the firm's exploitative innovation activities (i.e. of the I-Factory). Thus, the I-Factory refers to incremental changes within the firm's actual VD-system. Exploitative innovation activities are about scrutinizing all elements of the company's VD-system for incremental innovations, product upgrades, product and module variants, line extensions and new combinations of existing modules. The aim is to generate a continuous flow of incremental innovations, which enables the firm to adapt to immediate and mediate environmental changes. Similarly to the product architecture used as a base for structuring R&D activities, the VD-system can be represented as a multi-level architecture composed of modular sub-scopes (further referred to as VD-architecture). It is used as a base for structuring the I-Factory. Specifically, it defines the sub-scopes that are exploited by 'exploitative' sub-processes. The sub-scopes and their allocated sub-processes give rise to sub-routines. These are coupled based on the interfaces defined by the VD-architecture to give rise to irreducible emergent properties at the level of the VD-system (i.e. the value delivered to the customer) and at the level of the I-Factory (i.e. the generation of a continuous flow of incremental innovations of the value delivered to the customer). In line with Simon (1996) we define emergent properties as properties of the higher-rank system that are irreducible to its sub-systems. For further illustration of the concept of VD-architecture and its applicability in innovation management, we refer to our publication attached in chapter 12.3, 12.6, 12.8, and 12.9.

Conclusion XI / sct. 8:

- *The I-Factory can be viewed as a modular system composed of specialized sub-routines, the coupling of which gives rise to irreducible emergent properties, i.e. the ability to generate a continuous flow of incremental innovations associated with exploitation.*
- *The scope of the I-Factory are incremental changes within the firm's actual VD-system. Similarly to the product architecture used as a based to structure R&D activities, the VD-system can be represented by a multi-level architecture composed of modular sub-scopes (referred to as VD-architecture). These sub-scopes combined with their allocated sub-processes give rise to sub-routines that are coupled to compose the I-Factory. In our publications attached in chapters 12.3, 12.6, 12.8, and 12.9 we describe the I-Factories of a FMCG manufacturer and a maintenance company, that are structured into sub-routines, each having a scope determined by the VD-architecture.*

8.4.2 I-Atelier

The I-Atelier refers to innovation beyond the firm's VD-system (conclusion III/sct.8). It deals with the 'creative destruction' associated with a corporation's long-term competitiveness and performance (Foster and Kaplan 2001). Explorative innovation activities aim at expanding or replacing the company's current VD-architecture or significant parts of it with new architectures. The outputs of the I-Atelier are completed development projects ready for diffusion and adoption internally or externally. They include fundamental changes of some key components of the business, architectural changes, new platforms, new technologies and new business models. The scope of the I-Atelier is thus a 'landscape' of more or less pre-defined projects. In a context of rationality of means, these projects are structured based on means-oriented modularity into project architectures composed of modular sub-tasks (finding VIII/sct.7). These sub-task are subsequently coordinated for project completion.

Conclusion XII / sct. 8:

- *The scope of the I-Atelier is a landscape of projects. These are structured into modular sub-tasks (represented by project architectures composed of modular sub-*

tasks). These sub-tasks are subsequently coordinated for project completion. Projects that share common requirements of functional expertise are grouped in project portfolios. These portfolios are structured to allow for optimal usage of the resources shared across various projects in the portfolio.

- *The I-Atelier can be viewed as a system composed of sub-routines that structure projects into sub-tasks and coordinate these for project completion (similar to project production). The objective of the I-Atelier is to generate a stream of explorative innovations referring to changes of and beyond the firm's actual VD-system.*

8.5 Analogies at the level of the I-Atelier and I-Factory

In order to draw implications from the findings in sections 6 and 7 on R-IA at the level of the I-Atelier and I-Factory, we define hereafter analogies between the firm's I-system and its production system in addition to the analogies established in chapter 8.2.

(i) The firm's production system is a complex system structured based on the generalized concept of modularity into a multi-level, hierarchical structure composed of sub-routines. These are coupled to give rise to irreducible emergent properties (i.e. adaptability and output variety) at the level of the production system (finding VII/sct.7). Similarly, the firm's I-system is a complex system with a modular multi-level structure of explorative and exploitative sub-routines. These are coupled to give rise to irreducible emergent properties at the level of the I-system, i.e. ambidexterity or the capability to generate parallel streams of exploitative and explorative outputs (finding VI/sct.8).

Conclusion XIII / sct. 8:

- *Based on their similar nature, we draw an analogy between the firm's production system and its I-system.*

(ii) The firm's production system and I-system are both dealing with scopes consisting of heterogeneous outputs. In production and innovation alike, outputs are differentiated based on whether or not they have a common underlying product structure (finding XII/sct.6 and conclusion III/sct.8). In production, unique and distinct products have no common underlying product structure, whereas product variants and standardized products refer to a common underlying product structure (finding XII/sct.6). Similarly, the I-Factory's exploitative outputs refer to innovation within the VD-architecture, whereas the I-Atelier's explorative outputs stem from innovation of and beyond the VD-architecture (conclusion III and XI/sct.8).

Conclusion XIV / sct.8:

- *Based on their similar typological criteria, we draw an analogy between the firm's production outputs and innovation outputs. Specifically, (i) unique and 'distinct' production outputs are associated with explorative innovation outputs, and (ii) product variants and standardized products are associated with exploitative innovation outputs.*

(iii) In production the typology of outputs gives rise to a typology of specialized production processes. Unique and distinct products are associated with the rather broadly defined routines of project and jobbing production. Product variants and standardized products are associated with rather narrowly defined routines of batch, line and flow production (finding XIII/sct.6). Similarly, explorative outputs are associated with broadly defined explorative processes and exploitative outputs with narrowly defined exploitative processes (conclusions I and II/sct.8).

Conclusion XV / sct.8:

- *Based on their similar nature and the similar nature of their allocated scopes, we draw an analogy between the firm's production processes and innovation processes. Specifically, (i) processes of project and jobbing production are associated with explorative processes, and (ii) processes of batch, line and flow production are associated with exploitative processes.*

Conclusion XVI / sct.8:

- *Combining conclusions XIV and XV/sct.8, we draw an analogy between production routines and innovation routines. Specifically, (i) routines of project and jobbing production are compared to the explorative routines of the I-Atelier, and (ii) routines of batch, line, and flow production are compared to the exploitative routines of the I-Factory.*

(iv) Production routines associated with outputs sharing a common underlying product structure (i.e. batch, line and continuous flow production) are structured based on the requirements of the underlying product architecture (finding XII/sct.6). Similarly, the scope of the I-Factory is structured according to the underlying VD-architecture (conclusion XI/sct.8). Both, product architecture and VD-architecture are modular structures based on the generalized principle of ends-oriented modularity (finding VIII/sct.7).

Conclusion XVII / sct.8:

- *Based on their similar (ends-oriented) modular nature, we draw an analogy between the product architecture and the VD-architecture.*

(v) Production routines such as project and jobbing production are associated with outputs that don't share a common underlying product structure (i.e. unique and distinct products) (finding XII/sct.6). These undertakings are structured into means-modular architectures composed of modular sub-tasks (findings VIII/sct.7). Similarly, exploitative outputs do not share a common VD-architecture and are structured into means-modular project architectures composed of modular sub-tasks.

Conclusion XVIII / sct. 8:

- *Based on their similar (means-oriented) modular nature, we draw an analogy between the structures of sub-tasks used in project/jobbing production and the project architectures used in explorative innovation.*

8.6 R-IA at the level of the firm's I-Atelier and I-Factory

The pivot points of analogy established in chapter 8.5, allow to apply the findings in sections 6 and 7 to the firm's innovation activities and draw implications for R-IA at the level of the firm's I-Atelier and I-Factory.

The unprecedented changes of the business environment give rise to new requirements, both in production and innovation. This external variance drives complex systems (i.e. the firm's production system and I-system alike) along an evolutionary path reducible to a generalized pattern of internal/external variation-and-selection (finding VI/sct.7). In the context of rationalization, the evolution of modular complex systems is reflected in the progressive modularization of their modular structures. It has further been established that rationalization moves along a quasi-continuum of rationalization based on rationality of means (finding IX/sct.6) and rationalization based on rationality of ends (finding X/sct.6). Hereby, the I-Atelier is associated with a context of rationality of means (conclusion VI/sct.8) and the I-Factory with a context of rationality of ends (conclusion VII/sct.8). In this chapter, we draw implications for R-IA as it manifests itself at the levels of the firm's I-Factory (chapter 8.6.1) and the I-Atelier (chapter 8.6.2).

8.6.1 R-IA at the level of the I-Factory

In production, external variance (such as the emergence of new requirements of adaptability and output variety) gave rise to the emergence of specialized production sub-routines, which combined ensure the emergent properties at the level of the firm's production system. Similarly, we maintain with regard to the firm's I-Factory, that R-IA manifests itself in the increasing specialization of the exploitative sub-routines (chapter 8.6.1.a), and the differentiated coupling thereof to ensure irreducible emergent properties (chapter 8.6.1.b). The argument is further supported by findings stemming from our empirical research and case studies (chapter 8.6.1.c). Additionally, we allude to some implications for organizational design based on R-IA (chapter 8.6.1.d).

8.6.1.a Specialization of exploitative sub-routines

In production, rationalization manifests itself in the progressive modularization of the underlying product architecture and gives rise to specialization at the level of the production sub-routines. Production outputs based on a common underlying product structure are associated with specialized sub-routines of batch, line and flow production. Their coupling ensures the required emergent properties at the level of the production system. Similarly, in a context of rationality of ends, it can be concluded for the I-Factory that rationalization manifests itself in the progressive modularization of the VD-architecture. As the VD-architecture is the scope of the I-Factory, it can be concluded that this latter is composed of increasingly specialized, modular sub-scopes, which gives rise to increasingly specialized exploitative sub-routines (conclusion VIII/sct.3)

Conclusion XIX / sct. 8:

- *R-IA manifests itself at the level of the I-Factory in the progressive modularization of the underlying VD-architecture. This gives rise to progressive specialization at the level of the sub-routines of the I-Factory.*

8.6.1.b Differentiated coupling for emergent properties

Insights from systems theory and from production management show that irreducible emergent properties (e.g. adaptability and output variety) at the system-level are achieved through the coupling of its specialized sub-routines. Findings from our literature review in production management suggest that, pending on the required emergent properties, the coupling of the sub-routines can be tight, loose, time de-coupled, and dynamic (findings XIV, XV, XVI and XVII/sct.6). For example, production routines based on a logic of 'assembly-on-demand' consist of specialized sub-routines of flow production and assembly. These are time de-coupled (finding

XVI/sct.6) and their combination gives rise to emergent properties at the level of the production system, i.e. the generation of a continuous flow of outputs in an environment characterized by requirements of adaptability and output variety.

Based on the similar external variance giving rise to requirements of similar emergent properties (i.e. generation of a continuous flow of outputs in an environmental context requiring adaptability and output variety) and the analogy drawn between exploitative sub-routines and the specialized routines of batch, line and flow production (conclusion XV/sct.8), it can be further concluded as follows:

Conclusion XX / sct. 8:

- *R-IA manifests itself at the level of the I-Factory in a differentiated coupling of specialized sub-routines, which gives rise to irreducible emergent properties at the level of the I-Factory, i.e. the ability to generate a continuous flow of incremental innovative outputs in an environmental context requiring adaptability and output variety.*

Conclusion XXI / sct. 8:

- *Combining conclusions X, XIX and XX/sct.8 it can be further concluded that R-IA at the level of the I-Factory manifests itself in the expansion of its scope and the progressive modularization of the underlying VD-architecture. This gives rise to (i) specialization at the level of the sub-routines, and (ii) differentiated coupling of specialized sub-routines to allow for irreducible emergent properties at the level of the I-Factory, i.e. the ability to generate a continuous flow of incremental innovations in the face of environmental requirements of adaptability and output variety.*

8.6.1.c Supporting findings from empirical research

In support of this argument, we refer to findings from our empirical research discussed in our publications attached in chapters 12.3, 12.4, 12.5, 12.6, 12.8 and 12.9. Specifically, the publication in chapter 12.3 illustrates the I-Factory of an FMCG (i.e. fast moving consumer goods) manufacturer. It is based on the principles of 'assembly-on-demand' production. The I-Factory is structured based on the underlying VD-architecture of the FMCG manufacturer. It is composed of specialized sub-routines of flow production at the module-level. These sub-routines are time-decoupled and develop for stock incremental changes at the module-level. According to short-and mid-term market developments, a specialized assembly-routine combines the semi-finished innovative outputs at module level to generate a continuous flow of incremental innovations.

8.6.1.d Implications for organizational design based on R-IA

To capitalize on the phenomenon of R-IA at the level of the I-Factory, firms need to design I-Factories that allow for the generation of a continuous flow of incremental innovations in the face of environmental requirements of adaptability and output variety. The findings from this research project suggest that this can be achieved based on a set of specialized sub-routines that are coupled to give rise to emergent properties at the level of the I-Factory. Specifically, the challenge for organizational design is to (i) design the firm's VD-architecture, which provides the modular sub-scopes of the I-Factory, (ii) design sub-processes according to the sub-scopes, and (iii) design the coupling of the specialized sub-routines according to the emergent properties required at the level of the I-Factory.

8.6.2 R-IA at the level of the I-Atelier

In production, routinization gives rise to the differentiation between routines of project production and routines of jobbing production. In the latter, similar functional sub-tasks shared across various products are grouped into specialized sub-routines. These are not managed from a single-project perspective, but from a perspective of multiple projects. This is also in line with findings from theories of project management that adopt the modular concept of 'project architecture' to structure projects such as the explorative projects of the I-Atelier. (For a comparative discussion of project management, lean project management and multi-project management, we refer to Deplazes 2008b). Hereby projects are structured into modular and manageable sub-tasks (task-oriented modularity). With regard to R-IA at the level of the I-Atelier, we conclude that the progressive modularization of means-modular project architectures gives rise to increased clustering of projects (or parts thereof) in portfolios based on commonalities of their underlying architectures (chapter 8.6.2.a) and the emergence of specialized routines of single-project and multi-project management (chapter 8.6.2.b). The argument is supported by findings from our empirical research and case studies (chapter 8.6.2.c). Additionally, we mention some implications for organizational design based on R-IA (chapter 8.6.2.d).

8.6.2.a Grouping of projects and sub-tasks

In the context of rationality of means, rationalization gives rise to progressive modularization of means-modular architectures composed of modular sub-tasks (finding

VIII/sct.7). In production, such architectures are applied for outputs that do not share a common underlying product structure, i.e. unique products and ‘distinct’ products. Unique products share no (or only limited) commonalities with other projects and ‘distinct’ products share similar requirements of functional expertise with other products. Similarly, theories of project management differentiate between heterogeneous, unique projects having no or limited commonalities (associated with single-project management) and more homogeneous projects showing commonalities among their project architectures (associated with multi-project management).

With regard to the I-Atelier, rationalization based on rationality of means gives rise to a broadening uncertainty-based strategic framework of the firm (conclusion V/sct.8). This translates into a progressively expanding scope of the I-Atelier (conclusion IX/sct.8). As the scope of the I-Atelier is a landscape of projects, it can be concluded that rationalization leads to an increasing number of potential explorative projects that refer to changes of and beyond the firm’s actual VD-architecture. Based on insights from theories of project management and in analogy with routinization in production, it can be concluded that R-IA at the level of the I-Atelier gives rise to the emergence of commonalities among project architectures (or parts thereof) of various explorative projects. This gives rise to the constitution of portfolios of projects based on commonalities of their project architectures (or parts thereof), i.e. modular sub-tasks requiring similar functional expertise.

Conclusion XXII / sct. 8:

- *R-IA manifests itself at the level of the I-Atelier in the emergence of commonalities among explorative projects that share similar sub-tasks. This gives rise to the grouping of similar projects into project portfolios and the grouping of similar sub-tasks into specialized routines that intervene in the completion of various similar projects.*
- *R-IA gives rise to differentiation of the scope of the I-Atelier into (i) single-projects sharing no or only limited commonalities and (ii) similar projects sharing commonalities.*

8.6.2.b Emergence of specialized sub-routines

In production, unique products are associated with routines of project production that adopt a single-project perspective. ‘Distinct’ products are associated with routines of jobbing production. Hereby, the shared requirements of functional expertise are grouped in task-oriented sub-routines (e.g. forging, wielding) that intervene in the completion of various ‘distinct’ products. Theories of project management in the field of innovation differentiate between routines of single-project management and multi-project management. The first adopt a perspective of completion of single-projects, while the latter adopt a perspective of completion of portfolios of similar projects. For a detailed review of theories of project management, we refer to Deplazes (2008b). Based on insights from theories of project management and in analogy with routinization in production, it can be concluded that the dual scope of the I-Atelier (conclusion XXII/sct.8) gives rise to specialized sub-routines referring to (i) single-projects and (ii) portfolios of similar projects.

(i) *Single-projects* in innovation compare to unique products in production. They are associated with routines of single-project management (comparing to routines of project production). These routines focus on the efficient completion of single-projects and include the structuring of individual projects into sub-tasks and coordinating these for project completion. Earlier we associated this with broadly defined search-type processes or explorative processes (conclusion II/sct.8). (ii) *Similar projects* in innovation compare to ‘distinct’ products in production. They are grouped into portfolios associated with routines of multi-project management (comparing to routines of jobbing production). These routines focus on the efficient completion of portfolios of projects. Hereby, similar projects are grouped into portfolios based on commonalities among their project architectures or parts thereof (i.e. sub-tasks requiring similar functional expertise). These portfolios of projects are structured into portfolio architectures composed of modular sub-tasks, which are coordinated for completion of portfolios of projects. This gives rise to the emergence of task-specialized sub-routines that perform specialized functional tasks on a stream of similar projects.

Conclusion XXIII / sct. 8:

- *Rationalization at the level of the I-Atelier drives the expansion of its scope and the commonalities among the projects’ architectures. This gives rise to task-oriented sub-routines that can be shared across a variety of projects, although these don’t share a common underlying structure. The sub-routines are loosely coupled and can be re-configured pending on the underlying structure of the specific product.*

8.6.2.c Supporting findings from empirical research

A variety of processes, tools and techniques are proposed by the burgeoning literature in the field of project management. For a comparative analysis of single- and multi-project management, we refer to Deplazes 2008b. Further, our publications attached in chapter

12.6, 12.8 and 12.9 illustrate the case of a maintenance company that structured its I-Atelier into modular 'innovation fields' that are explored systematically to generate explorative projects. Our publications attached in chapter 12.3, illustrates the case of an FMCG (i.e. fast-moving consumer goods) manufacturer that structured its I-Atelier in projects dealt with by ad-hoc multi-functional teams.

8.6.2.d Implications for organizational design based on R-IA

To capitalize on R-IA at the level of the I-Atelier, firms need to design their I-Ateliers to allow for the completion of single-projects and portfolios of projects. Specifically, the challenges of organizational design are (i) the structuring of the explorative projects into modular architectures, (ii) the grouping of projects with similar requirements into portfolios of projects, (iii) the design of routines of single-project management for unique projects, and (iv) the design of routines of multi-project management for portfolios of projects, which includes the design of specialized sub-routines that contribute to various similar projects.

9 Main findings and outlook

The insight that routinization of innovation is a key driver of the unprecedented growth in free-market economies suggests there is potential to investigate how companies could capitalize on the phenomenon of routinization of innovation to achieve sustainable long-term growth. This gives rise to two combined research questions, i.e. (i) How does routinization manifest itself at the level of the firm's innovation activities? and (ii) How can firms capitalize on the phenomenon of R-IA? The second question is dealt with in a fellow research project (Deplazes 2008a). The current research project explores the first question and proposes a theory of R-IA, i.e. of routinization as it manifests itself at the level of the firm's innovation activities. In the following we discuss the main findings of this research project and formulate recommendations for further research.

9.1 Conceptual framework for studying routinization

We base our study of routinization on a conceptual framework grounded on foundations of transcendental realism. The phenomenon of routinization is thus analyzed at its empirical, actual, and real ontological levels. Our differentiated analysis based on explicit and consistent ontological assumptions allowed us to draw consistent findings from various theories and empirical research related to routinization, despite their diverging ontological assumptions. We applied these findings to the firm's innovation activities to draw implications for R-IA.

Further research is required to better understand the dynamics and mechanisms of the 'tendencies' (Lawson 1998) linking the different ontological levels and particularly those tendencies linking the actual and the empirical level. Specifically, a clearer understanding as to (i) how routinization gives rise to accelerating flows of innovative outputs, and as to (ii) which elements of routinization at the actual ontological level are associated with which specific experiences at the empirical level. This would be of great value to theorists of routinization and practitioners wishing to reap the benefits associated with routinization.

9.2 Concept of the firm's innovation activities

We adopted a concept of the firm's innovation activities based on foundations of systems theory, process philosophy, insights from theories of routines, and theories related to innovation in various fields. The firm's innovation activities are viewed as a complex system of routines composed of the I-Atelier (i.e. explorative sub-system) and the I-Factory (i.e. exploitative sub-system). The routine is the unit of analysis that is processual in nature.

9.3 Proposed theory of R-IA

Based on the proposed conceptual framework for studying routinization, we established pivot points of analogy between the firm's I-system and systems such as Schumpeter's self-transforming system, Weber's social system, the firm's production system. This allowed us to apply the findings and conclusions to the firm's innovation activities and drew implications for R-IA that are further supported by findings from our further empirical research. This gave rise to the proposed theory of R-IA. Essentially, it produces the following insights at the real (chapter 1.1.3.a) and actual ontological levels (chapter 1.1.3.b).

9.3.1 Real ontological level

The proposed theory refers to R-IA as driven by the underlying mechanism of progressive rationalization. This mechanism has been described (i) in terms of its generalized pattern encompassing rationalization based on assumptions of rationality of means and rationality of ends, (ii) in terms of the generalized mechanisms of feedback giving rise, in the context of rationalization, to a complex system's generalized evolutionary pattern based on variation-and-selection, and (iii) in terms of generalized concepts of rationalization, such as modularity and advancements thereof.

As the proposed theory of R-IA applies to the context of rationalization, further research is required to identify additional underlying mechanisms impacting on R-IA. Of particular interest are those having a restraining effect on R-IA, such as path dependency, traditionalization, and conventionalization. Weber discusses an evolutionary dynamic where instrumentally rational social systems evolve into value rational systems. He maintains that rationally chosen individual ends give rise to increasingly similar and uniform attitudes by the actors (conclusion II/sct.6). Hereby rational ends become conventional. Further research adopting this perspective beyond rationalization will be concerned with how 'what is generally done' passes into convention and how 'matters of taste' become 'matters of principle' (Weber 1968).

9.3.2 Actual ontological level

The proposed theory describes R-IA as it manifests itself at various levels of the firm's innovation activities, i.e. (i) at the level of the I-system, (ii) the I-Factory, and (iii) the I-Atelier. (i) At the level of the I-system, R-IA has been associated with the progressive expansion of the scope of the I-system and, based on the dynamic division of labour between the I-Atelier and I-Factory, with the progressive expansion of the firm's VD-system. (ii) At the level of the I-Factory, R-IA manifests itself in the increasing modularization of the VD-architecture and the progressive specialization at the level of the exploitative sub-routines. Their differentiated coupling allows for irreducible emergent properties at the level of the I-Factory, i.e. the ability to generate a continuous flow of incremental innovations in the face of environmental requirements of adaptability and output variety. (iii) At the level of the I-Atelier, R-IA gives rise to the emergence of commonalities among explorative undertakings that do not share a common underlying VD-architecture. This allows for the progressive grouping of projects (or parts thereof) based on their commonalities of requirements of functional expertise. R-IA manifests itself in the emergence of specialized sub-routines referring to the completion of single-projects and of portfolios of multi-projects.

The proposed theory of R-IA attempts to describe R-IA in the context of the firm's I-system and its sub-systems. It considers environmental variance stemming from beyond the firm's boundaries as external to the I-system. In this practical perspective, external variance is captured by a combination of continuity- and uncertainty-based strategy development (finding V/sct.8) associated with exploration and exploitation (finding VI/sct.8) and the making conscious of unconscious ends (finding II/sct.7). This view allowed to formulate a variety of implications for R-IA and organizational design based on R-IA. As evidenced by our empirical research, it generated significant implications also from a practitioner's perspective.

However, a more holistic view suggests that not only the firm's I-system and its I-Atelier and I-Factory, but all its multi-level sub-systems are each embedded collectively and individually in a multitude of higher-rank systems beyond the firm's boundaries. Such a holistic perspective reduces external variance at the level of the firm's I-system (and the I-Atelier and I-Factory) to internal variation at the level of the higher-rank systems. As the underlying mechanism of rationalization acts upon these higher-rank systems, it gives rise to routinization at the level of these multiple higher-rank systems beyond the firm's boundaries. The firm is thus subject to parallel and dissipated evolutions affecting its multi-level sub-systems both collectively and individually.

In line with the focus of this research project on the firm, such developments were discussed in terms of increased connectivity of the firm with its environment at the level of all its sub-systems. It was established that this gives rise to the emergence of interface standards and component standards (at the level of networks) and eventually to the emergence of dominant designs (at the level of entire industries). However, a more holistic perspective of networks of multiple higher-rank systems beyond the firm's boundaries calls for further research to (i) conceptualize these multi-level networks, (ii) draw implications for a pattern of routinization thereof, and (iii) define implications thereof at the level of the firm's multi-level sub-systems individually and collectively at the level of the I-Atelier and I-Factory. Findings from multi-disciplinary theories of self-organization and self-transformation refer to similar phenomena and could provide useful insights for further research on R-IA in this context.

9.4 Implications for operationalization

Additional research is required to further validate the proposed theory of R-IA. Specifically, its validity needs to be established in specific empirical contexts, such as industries and geographies. This will give rise to further insights as to when and how the theory applies.

The proposed theory of R-IA allowed me to formulate some general implications for organizational design based on R-IA. Further research is required to develop a systemic framework and approaches of organizational design based on R-IA. These will allow for operationalization of the proposed theory of R-IA from the perspective of the individual firm. This is dealt with by the second research question that asks how companies can capitalize on the phenomenon of R-IA. For further research on this we refer to the fellow research project (Deplazes 2008a).

10 References

Abernathy W J (1979) The Productivity Dilemma: Roadblock to Innovation in the Automobile Industry. John Hopkins University Press, Baltimore

Abernathy W J and Clark K (1985) Innovation. Mapping the Winds of Creative Destruction. Research Policy 14(1):3-22

Anterasian C and Phillips J L (1988) Discontinuities, Value Delivery, and the Share-Return Association: A Re-Examination of the 'Share-Causes-Profit' Controversy. Market Science Institute pp. 88-109, available: http://www.msi.org/publications/publication.cfm?pub=219

Baldwin C and Clark K B (2000) Design Rules: The Power of Modularity. MIT Press, Cambridge MA

Baumol W J (1993) Entrepreneurship, Management and Structure of Payoffs. MIT Press, Cambridge MA

Baumol W J (2002) Entrepreneurship, Innovation and Growth. The David-Goliath Symbiosis. Presentation at New York University, available: http://www.econ.nyu.edu/user/baumolw/sfg.pdf

Baumol W J (2004a) On Entrepreneurship, Growth and Rent-Seeking: Henry George Updated. American Economist 48: 1-11, available: http://findarticles.com/p/articles/mi_qa5461/is_200404/ai_n21349893

Baumol W J (2004b) The Free-Market Innovation Machine. Analyzing the Growth Miracle of Capitalism. Princeton University Press, Princeton Oxford

Baumol W J (2004c) Towards Microeconomics of Innovation: Growth Engine Hallmark of Market Economics. Presentation at New York and Princeton University, available: http://www.iaes.org/journal/aej/march_02/baumol.pdf

Becker M C (2004) Organizational Routines: a Review of the Literature. Industrial and Corporate Change 13(4):643-677.

Becker M C (2005a) The Concept of Routines: Some Clarifications. Cambridge Journal of Economics 29:249-262

Becker M C (2005b) A Framework for Applying Organizational Routines in Empirical Research: Linking Antecedents, Characteristics and Performance Outcomes of Recurrent Interaction Patterns. Industrial and Corporate Change 14(5):817-846

Becker M C, Lazaric N, Nelson R R and Winter S G (2005) Applying Organizational Routines in Understanding Organizational Change. Industrial and Corporate Change 14(5):775-791

Becker M C and Knudsen T (2003) The Entrepreneur at a Crucial Juncture in Schumpeter's Work : Schumpeter's 1928 Handbook Entry Entrepreneur. Advances in Austrian Economics. 6:199-234

Becker M C, Knudsen Thorbjörn and March J G (2006) Schumpeter, Winter and the sources of novelty. Industrial and Corporate Change 15(2):353-371

Benner M J and Thushman M L (2003) Exploitation, Exploration , and Process Management. The Productivity Dilemma revisited. Academy of Management Review 28:238-256

Bergson H (1957) L'Evolution Créatrice. Les Presses universitaires de France, available: http://classiques.uqac.ca/classiques/bergson_henri/evolution_creatrice/evolution_creatrice.pdf

Bhaskar R (1997) A Realist Theory of Science. Verso, New York and London

Blackburn J (1991) Time-Based Competition. The Next Battleground in Manufacturing. Business One, Homewood IL

Blecker T and Abdelkafi N (2006) Complexity and Variety in mass Customization Systems: Analysis and Recommendations. Management Decision 44(7):908-926

Boutellier R. and Rohner N (2006) Technologiegeschwindigkeit und Technologieplanung. In: Gausemeier J (ed) Vorausschau und Technologieplanung. Westfalia, Paderborn pp. 291-316

Braverman H (1974) Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century. Monthly Review Press, New York

Brunsson N and Jacobsson B (2000) A World of Standards. Oxford University Press, New York

Bryan L and Joyce C (2007) Better Strategy through Organizational Design. The McKinsey Quarterly 2:21-29

Burnet J (1920) Early Greek Philosophy. London: A&C Black Ltd, London, available: http://faculty.evansville.edu/tb2/courses/phil211/burnet/ch3.htm#65

Burns J (2000) The Dynamics of Accounting Change: Interplay between New Practices, Routines, Institutions, Power and Politics. Accounting, Auditing & Accountability Journal 13:566-586

Carrara M and Varzi A C (2001) Ontological Commitment and Reconstructivism. Erkenntnis 55:33-50

Chesbrough H (2005) Towards a Dynamics of Modularity: A Cyclical Model of Technical Advance. In Prencipe A, Davies A and Hobday M (eds) The Business of Systems Integration. Oxford University Press, Oxford pp.174-198

Chesbrough H and Kusunoki K (2001) The Modularity Trap: Innovation, Technology Phases Shifts and the Resulting Limits of Virtual Organizations. In: Nonaka I and Teece D (eds) Managing Industrial Knowledge. Sage Press, London

Christensen C M and Chesbrough H (1999) Technology Markets, Technology Organization, and Appropriating the Returns to Research. Working Paper Harvard Business School

Christensen C M and Raynor M F (2003a) The Innovator's dilemma. Creating and sustaining successful growth. Harvard Business School Press, Boston MA

Christensen C M and Raynor M F (2003b) The Innovator's solution. Creating and sustaining successful growth. Harvard Business School Press, Boston MA

Cohen M D (1991) Individual Learning and Organizational Routine: Emerging Connections. Organization Science 2:135-139

Cohen M D, Burhhart R, Dosi G, Egidi M, Marengo L, Warglien M and Winter S (1996) Routines and Other Recurring Action Patterns of Organizations: Contemporary Research Issues. Industrial and Corporate Change 5:653-698

Cohen M and Bacdayan P (1994) Organizational Routines are Stored as Procedural Memory. Evidence from a Laboratory Study. Organization Science 5:554-568

Costello N (2000) Stability and Change in High-Tech Enterprises – Organizational Practices and Routines. Routledge, London.

Courtney H, Kirkland J and Viguerie S P (1997) Strategy under Uncertainty, Harvard Business Review 75(6): 67-79.

Cyert R M and March J G (1963) A Behavioral Theory of the Firm. Blackwell, Oxford

Daft R L (1987) A Dual-Core Model of Organizational Innovation. Academy of Management Journal 21(2):193-210

Damanpour F and Wischnevsky J D (2006) Research on Innovation in Organizations: Distinguishing Innovation-Generating from Innovation-Adopting Organizations. Journal of Engineering Technology Management 23:269-291

Damanpour F and Gopalakrishnan (2001) The Dynamics of the Adoption of Product and Process Innovations in Organizations. Journal of Management Studies 38:45-65

Daneels (2002) The Dynamics of Product Innovation and Firm Competences. Strategic Management Journal 23:1095-1121

Davenport T H (1993) Process Innovation. Harvard Business School, Boston

Delmestri G (1998) Do All Roads Lead to Rome… or Berlin? The Evolution of Intra- and Inter-Organizational Routines in the Machine-Building Industry. Organization Studies 19:639-665

Deplazes U, Deplazes W and Boutellier R (2008a) Design of Engines of Growth based on 'Routine Innovation Activities'. Forthcoming publication in proceedings ICMIT Conference 2008 (Bangkok/Singapore)

Deplazes U, Deplazes W and Boutellier R (2008b) Innovation Factory and Innovation Atelier. Business Design for 'Routinized Innovation'. Forthcoming publication in proceedings ICMIT Conference 2008 (Bangkok/Singapore)

Deplazes U and Deplazes W (2008c) Process Philosophy and Creativity in management. Contributions of Process Philosophy to Innovation Management. Forthcoming publication in proceedings of EURAM Conference 2008

Deplazes W (2008a) Organizational Design Based on Routinization of Innovation, forthcoming dissertation. The Swiss Federal Institute of Technology, Zurich

Deplazes W (2008b) Project- and Process-Orientation in Innovation Management. Introducing 'Innovation Ateliers' and 'Innovation Factories', unpublished

Devan J, Klusas M B and Ruefli W (2007) The Elusive Goal of Corporate Outperformance. The McKinsey Quarterly, web exclusive, April, available: www.mckinseyquarterly.com

Doll W J and Vonderembse M A (1991) The Evolution of Manufacturing Systems. Towards the Post-Industrial Enterprise. Omega 19(5):401-411

Dosi G, Tecce D J and Winter S G (1992) Toward a Theory of Corporate Coherence: Some Preliminary Remarks. In: Dosi G, Gianetti T and Toninelli P A (eds) Technology and Enterprise in a Historical Perspective. Clarendon Press, Oxford pp.185-211

Drucker P (1993) The Practice of Management. Harper Business, New York

Duncan R B (1976) The Ambidextrous Organization. Designing Dual Structures for Innovation. In: Kilmann R and Pondy L (eds) The Management of Organizational Design. Strategy Implementation. vol 1, North Holland, New York pp. 167-188

Egidi M (1992) Organisational Learning, Problem Solving and the Division of Labor. In: Simon H A, Egidi M, Marris R and Viale R (eds) Economics, Bounded Rationality and the Cognitive Revolution. Edward Elgar, Aldershot pp. 148-173

Egidi M (1996) Routines, Hierarchies of Problems, Procedural Behavior some Evidence from Experiments. In: Arrow K, Colombatto E, Perlman M and Schmidt C (eds) The Rational Foundations of Economic Behaviour. Macmillan, London pp. 303-333

Feldman M S (2000) Organisational Routines as a Source of Continuous Change. Organisation Science 11:611-629

Feldman M S and Pentland B T (2003) Reconceptualizing Organizational Routines as a Source of Flexibility and Change. Administrative Science Quarterly 48:94-118.

Feldman M S and Rafaeli A (2002) Organizational Routines as Sources of Connections and Understandings. Journal of Management Studies 39:63-91.

Foster R and Kaplan S (2001) Creative Destruction. The McKinsey Quarterly 3:41-51

Frandberg T (2005) Living Systems and its Philosophy Considered at the Level of the Earth. Systems Research and behavioral Science 22(5):373-383

Freeman C (1982) The Economics of Industrial Innovation. MIT Press, Cambridge

Gallagher S (2007) The Complementary Role of Dominant Designs and Industry Standards. IEEE Transactions on Engineering Management 54(2):371-379

Gerwin D and Kolodny H (1992) Management of Advanced Manufacturing Technology. Strategy, Organizations, and Innovation. Wiley, New York

Gibbert M et al (2002) Five Styles of Customer Knowledge Management, and How Smart Companies use them to Create Value. European Management Journal 10(5):459-469

Giddens A (1984) The Constitution of Society: Outline of the Theory of Structuration. Polity Press, Cambridge

Giddens A (1984) The Constitution of Society. University of California Press, Berkeley

Gittell J H (2002) Coordinating Mechanisms in Care Provider Groups: Relational Coordination as a Mediator and Input Uncertainty as Moderator of Performance Effects. Management Science 48:1408-1426

Guala F (2005) An Ontology of Economics? available: http://www.people.ex.ac.uk/fguala/OntologyLong.pdf

Hage G (1995) Routinization. In: Nicholson N (ed) Encyclopedia Dictionary of Organizational Behavior. Blackwell, Oxford

Hall R L and Hitch C J (1939) Price Theory and Business Behavior. Oxford Economic Papers 2:12-45

Hamel G (2002) Leading the Revolution. Harvard Business School Press, Boston MA

Hammer M and Champy J (1993) Reengineering the Corporation. A Manifest for Business Revolution. Summaries.com, available: http://www.corporatesolutionsinc.ca/lib-documents/Reengineering%20The%20Corporation.pdf

Hargadon A and Sutton R I (2000) Building an Innovation Factory. Harvard Business Review May-June: 157-166

Heylighen F (1989) Self-Organization, Emergence and the Architecture of Complexity. Proceedings of the 1st European Conference on System Science (AFCET, Paris) pp. 23-32

Hodgson G M (2003) The Mystery of the Routine. The Darwinian Destiny of *An Evolutionary Theory of Economic Change* 54:355-384

Hodgson G M and Knudsen T (2004) The Firm as an Interactor: Firms as Vehicles for Habits and Routines. Journal of Evolutionary Economics 14:281-307

Huber G P (1984) The Nature and Design of post-industrial Organizations. Management Science 30(8):928-951

Hutchins E (1991) Organizing Work by Adaptation. Organization Studies 2:14-39

Jaffe A B and Lerner J (2004) Innovation and its Discontents: How our Broken Patent System is Endangering Innovation and Progress, and What to Do about it. Princeton University Press, Princeton, 2004

Jarzbkowski P and Wilson D C (2002) Top Teams and Strategy in a UK University. Journal of Management Studies 39:368-380

Jewell B R (2003) An Integrated Approach to Business Studies. Pearson, Essex

Johansson H J, McHugh P, Pendlebury A.J. and Wheeler W.A. (1993) Business Process Reengineering: Break Point Strategies for Market Dominance John Wiley & Sons, San Francisco

Kalberg S (1980) Max Weber's Types of Rationality: Cornerstones for the Analysis of Rationalization Processes in History. American Journal of Sociology 85:1145-1179

Kaldor A G (1971) Imbricative Marketing. Journal of Marketing 35:19-25

Katona G (1946) Psychological Analysis of Business Decisions and Expectations. American Economic Review 36:44-46

Klein B H (1977) Dynamic Economics. Harvard University Press, Cambridge MA

Knudsen T (2002) The Significance of Tacit Knowledge in the Evolution of Human Language. Selection 3:93-112

Koch C and Laurent G (1999) Complexity and the Nervous System. Science 285 5411:96-98

Koufteros X A, Vonderembse M A and Doll W J (1997) Competitive Capabilities: Measurement and Relationships. Proceedings Decision Science Institute 3:1067-1068

Kraft P (1977) Programmers and Managers: The Routinization of Computer Programming in the United States. Springer Verlag, New York

Kurzweil R (2003) Exponential Growth an Illusion? Response to Ilkka Tuomi, available: http://www.kurzweilai.net/meme/frame.html?main=/articles/art0593.html

Kusunoki K (2006) Invisible Dimensions of Innovation: Strategy for De-commoditization in the Japanese electronics Industry. Springer, Berlin.

Langlois R N (2007) The Dynamics of Industrial Capitalism. Schumpeter, Chandler, and The New Economy. Routledge, London & New York, available: http://Ib.uconn.edu/ciom/Graz.pdf

Lawson T (1997) Economics and Reality. Routledge, London

Lawson T (2003) Theorizing Ontology. Feminist Economics 9(1):161-169

Leidner R (1993) Fast Food, Fast Talk: Service Work and the Routinization of everyday Life. University of California, Berkeley

Levinthal D A and March J G (1993) The Myopia of Learning. Strategic Management Journal 14:95-112

Levitt B and March J (1988) Organisational Learning. Annual Review of Sociology 14:319-340

Luhmann N (2007) Politische Planung. Aufsätze zur Soziologie von Politik und Verwaltung. VS Verlag, Wiesbaden

March J G and Simon H A (1958) Organizations. Blackwell, Oxford

McCutcheon D M and Raturi A S (1994) The Customization-Responsiveness Squeeze. Sloan Management Review, Winter:89-99

Miller J G (1978) Living Systems. McGrawHill, New York

Mitterdorfer D (2001) Modellierung unternehmensspezifischer Innovations-Prozesse. PhD, ETH Zurich

Mintzberg H (1979) The Structuring of Organizations. Prentice-Hall, Englewood Cliffs NJ

Moore G E (1965) Cramming more Components onto Integrated Circuits. Electronics 38(8), available:
ftp://download.intel.com/museum/Moores_Law/Articles-Press_Releases/Gordon_Moore_1965_Article.pdf

MORI (2005) 2005 Innovation Survey. available:
http://www.cbi.org.uk/ndbs/press.nsf/0363c1f07c6ca12a8025671c00381cc7/527ea441843232d8802570ba005a614e/$FILE/MORI%20Innovation%20Survey%202005%20-%20CBI%20QinetiQ.pdf

Narduzzo A, Rocco E and Warglien M (2000) Talking about Routines in the Field. In: Dosi G, Nelson R R and Winter S G (eds) The Nature and Dynamics of Organizational Capabilities. Oxford University Press, Oxford, pp 27-50

Nelson R R (1977) The Moon and the Ghetto, Norton, New York

Nelson R R and Winter S G (1982) Evolutionary Theory of Economic Change. Belknap Press of Harvard University Press, Cambridge MA

Nord W R and Tucker S (1987). The Organizational Dynamics of Implementing Innovation. Implementing Routine and Radical Innovations. Lexington Books, Lexington MA

Oosterman B J (2001) Improving Product Development Projects by Matching Product Architecture and Organization. available: http://irs.ub.rug.nl/ppn/230385117

O'Reilly C A and Tushman M L (2000) The Ambidextrous Organization. Harvard Business Review, May-June:157-166

Orlikowski W J (1996) Improvising Organizational Transformation over Time: a situated Change Perspective. Information Systems Research 7:63-92

Orlikowski W J (2002) Using Technology and constituting Structures: a Practice Lens for studying Technology in Organizations. Organization Science 11:404-428

Parsons S D (1999) Economics and Reality. A philosophical critique of transcendental Realism. Review of political Economy 11(5):555-566

Pentland B T and Rueter H (1994) Organisational Routines as Grammars of Action. Administrative Sciences Quarterly 39:484-510

Perrow Ch (1963) Goals and Authority Structures: a historical Case Study. In Eliot Friedson (ed) The Hospital in Modern Society, Free Press, New York, ch 4:112-146

Phillips A (1971) Technology and Market Structure. A Study of the Aircraft Industry, Heath, Lexington MA

Pluye P, Potvin L and Denis J-L (2004) Making Public Health Programs Last: Conceptualizing Sustainability. Evaluation and Program Planning 27:121-133

Porter M E (1986) Competition in Global Industries. Harvard Business School Press, Boston Mass

Powell M W and DiMaggio P J (1991) The new Institutionalism in Organizational Analysis. The University of Chicago Press, Chicago

Rescher N (1996) Process Metaphysics. An Introduction to Process Philosophy. State University of New York Press, New York

Rescher N (1998) Complexity. A philosophical Overview. Transaction Publishers, New Brunswick

Reynaud B (1998) Les Propriétés des Routines: Outils Pragmatiques de Décision et Modes de Coordination Collective. Sociologie du Travail 1998:465-477

Riepe B (2003) Integrierte Produktstrukturmodellierung in den frühen Phasen der Produktentstehung. Eine Methode zur Modularisierung variantenreicher mechatronischer Produkte. Books on Demand, Norderstedt

Rogers E M (1995) Diffusion of Innovations. Free Press, New York

Rosenblueth A, Wiener N and Bigelow J (1943) Behavior, Purpose and Teleology. Available: http://links.jstor.org/sci?sci=0031-8248(194391)10%3A1%3C18%3ABPAT%3E2.0.CO%3B’’-8

Rothaermel F T and Deeds D L (2004) Exploration and Exploitation Alliances in Biotechnology. A System of new Product Development. Strategic Management Journal 25:201-222

Sanchez R (1995) Strategic Flexibility in Product Competition. Strategic Management Journal 16:135-139

Schumpeter J A (1950) Capitalism, Socialism and Democracy. Harper & Row, New York

Schumpeter J A (1955) The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle. Harvard University Press, Cambridge MA

Shane S and Vekataraman (2000) The Promise of Entrepreneurship as a Field of Research. Academy of Management Review 25:217-226

Simon H A (1965) Decision Making as an Economic Resource. In: Seltzer L H (ed) New Horizons of Economic Progress. Wayne State University, Detroit MI, ch. 3

Simon H A (1967) Programs as Factors of Production, Nineteenth Annual Winter Meeting 1966. Industrial Relations Research Association, 178-188

Simon H A (1977) The New Science of Management Decision. Prentice-Hall, Englewood Cliffs NJ

Simon H A (1996) The science of the Artificial. MIT Press, Cambridge

Stalk G and Hout T (1990) Competing Against Time. Free Press, New York

Steyaert Ch (1997) A qualitative Methodology for Process Studies of Entrepreneurship. Creating local Knowledge through Stories. International Studies of Management & Organization 27(3):13-37

Stüttgen M (2003) Strategien der Komplexitätsbewältigung in Unternehmen. Ein interdisziplinärer Bezugsrahmen. Haupt, Bern

Suchman L A (1987) Plans and Situated Actions – The Problem of Human-Machine Communication. Cambridge University Press, Cambridge

Suh N P (2005) Complexity Theory and Applications. Oxford University Press, New York

Suh N P (1990) The Principles of Design. Oxford University Press, New York

Tapscott D (1997) Strategy in the New Economy. Strategy and Leadership 25(6):8-14.

The ISO Survey of Certifications 2006, available: http://www.iso.org/iso/survey2006.pdf

Thompson J D (2003) Organizations in Action: Social Science Bases of Administrative Theory. Transaction Publishers, New Jersey

Tidd J (2001) Innovation Management in Context: Environment, Organization and Performance. International Journal of Management Review 3:169-183.

Toffler A (1970) Future Shock. Random House, New York

Transfield D and Smith S (1998) The strategic Regeneration of Manufacturing by changing Routines. International Journal of Operations & Production Management 18:114-129

Treacy M and Wiersema F (1995) The Discipline of Market Leaders. Addison-Wesley, München

Tushman M L and Anderson P (1986) Technological discontinuities and organizational environments. Administrative Science Quarterly 31(3):439-465

Tushman M L and Nelson R R (1990) Introduction. Technology, Organizations, and Innovation. Administrative Science Quarterly 25:1-8

Tushman M L and O'Reilly Ch A (1996) Ambidextrous Organizations. Managing Evolutionary and Revolutionary Change. California Management Review 38(4):8-30

Ulrich K (2003) The Role of Product Architecture in the Manufacturing Firm. In: Garud R, Kumaraswamy A and Langlois R N. Managing in the Modular Age. Blackwell, Oxford

Utterback J M and Abernathy W J (1975) A Dynamic Model of Process and Product Innovation. OMEGA 3(6):639-656

Vera D and Crossan M (2004) Strategic Leadership and Organizational Learning. Academy of Management Review 29(2): 222-240

Von Hayek F A (2001) Wirtschaft, Wissenschaft und Politik. Aufsätze zur Wirtschaftspolitik. Mohr, Tübingen

Von Hippel E (2005) Democratizing Innovation, available: http://web.mit.edu/evhippel/www/democ1.htm

Voelpel S C, Leibold M and Tekie E B (2006) Managing Purposeful Organizational Misfit. Exploring the Nature of Industry and Organizational Misfit to enable Strategic Change. Journal of Change Management 6(3):257-276

Watson T J (1995) Sociology of Work and Industry. Routledge, London

Weber M (1947) The Theory of Social and Economic Organization. Oxford University Press, New York

Weber M (1968) Economy and Society. Roth G and Wittich C (eds) Badminister, New York.

Weber M (1980) Wirtschaft und Gesellschaft. Mohr, Tübingen

Webster F E (2002) Market-Driven Management: How to Define, Develop and Deliver Customer Value. Wiley & Sons, Hoboken New Jersey

Weng G, Bhalla U and Iyengar R (1999) Complexity in Biological Signalling Systems. Science 284 5411:92-96

Whitehead A N (1990) An Introduction to Mathematics, Oxford University Press, Oxford

Whitesides G M and Ismagilov R F (1999) Complexity in Chemistry. Science 284 5411:89-92

Wiener N (1948) Cybernetics or Control and Communication in the Animal and the Machine. MIT Press, Cambridge MA

Winter S (2006) Toward a Neo-Schumpeterian Theory of the Firm. Industrial and Corporate Change 15(1):125-141.

Witt U (2002) How Evolutionary is Schumpeter's Theory of Economic Development?" Industry and Innovation 9(1/2):7-22

Wright M (2006) Miniaturization Enables Innovation – Past, Present, and Future. EDN Sept 28:172-186, available: http://www.edn.com/article/CA6372831.html

Zellmer-Bruhn M E (2003) Interruptive Events and Team Knowledge Acquisition. Management Science 49:414-528

Zollo M and Winter S G (1999) From Organizational Routines to Dynamic Capabilities. INSEAD Working Paper Series

Zollo M and Winter S G (2002) Deliberate Learning and the Evolution of Dynamic Capabilities. Organization Science 13:339-351

11 Summary of publications and details of empirical research

In the following we give an overview of the publications that form an integral part of our research project. These publications present different aspects of the phenomenon of R-IA and support these with findings from case studies. Table 3 presents an overview of the articles. Nine of these articles have passed a qualified review process, of which seven articles have been double-blind reviewed. Two articles have passed an editorial review.

Article	Co-authors	Journal/Book	Review process	Published	
Process philosophy and Creativity in Management	Wolfgang Deplazes	EURAM proceedings	Reviewed (double-blind)	Not published	Scientific review
Wie Innovation zur Routine wird	Wolfgang Deplazes, Roman Boutellier	Vorausschau und Technologieplanung	Reviewed (double-blind)	Published	
Business Design for 'Routinized Innovation'	Wolfgang Deplazes, Roman Boutellier	ICMIT/IEEE Proceedings	Reviewed (double-blind)	Published	
Design of Engines of Growth	Wolfgang Deplazes, Roman Boutellier	ICMIT/IEEE Proceedings	Reviewed (double-blind)	Published	
Model of Technology Foresight	Roman Boutellier, Karin Löffler	IEMC/IEEE Proceedings	Reviewed (double-blind)	Published	
Systematic approach to superior Innovation structures	Roman Boutellier, Wolfgang Deplazes	IEMC/IEEE Proceedings	Reviewed (double-blind)	Published	
Auswirkungen von neuartigen Unternehmensrisiken	Wolfgang Deplazes, Roman Boutellier	Versicherungsrundschau	Reviewed (double-blind)	Published	
Unternehmensdesign	Wolfgang Deplazes, Roman Boutellier	io new management	Reviewed	Published	
Making Business Design the Heart of Strategy	Roman Boutellier, Wolfgang Deplazes	CINet Proceedings	Reviewed	Published	
Von der Umsetzung einer dualen Innovationsstrategie	Wolfgang Deplazes, Roman Boutellier	Swiss Innovation Guide	Reviewed by editor	Published	
Keine innovativen Unternehmen ohne innovative Versicherungen	Wolfgang Deplazes, Roman Boutellier	Helvetia Jubiläumsschrift	Reviewed by editor	Published	

Table 7: Overview of publications

11.1 Process Philosophy and Creativity in Management

Deplazes U and Deplazes W (2008) Process Philosophy and Creativity in Management: Contribution of Process Philosophy to Innovation Management. Proceedings of EURAM Conference

In the business environment of the early 21st century change has become an ordinary fact of life. Management and particularly innovation management need to account for this reality. Rather than further building on approaches associated with static equilibrium-based models, we advocate for more dynamic approaches viewing change as the normal state of the business environment and of the firm. Process philosophy provides a sound basis for a broader perspective in management sciences as it prioritizes evolution over stability. This conceptual paper discusses potential contributions of process philosophy to innovation management.

Process philosophy belongs to the field of metaphysics and is concerned with what really exists in the world. “Everything is in a state of flux”. This aphorism attributed to Heraclitus of Ephesus (about 534 – 475 BC) describes the most basic statement of process philosophy. Priority is given to change (i.e. processes) over states of being. “(B)eing is constituted by its becoming” (Whitehead 1979). Change is brought about by creativity. Bergson has coined the expression “creative evolution” to describe the changing of the world. The paper maintains that this focus on dynamic evolution offers great potential for management sciences and specifically for innovation management as evidenced by the concept of routinization of innovation management. The paper’s contribution to my research project lies in its discussion of process philosophy. My research project is grounded on theoretical foundations stemming from process philosophy. Hereby, the firm, and specifically its innovation activities, are viewed from a dynamic and processual perspective.

The main conclusions of the paper are: Process philosophy provides a solid theoretical foundation for conceptualizing the firm. It accommodates for the continuous change of the environment in the early 21st century. With regard to the present research project, process philosophy provides a sound theoretical foundation for conceptualizing the firm’s innovation activities.

Copy of the publication to be found in chapter 12.1.

11.2 Wie Innovation zur Routine wird

Deplazes U, Deplazes W and Boutellier R (2007) Wie Innovation zur Routine wird: Wie Unternehmen den bevorstehenden Innovationsschub bewältigen können. In Gausemeier J (ed) Vorausschau und Technologieplanung. Istfalia, Paderborn

This paper deals with routinization of innovation. It maintains that in the present business environment business organization need to generate a continuous flow of innovations to secure future competitive positions. The paper maintains that to achieve this firms need to have the ability to systematically capitalize on routinization in their innovation management. The article introduces the concept of innovation factory that is composed of 'routines in the narrow sense'. These combined allow for systematic exploitation associated with the generation of a continuous flow of incremental innovative outputs. The paper underlines the importance of modularization and miniaturization for routinization of innovation. Further, it provides a variety of examples at the empirical, actual and real ontological levels of routinization defined in the conceptual framework adopted in my research project.

The main findings of the paper are:

- In a variety of industries, companies come under increasing pressure to generate a predictable and manageable flow of innovative outputs. Hereby, it concludes that R-IA increasingly becomes a must for the survival of the firm rather than a source of competitive advantage.
- Routinization and creativity are not conflicting concepts. This is evidenced by the argument that the aspect of automaticity that routines introduce in innovation management frees cognitive resources rather than suppresses them. This gives rise to the view maintained in this paper that routinization fosters innovation and creativity.
- Routinization is associated with modularization and miniaturization. These are separate, yet interrelated phenomena that both drive routinization.

Copy of the publication to be found in chapter 12.2.

11.3 Business Design for 'Routinized Innovation'

Deplazes W, Deplazes U and Boutellier R (2008) Innovation Factory and Innovation Atelier: Business Design for 'Routinized Innovation', Proceedings of ICMIT (IEEE Conference)

The paper stresses the importance of routinized innovation for economic growth and maintains that companies have potential to capitalize on this phenomenon. Some principles of routinized innovation are discussed and an approach of organizational design based on R-IA is introduced. The paper illustrates some key concepts such as the firm's I-system and its I-Atelier and I-Factory. From an organizational design perspective, it introduces concepts for differentiating the scopes of the I-Atelier and I-Factory (i.e. VD-system), and for structuring these further into sub-systems (i.e. project architecture and VD-architecture). Further the paper illustrates an approach of organizational design based on R-IA with findings from a case study of an international FMCG company. It illustrates an approach of organizational design based on R-IA and the benefits associated with organizational set-ups building on R-IA.

The main conclusions of the paper are:

- Business organizations aiming at capitalizing on R-IA can reap significant benefits. This is illustrated by a case study showing that organizational design based on R-IA generates significant benefits for business organizations.
- The proposed approach of organizational design is based on principles of R-IA. It allows for operationalization of these principles at the level of the individual firm. It defines and builds on the concepts of I-system, I-Atelier, and I-Factory. And allows to meet the design imperatives of design for routinization, design for ambidexterity, and design for contingency.

Copy of the publication to be found in chapter 12.3.

11.4 Design of Engines of Growth based on 'Routine Innovation Activities'

Deplazes U, Deplazes W and Boutellier R (2008) Design of Engines of Growth based on 'Routine Innovation Activities', Proceedings of ICMIT (IEEE Conference)

This paper deals with R-IA from a growth perspective. It aims at determining a concept of R-IA in order to support business organizations in their search for economic growth. The approach adopted is interdisciplinary and draws on findings in economics to specify the concept of R-IA in business studies. Focus is put on Schumpeter, Baumol and Romer and their statements on routinization of innovation. The paper concludes with design principles of the Innovation Factory and Innovation Atelier. A case study is provided as an illustration of the approach adopted.

The paper conceptualizes the phenomenon R-IA focussing on the actual and the real ontological level of the framework I adopt in this dissertation. Thus learnings about routinization of innovation in economics are adapted to the business management environment. The paper also shows the link to organizational design and thus the practical implementation of the learnings drawn from the concept of R-IA.

The main findings of the paper are:

- Specialization in innovation activities between the independent entrepreneur and large corporations and mechanisms of self-transformation drive R-IA.
- Progressive rationalization is viewed as a mechanism underlying R-IA. It is a process whereby innovation activity becomes increasingly rule-governed in order to better meet the requirements of the particular economic situation faced by the firm. Uncertainty is replaced by plans and predictability.
- There are different degrees of routinization. In fact there is a continuum of degrees of routinization reaching from highly routinized to highly non-routinized behaviour.

Copy of the publication to be found in chapter 12.4.

11.5 Model of Technology Foresight

Boutellier R, Deplazes U and Löffler K (2007) Model of Technology Foresight: An innovative Approach. Proceedings of IEMC (IEEE Conference)

The strategic importance of technology foresight is generally accepted in business management. The paper establishes an "implementation gap" in technology foresight practices. It accuses the neglecting of technology foresight results in strategy and innovation management. The paper suggests a model to overcome this implementation gap. The model is based on the concepts of "backcasting", "functionalities" and "bottleneck technologies".

Foresight deals mainly with dimensions of forecasting that are not covered by extrapolation. They refer to discontinuous evolutions in the mid- and long-term, that I associated with the uncertainty-based strategic framework of the firm (in section 8). Techniques of foresight thus contribute toward reducing uncertainty and broadening the scope associated with the firm's innovation activities.

The main conclusions of the paper are:

- The results of technology foresight represent important inputs for business management and specifically innovation management. Firms can reap significant benefits from systematically integrating these results into innovation management.
- Innovation 'backcasting' methodologies play a crucial role in overcoming the 'implementation' gap. They enable managers to systematically introduce technology foresight results into innovation management. These backcasting methods allow for a widening scope of routine-based innovation management.

Copy of the publication to be found in chapter 12.5.

11.6 Systematic approach to superior innovation structures

Boutellier R, Deplazes U and Deplazes W (2007) Systematic approach to superior innovation structures. Proceedings of IEMC (IEEE Conference)

Business organizations are aware of the new challenges arising from disruptive business environments and routinization of innovation. However, their track record in successfully accommodating for both, incremental and radical change, has been relatively poor. This paper discusses a systematic approach to the design of innovation structures and process architectures. It aims at establishing consistent organizational set-ups in line with concepts associated with R-IA, i.e. modularity, complexity reduction, ambidexterity and a process-based organizational view. A case study illustrates the proposed approach of organizational design and the potential offered by R-IA to the individual firm.

The main conclusion of the paper is:

- The systemic framework for modelling innovation structures proposed in this paper allows a company to capitalize on the challenges of R-IA. The systemic framework is based on the concepts of modularity, complexity and process-based organizational design. It is structured in five main phases: (i) identify and structure the firm's value proposition, (ii) develop the process architecture for the operative business, (iii) set up the process architecture for the incremental innovation business, (iv) establish the process-based organization, and (v) accommodate for the development of future value propositions.

Copy of the publication to be found in chapter 12.6.

11.7 Auswirkungen von neuartigen Unternehmensrisiken auf die Versicherer

Deplazes U, Deplazes W and Boutellier R (2007) Auswirkungen von neuartigen Unternehmensrisiken auf die Versicherer. Versicherungsrundschau - Zeitschrift für das Versicherungswesen 10:29-35

This paper builds on the previous paper in chapter 11.11. Reducing cost of covering risks is no more the result of more efficient negotiations with insurance companies. Modern corporate risk management adopts a wider perspective of risk prevention and risk diversification. This gives rise to a demand-driven change of the traditionally supply-driven insurance market and is manifested by the emergence of a new market structure with new segments and new success factors.

This paper goes beyond the discussion of the new perspective on risk management in corporations and the resulting new requirements of risk coverage. It discusses further the implications for the insurers. Specifically, based on the typology of new requirements of risk coverage it derives success factors for insurers. Traditional success factors, such as equity and critical mass, tend to lose their relative importance in favour of knowledge of risk profiles, and service needs at the level of the individual firm rather than at the collective level of clusters of companies.

The paper reaches the conclusion that there are three generic strategies in this changing insurance market. These strategies are referred to as (i) process factory, (ii) risk structuring, (iii) risk transfer. A discussion of the strategies and the associated success factors produces the conclusion that the traditionally rather closed insurance market is opening up to new competitors traditionally not associated with insurance. These include competitors such as systems implementers (for process factories) and investment banks (for risk transfer). Thus, insurers need to question traditional models and implement more differentiated strategies aiming at the new potentials offered by the market.

Copy of the publication to be found in chapter 12.7.

11.8 Unternehmensdesign als Herzstück der Firmenstrategie

Deplazes U, Deplazes W and Boutellier R (2007) Unternehmensdesign als Herzstück der Firmenstrategie. io new management. 12:33-37

In the face of a disruptive environment conventional concepts of management reach their limits. Developing new strategies according to a changing environment is not sufficient to allow for innovation. In many cases, innovative capability in an uncertain environment requires the re-structuring of the organization. The paper maintains that CEOs are challenged to question their business design in the light of its compatibility with the business strategy.

The article discusses the key challenges at the interface between strategy development and organizational design, i.e. increasing complexity, routinization of innovation, and discontinuous environmental developments. Additionally, a methodical approach is introduced how companies can design organizational set-ups that allow them to overcome these challenges and allow for the implementation of their business strategies. The argument is supported by a case study.

The main conclusions of this paper are:

- Organizational set-ups need to be questioned in the light of their compatibility with the business strategy.
- Organizational design is a key lever allowing for the implementation of a firm’s strategy. Key challenges at the interface between organizational set-up and strategy are increasing complexity, routinization of innovation, and discontinuous environmental developments.

Copy of the publication to be found in chapter 12.8.

11.9 Making Business Design the Heart of Strategy

Boutellier R, Deplazes U and Deplazes W (2007) Making Business Design the Heart of Strategy – The Strategic Importance of Innovation Factories & Ateliers. Proceedings of CINet Conference

This article presents a comprehensive approach to organizational design (also referred to as business design) based on principles associated with R-IA. It maintains that modularity alone is not sufficient to account for the complexity of complex systems such as the firm's innovation activities. In line with this finding, the paper discusses concepts associated with R-IA, specifically modularity and advancements thereof as proposed by theories of complexity. Based on a thorough literature review the paper adopts the concept of 'relative' complexity, which is in line with the perspective of R-IA. Complexity is measured with respect to the strategic goals of the organization. Thus, the objective for business design is not to eliminate complexity undifferentiatedly, but to distinguish productive (i.e. value creating) complexity from unproductive (i.e. value destroying) complexity. Hereby, the former is desirable, while the latter needs to be eliminated. From these findings, implications are drawn for organizational design based on R-IA. Subsequently a design approach is presented. It is based on the basic concepts of I-Atelier and I-Factory associated with exploration and exploitation respectively. The argument is illustrated by a case study. Further, the paper discusses the interdependence of business strategy and business design and comes to the conclusion that companies can draw significant benefits from "making business design the heart of strategy". This understanding gives rise to a business design approach that systematically links strategy and organizational set-up. It is based on findings stemming from Suh's theory of complexity and principles of axiomatic design.

The main conclusions of the paper are:

- Organizational design based on R-IA needs to accommodate for requirements of ambidexterity, modularity, and complexity. Additionally, it has to establish a systemic link between the firm's strategy and its organizational set-up.
- There is significant potential for firms wishing to capitalize on the phenomenon of R-IA. Organizational design based on R-IA produces significant strategic implications and can be seen as 'at the heart of business strategy'.

Copy of the publication to be found in chapter 12.9.

11.10 Umsetzung einer dualen Innovationsstrategie

Deplazes U, Deplazes W and Boutellier R (2007) Von der Umsetzung einer dualen Innovationsstrategie. Swiss Innovation Guide. 10-13

A variety of studies produced that CEOs rate their companies' innovative capacity and efficiency among their top priorities. Companies need to have the ability to generate parallel streams of incremental and more disruptive innovations. Hereby, the importance of generating plannable and predictable flows of innovative outputs is underlined.

Organizational design is established as a key lever in the implementation of dual innovation strategies. Specifically, incremental and disruptive innovation, each have specific requirements and can be viewed separately. The paper proposes a concept of organizational design based on I-Factory and I-Atelier. Hereby, the I-Factory is associated with incremental innovation and serves to secure the firm's current market positions. The I-Atelier is associated with more disruptive innovations and serves to build future strategic positions. The paper further outlines the importance of innovation of the company's business model.

The main conclusions of the article are:

- A dual innovation strategy encompassing its explorative and exploitative dimensions gives rise to differentiated requirements on the business organization. These are associated with the I-Factory and I-Atelier respectively.

Copy of the publication to be found in chapter 12.10.

11.11 Keine innovativen Unternehmen ohne innovative Versicherungen

Boutellier R, Deplazes U and Deplazes W (2007) Keine innovativen Unternehmen ohne innovative Versicherungen. In: 150 Jahre Helvetia Versicherungen. 103-108, Heer, Sulgen.

This paper has been written for the jubilee of the Helvetia insurance company: 150 years since its foundation. Its foundation dates back to times characterized by disruptive environmental changes and uncertainty related to technological breakthroughs. Similarly, corporations are facing today unprecedented risks and uncertainty in a disruptive environment. Particularly the accelerating technology cycles give rise to new technologies associated with unpredictable risks (specifically of product liability), such as nuclear technologies, biotechnologies, and nanotechnologies.

In the face of this situation, conventional offers by insurers do not meet the requirements of the corporations. The high cost of risk coverage combined with the low coverage levels achieved spurred increased attention on risk management among corporate management. The paper maintains that, in the past decade, corporations have been adopting a broadening view of risk management. They approach it comprehensively at the level of the corporation and resort to a combination of strategies for reduction of costs associated with risk. These strategies include risk prevention, risk diversification, and risk reduction. The paper maintains that this changed perspective gives rise to new requirements of risk coverage and significant changes of the insurance market. It attempts to categorize the new types of risks corporations are facing. Based on a combination of the differentiating criteria (i) ‘extent of the potential risks’ and (ii) ‘the expected frequency of occurrence’ the paper defines 4 emerging risk types corporations are facing. For each type, the paper defines success factors and basic strategies for insurers to succeed - particularly in the face of the threat by new competitors such as system implementers and investment banks.

Copy of the publication to be found in chapter 12.11.

12 Publications

12.1 Process Philosophy and Creativity in Management

Deplazes U and Deplazes W (2008) Process Philosophy and Creativity in Management: Contribution of Process Philosophy to Innovation Management. Proceedings of EURAM Conference

Process Philosophy and Creativity in Management.

Contribution of Process Philosophy to Innovation Management

ABSTRACT

This conceptual paper aims at deepening our knowledge of the contribution of process philosophy to creativity in management – specifically, innovation management. The intention is to discuss basic ideas of process philosophy and apply them to the concept of creativity in business management. The paper focuses on innovation management where creativity is managed in a systematic way and where process philosophy can provide alternative perspectives to traditional innovation management.

Keywords:

Process philosophy; creativity; innovation management; substance philosophy

Process Philosophy and Creativity in Management.

Contribution of Process Philosophy to Innovation Management

INTRODUCTION

We are living in a world where "change is the only certainty of life". Especially in the early 21st century are business organizations facing a rapidly changing business landscape (among others: Voelpel, Leibold, & Eden, 2006; Christensen & Raynor, 2003a, 2003b; Hamel, 2002; Gibbert et al., 2002). In such a world where change has become an ordinary factor of business life, there is a strong need to adopt a dynamic view of the business organization. Classical theories of the firm based on static models and aiming at achieving an equilibrium are often not appropriate to deal with a world defined as movement. In this paper we suggest process philosophy as a conceptual foundation of the firm based on evolution. This approach is coherent with recent literature such as Steyaert (1997:16) who mentions in the context of entrepreneurship that "a process approach to entrepreneurship is seen more and more as an appropriate way to develop knowledge about entrepreneurship in that it allows us to address a changing and highly dynamic entrepreneurial reality more closely than we can using static and equilibrium-focused models". The main contribution of this paper is to discuss the conceptual value-added of process philosophy in the context of creativity – specifically, innovation management and thus hopefully contribute to establishing an innovation theory based on a creative evolution of the firm.

This paper is structured as follows: (i) what are the basic concepts of process philosophy; (ii) what is the contribution of process philosophy to innovation management?

KEY CONCEPTS OF PROCESS PHILOSOPHY

The objective of this section is to grasp the main precepts of process philosophy. We first elaborate the key concepts and present some proponents of process philosophy. Then we contrast process philosophy with substance philosophy and summarize our findings.

Key Concepts and Proponents of Process Philosophy

Process philosophy belongs to the field of metaphysics and is concerned with what really exists in the world. It considers processes of change – as opposed to substances (i.e. objects) - as the basic building blocks of reality. The world is viewed in its dynamic dimension. Change – be it physical or psychological – is all there is in this world. Panta rhei - "everything is in a state of flux". This aphorism is attributed to Heraclitus of Ephesus (ca. 534 – 475 B.C.). It underlines the importance of the "process of becoming" over the "particular states of being". Indeed, being is but a constant process of becoming. "(B)eing is constituted by its becoming" (Whitehead 1979:23). The driver of this constant change is creativity, a force underlying all states of being and relentlessly pushing them toward novelty. "Creativity is the principle of novelty" (Whitehead 1979:26). Thus evolution is viewed as constant becoming, the perpetual creation of novelty.

Even though basic ideas of process philosophy can be found in both, "Eastern thought" and "Western philosophy", we will focus on some philosophers having contributed significantly to the systematic philosophical approach known as "process philosophy". Specifically, Heraclitus of Ephesus, Henri Bergson and Alfred North Whitehead. Other important proponents are: Gottfried Wilhelm Leibniz (1646 – 1717), Charles Sanders Peirce (1839 – 1914), William James (1842 – 1910), John Dewey (1859 – 1952) and Wilmon H. Sheldon (1875 – 1981).

Heraclitus of Ephesus (ca. 534 – 475 B.C.) – known as the "obscure" – is the founding father of the process approach. Indeed, he is the first philosopher in Ancient Greece to develop some basic concepts of process philosophy. "(T)he whole world of reality is like an ever-flowing stream, and nothing is ever at rest for a moment"(Heraclitus acc. to Burnet 1920:ch3). Thus the world is not an object. It is movement, activity, change. Heraclitus used yet another metaphor for the world: fire. "This world (…) was ever, is now, and ever shall be an ever-living fire" (Heraclitus acc. to Burnet 1920:ch. 3, fr 20). The world is compared to a fire incessantly transforming itself. It is made out of forces creating activity. Heraclitus' principle "panta rhei" ("everything flows") "exerted a profound influence on classical antiquity" (Rescher 1996:10) (For a more detailed discussion refer to Bernet 1920: ch3).

Henri Bergson (1859 – 1941)*,* who won the Nobel Prize in literature in 1927, is a French philosopher who developed the first systematic philosophy that can be termed "process philosophy". In this paper focus is put on his evolutionary theory. In the book "Creative Evolution", published in 1907, Bergson develops an evolutionary philosophy based on the mechanisms of continuous creation of life. "Chacun d'eux (i.e. des moments de notre vie) est une espèce de création" (Bergson 1959:15) (Each moment of our life is a kind of creation). Indeed, life itself is viewed as "creative evolution" ("cette évolution créatrice (…) est la vie" (Bergson 1959:100)). It is a continuous sequence of creative evolutionary acts. Each of these acts invents new forms of the things in the world. "L'évolution des choses (est) une invention continue de formes nouvelles" (Bergson 1959:200). The originality of Bergson's evolutionary theory lies in the creative force underlying all things and pushing them unremittingly in a state of continuous change. This creative force, which Bergson called "élan vital" (Bergson 1959: 152/154), is the source of novelty. It is not directed toward achieving a final goal, as it is in teleological evolutionary theories (see Bergson's criticism of

Spencer's theory in Bergson 1959:esp. 210-214). It rather creates a future that cannot be predicted. This is due to the fact that each evolutionary step creates unforeseen possibilities of further evolution. Bergson also differentiates his approach from Darwin's theory of natural selection. "(T)he theory of descent with modification through variation and natural selection" (Darwin 1872:ch 15) was presented by Darwin in "The Origin of Species". Spencer called Darwin's evolutionary theory the "Survival of the Fittest". Instead of the random variations supposed by Darwin, Bergson views the creative force as the source of all changes and this force is affected by contradictory tendencies (such as individuality - association; unity - multiplicity). "L'évolution de la vie dans la double direction de l'individualité et de l'association n'a donc rien d'accidentel" (Bergson 1907 :154) (Evolution of life with its two tendencies individuality and association is not random at all). Bergson thus introduced creativity as the driver of evolution.

Alfred North Whitehead (1861 - 1947) is one of the most prominent process philosophers of the 20th century. Educated in mathematics, he published extensively in different fields of science. His most famous book in mathematics is "Principia mathematica" which he wrote together with Bertrand Russell. His "Process and Reality", published in 1929, became a classic in process philosophy. The central concepts of Whitehead's metaphysics are processes and creativity, as in Bergson's philosophy. The world is made out of processes. Specifically, processual units called "actual occasions". Evolution is based on two types of creative processes: "those that are operative in shaping the internal make-up of a new concrete particular existent ("concrescence") and those that are operative other-orientedly when existents function so as to bring new successors to realization ("transition") (Rescher 1996:20). Existents, which are "actual occasions", are thus combined in the process of "concrescence" to create a new "actual occasion". Additionally, there is the process of "transition" where information about the environment of an "actual occasion" is gathered. This information feeds the "concrescence" process. Novelty is created in the interplay of concrescent and transitional processes. "The World is primordially many, namely, the many actual occasions. (…) (I)n the process (of evolution) it acquires a consequent unity, which is a novel occasion and is absorbed into the multiplicity of the primordial character. (…) The World is to be conceived as many and as one" (Whitehead 1979:ch. 5 section 5). Evolution is inherently creative. Whitehead postulates that this "production of novelty" cannot be explained in terms of the component parts that are combined. This is due to the fact that the result of "concrescence" is "a novel entity, disjunctively among the many entities which it synthesises" (Whitehead 1979:26). However, concrescence is postulated to be dialectical in nature. It thus it is based on contrasts that are to be resolved, just like Hegel's three-step theory of "thesis, antithesis and synthesis". Indeed, Whitehead mentions that "concrescence" "is nothing else than the Hegelian development of an idea" (PR 254) and that intuition is an important factor in understanding it.

Comparison with "Substance Theory"

Since pre-Socratic times, there have been two major philosophical traditions in Western philosophy opposing each other: process philosophy and substance philosophy. The latter views reality as made out of objects as opposed to the processes on which the former is based. Processes are subordinated to the objects. They are but transitional phases from one object to another without any ontological reality. Two famous proponents of substance philosophy are Parmenides (around 500 B.C.) and Aristotle (384 – 322 B.C.). There have been innumerable attempts to reconcile these two contrasting schools of thought – without success. "(I)t does not stretch matters unduly to say that the Aristotelian view of the primacy of substance and its ramifications (…) have proved to be decisive for much of Western philosophy" (Rescher 2000:4). The impact of substance philosophy on Western thought has been so significant that much of scientific progress (such as Newtonian physics and its popularity) is referred to a substance view of reality (Chia, 1999:214).

We conclude that process philosophy focuses on change as opposed to substance. "In a dynamic world, processes are more fundamental than things. Since substantial things emerge in and from the world's course of changes, processes have priority over things" (Rescher 1996:28). This statement seems to contradict the metaphysical contention fundamental to process philosophy, namely that substances are not an ontological category. But as Styhre (2002:581) mentions, Rescher views process metaphysics not so much as a theory than a point of view where processes are prioritized over things and activities over substances. We would like to retain this interpretation of process philosophy and apply it to innovation management. The main ideas of process philosophy have influenced different scientific fields especially in natural sciences (e.g. biology). Its influence on innovation management is only starting to manifest itself. In the following part of the paper, we would like to determine how process philosophy can contribute to innovation management.

CONTRIBUTION OF PROCESS PHILOSOPHY TO INNOVATION MANAGEMENT

The objective of this part of the paper is to make apparent the learnings that process philosophy offers to innovation management. Focus is put on the mindset of and general approach to innovation management.

Broadening of Mindset

The strong influence of substance philosophy on the Western mindset (see above: Comparison with "Substance Theory") has also affected the way in which innovation management is traditionally approached. There has been a tendency to focus on innovation products and services and view processes only as a means to achieve a certain predetermined innovation output. Process innovation is traditionally viewed as primarily aiming at efficiency improvements in the production of a pre-determined innovation output.

Insert Figure 1 about here

The classical model of "Innovation and Stage Development" by Utterback and Abernathy (1975: 645) is depicted in Figure 1. The model takes into account some dynamic aspects relevant to innovation management. In the first phase, the "Fluid Phase", innovation focuses on the product. Major process innovations tend to take place only once a dominant design is established in the market. This is the case in the second phase, the "Transitional Phase". The model reflects a "substance" mentality, where the innovation object is focused on. The drivers of process innovation are in the first phase, as shown in Figure 1, the output rate, then technology, and finally cost considerations. This reflects the idea that processes are to be optimized in order to deliver a predetermined innovation output more efficiently.

The contribution process philosophy can make in this context is to broaden the view of innovation management. It offers a complementary approach to management where processes are put at the forefront. The challenge for management is to question the hypotheses underlying the object and the process view of management respectively and determine when each approach is most appropriate.

Focusing on Change

Traditional management theories assumed that a business organization is faced with relatively stable environments. As this is often not the case any more in many business environments, new management approaches have to be developed to deal with changes as a normal phenomenon of business life in its own right, and not merely as the transition from one stable state to another. Process philosophy offers a framework for viewing the firm as being in continuous change. The focus of change is not a stable equilibrium that is to be attained at some point in the future. Change is continuous. It is a state of "disequilibrium" that is the normal condition of a business organization. Creativity manifests itself in change, offering opportunities for competitive advantage. Understanding the concept of creativity for all dimensions of a business organization will thus be decisive.

. Based on the above insights from process philosophy, we would like to stress innovation processes in their own right as an important source of competitive advantage. Do objects exist in process philosophy? Yes, they do. As opposed to nihilism, where objects to not exist at all, process philosophy views objects from the process perspective. They exist in their processual nature, i.e. in their processes of becoming.

CONCLUSION

Process philosophy offers a promising framework for reflecting upon traditional management theories and practices in the light of continuous change. There seems to be great potential for innovation management in integrating the learnings from process philosophy. However, further research is needed to develop a concept of innovation management focussing on change as a creative force.

REFERENCES

Bergson, H. 1959. **L'évolution créatrice**. Paris: Les Presses universitaires de France. Version numérique : http://www.laphilosophie.fr/ebook/Bergson%20-%20L'%E9volution%20creatrice.pdf

Burnet, J. 1920. **Early Greek Philosophy**. London: A&C Black Ltd. Online version: http://faculty.evansville.edu/tb2/courses/phil211/burnet/ch3.htm#65

Chia, R. 1999. **A "Rhizomic" Model of Organizational Change and Transformation: Perspective from a Metaphysics of Change**. British Journal of Management, 10: 209-227.

Christensen, C. M., & Raynor, M. E. 2003a. **The Innovator's dilemma**. Boston MA: Harvard Business School Press.

Christensen, C. M., & Raynor, M. E. 2003b. **The Innovator's solution. Creating and sustaining successful growth**. Boston MA: Harvard Business School Press.

Hamel, G. 2002. **Leading the Revolution**, Boston MA: Harvard Business School Press.

Gibbert, M. et al. 2002. Five styles of customer knowledge management, and how smart companies use them to create value. **European Management Journal**, 20(5): 459-469.

Rescher, N. 1996. **Process Metaphysics: An Introduction to Process Philosophy**. New York: State University of New York Press.

Rescher, N. 2000. **Process Philosophy. A Survey of Basic Issues**. Pittsburgh: University of Pittsburgh Press.

Steyaert, Ch. 1997. A qualitative methodology for process studies of entrepreneurship. Creating local knowledge through stories. **Int. Studies of Mgt. & Org.,** 27(3):13-33.

Styhre, A. 2002. How Process Philosophy Can Contribute to Strategic Management. **Systems Research and Behavioral Science**, 19: 577-587.

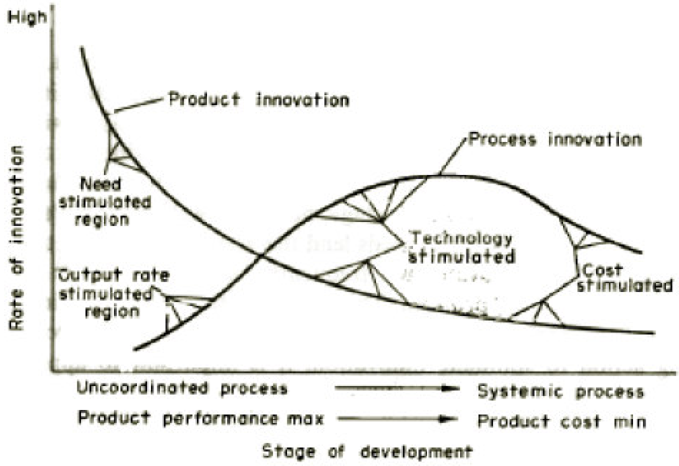
Utterback, J. M. & Abernathy, W. J. 1975. A Dynamic Model of Process and Product Innovation. **OMEGA**, 3(6): 639 – 656.

Voelpel, S. C., Leibold, M., & Eden, B. T. 2006. Managing purposeful organizational misfit: Exploring the nature of industry and organizational misfit to enable strategic change. **Journal of Change Management**, 6(3): 257-276.

Whitehead, A. N. 1979. **Process and Reality: An Essay in Cosmology**. Sherburne: Free Press.

FIGURE 1

Product and Process Innovation (Utterback & Abernathy 1975: 645).



12.2 Wie Innovation zur Routine wird

Deplazes U, Deplazes W and Boutellier R (2007) Wie Innovation zur Routine wird: Wie Unternehmen den bevorstehenden Innovationsschub bewältigen können. In Gausemeier J (ed) Vorausschau und Technologieplanung. Istfalia, Paderborn

Wie Innovation zur Routine wird. Wie Unternehmen den bevorstehenden Innovationsschub bewältigen können.

Ursula Deplazes, M.Sc. LSE, M.Sc. HEC
Wolfgang Deplazes, M.Sc. HEC
ETH Zürich, D-MTEC
Kreuzplatz 5, 8032 Zürich
Tel: +41 79 470 50 85
E-Mail: udeplazes@ethz.ch

Prof. Dr. sc. math. Roman Boutellier
ETH Zürich, D-MTEC
Kreuzplatz 5, 8032 Zürich
Tel: +41 44 632 05 85
E-Mail: rboutellier@ethz.ch

Zusammenfassung

Der Artikel befasst sich mit dem Phänomen der Routinisierung, der in zunehmendem Masse auch die innovativen Bereiche der Unternehmen beherrscht. Indem die Unternehmen diese Routinisierung antizipieren und systematisch in ihr Innovationsmanagement integrieren, können sie den in den meisten Industrien und Märkten unabdingbaren kontinuierlichen Ausfluss an Innovationen sicherstellen. Der Artikel führt das Konzept der „Innovationsfabrik“ ein und unterstreicht dessen Bedeutung für das langfristige Überleben eines Unternehmens. Ähnlich wie andere Managementkonzepte (wie CIM und TQM) wird auch die routinisierte Innovation den Unternehmen keine nachhaltigen Wettbewerbsvorteile bieten. Sie wird zu einem Muss, dem sich kein Unternehmen entziehen kann. In einigen Bereichen ist routinisierte Innovation bereits heute überlebensnotwendig.

Schlüsselwörter

Ideenmanagement; Innovationsvorausschau; Innovationsplanung; Innovationsmanagement

1 Einleitung

Im globalen Wettbewerb der Nationen und Unternehmen spielt Innovation eine entscheidende Rolle. Zahlreiche Studien bestätigen es: „Innovationsfähigkeit“ und „Innovationseffizienz“ sind aktuelle Top-Prioritäten der nationalen und internationalen Wirtschaftspolitik.

Die EU beabsichtigt im Rahmen der Lissabonpartnerschaft für Wachstum und Beschäftigung, die Innovationsdynamik in Europa anzukurbeln und die Verwertung von Forschungsergebnissen für die Schaffung neuer Produkte zu optimieren. Die Förderung der Innovationsfähigkeit und des internationalen Technologietransfers sind eines der Hauptziele der europäischen nationalen Reformprogramme und zahlreicher EU-Initiativen wie PAXIS, IRC (Innovation Relay Centers), Inkubatoren (Gründerzentren), PROTON und Europe INNOVA.

Für CEOs in praktisch allen Industrien nimmt Innovation heute den Platz ein, welcher in den 80er und 90er Jahren CIM (Computer Integrated Manufacturing) und TQM (Total Quality Management) zukam. Heute jedoch bilden staatliche Förderprogramme für diese Themen die Ausnahme und wenige CEOs würden CIM oder TQM zu einer strategischen Priorität erklären. Sie wurden detailliert beschrieben und nach dem „Hype“ in aller Stille viel breiter eingeführt als viele es erwartet hatten. CIM und TQM sind zu Routinen geworden, welche heute zum allgemeinen Standard gehören und somit wenig Differenzierungsvorteile bieten. Heute wird Innovationsfähigkeit für das Überleben eines Unternehmens als geradezu unverzichtbar beurteilt. Man muss davon ausgehen, dass das Thema „Innovation“ dasselbe Schicksal der Routinisierung erfährt.

In den meisten Industrien erwirtschaften die Unternehmen einen immer grösseren Anteil ihres Umsatzes mit neuen Produkten. So verfolgt das amerikanische Unternehmen 3M konsequent die Strategie, dass Produkte, die in den letzten drei Jahren eingeführt wurden, mindestens 50% des Umsatzes ausmachen. Der langjährige Chairman und CEO von L’Oréal, Sir Lindsay Owen-Jones, erklärte bereits vor einiger Zeit gegenüber der Financial Times: "We live or die by our ability to innovate, and everyone in the company knows that”. Solche Ansätze werden vermehrt zur Regel und tatsächlich bilden in vielen Industrien ausserordentliche Innovationsrenditen bereits heute die Ausnahme. So sind die Unternehmen vermehrt zu beständiger Innovation gezwungen, um überhaupt überleben zu können. Dabei ist – ganz im Sinne von „open innovation“ – immer weniger entscheidend, ob die Entwicklung der Innovation intern erbracht oder extern beschafft wird. Novartis hat sich beispielsweise zum Ziel gesetzt, bis 2010 etwa 50% des Umsatzes mit „fremden Produkten“ über In-Licensing und externe F&E-Leistung zu realisieren.

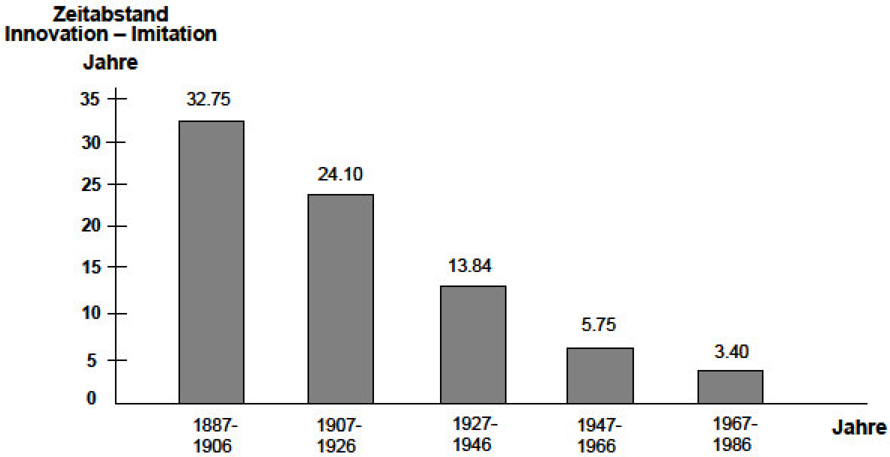


Bild 1: Imitationsgeschwindigkeit. Konkurrenten imitieren rascher [AG01]

Ein entscheidender Treiber dieser Entwicklung ist die allgemeine Tendenz, dass Imitationszeiten sich wesentlich stärker verkürzen als Innovationszeiten. Ebenfalls kann man über die vergangenen Jahrzehnte eine dramatische Erhöhung der Innovationsvielfalt beobachten. Die Entwicklung der innovativen „derivatives“ in der Finanzindustrie hat eine fast explosionsartige Ausweitung der Produktevielfalt ausgelöst. Auch in der IT- und Kommunikationsbranche kann das „was noch vor Jahresfrist nicht viel mehr als eine vage formulierte Zukunftsidee war, das Potenzial haben, morgen einen neuen Markttrend zu setzen.“ (Best Practice – Special Innovation 1/06). Ähnliche „Innovationsschübe“ kann man vor allem in Bereichen erwarten, in welchen die Innovationstätigkeit noch wenig strukturiert ist. Gemäss der Studie „Innovation Performance - Das Erfolgsgeheimnis innovativer Dienstleister“ (PriceWaterhouse Coopers, European Business School und Deutsches Zentrum für Luft- und Raumfahrt, 2006) verfügen zum Beispiel noch 57 % der befragten deutschen Dienstleister über keine oder nur eine rudimentäre Innovationsstrategie.

Die steigende Anzahl ISO-zertifizierter Unternehmen zeigt aber, dass der Innovationsprozess in der Praxis immer stärker strukturiert und enger geführt wird. Ende 2005 waren etwa 800'000 Unternehmen in 161 Ländern ISO 9001 zertifiziert und verfügten damit über einen etablierten und dokumentierten Innovationsablauf. Die Entwicklung von neuen Produkten folgt somit in immer mehr Firmen strukturierten und dadurch wiederholbaren Abläufen. Ähnlich dem traditionelle Produktionsansatz soll ein möglichst planbarer Ausfluss an neuen Produkten sichergestellt werden. Investitionen in Innovation werden dadurch transparent und können direkt mit anderen Investitionen, z.B. in Produktion von Gütern und Dienstleistungen, verglichen werden.

Das Phänomen der Routinisierung beherrscht also nicht nur die Produktion von Gütern und Dienstleistungen, sondern in zunehmendem Mass auch die innovativen Bereiche des Unternehmens. Der Innovationsprozess nähert sich wie alle anderen Geschäftsprozesse einer durchgehend definierten Abfolge von Aktivitäten mit ebenso präzise definiertem Output.

2 Konzepte der Routinisierung der Innovation

Verschiedene Literaturbeiträge zum Thema der Routinisierung der Innovation klären das Konzept der Routinisierung und der Routinen. Hier fokussieren wir uns auf die wichtigsten Beiträge aus den Bereichen der Volkswirtschaft, der Produktionswissenschaften und der Kreativitätswissenschaften.

2.1 Routinisierung der Innovation und volkswirtschaftliche Entwicklung

Baumol [Bau93] unterstreicht die Bedeutung der Routinisierung für die volkswirtschaftliche Entwicklung. Basierend auf Schumpeters „engine of growth“ [Bau93] versteht Baumol die Routinisierung des Innovationsprozesses als eine natürliche Folge der Gewinnorientierung der freien Marktwirtschaft: der Entrepreneur mit einer monopolähnlichen Marktposition erwirtschaftet ausserordentliche Gewinne und zieht so neue Konkurrenten an bis keine ausserordentlichen Gewinne mehr realisiert werden können. Die Routinisierung verwandelt innovative Unterfangen in „a regular and even ordinary component of the activities of the firm, thereby minimizing the uncertainty of the process. (…) (Innovative activities are now) incorporated into firms' day-to-day activities" [Bau04:4-5]. They become "an internal, bureaucratically controlled process" [Bau04:11]. Diese routinisierten Innovationen sind eine wichtige Wachstumsquelle für eine Volkswirtschaft. Sie bieten jedoch, nach einer Zeitspanne von hohen Gewinnen, nur noch limitierte Gewinnmöglichkeiten. Langfristig bieten routinisierte Innovationen keine Wettbewerbsvorteile, sondern werden zu einem „Muss“ für das Überleben eines Unternehmens.

Von einem volkswirtschaftlichen Standpunkt aus ist die Routinisierung also kein künstlich geschaffenes Phänomen, sondern ein notwendiger Entwicklungsschritt der freien Marktwirtschaft. Der Übergang von nicht-routinisierter zu routinisierter Innovation ist ein Fortschritt und schafft Reichtum und Wohlstand. Bereits anfangs des 20. Jahrhunderts bemerkte der Mathematiker Alfred N. Whitehead in seiner Einführung in die Mathematik: „Civilization advances by extending the number of important operations which we can perform without thinking about them“ [Whi91].

2.2 Routinisierung in den Produktionsabläufen

Routinisierung der Innovation geht auf das Konzept der Routinisierung in Taylors Scientific Management zurück. Es beinhaltet Arbeitsabläufe, die rationalisiert, standardisiert, formalisiert und routinisiert sind. Diese routinemässig ausgeführten Arbeiten sind teilweise für die negativen Konnotationen von Routinen verantwortlich. Sie werden oft mit monotonen Handlungen, die jegliche Kreativität ersticken, verbunden.

2.3 Routinisierung und Kreativität

Schadet Routinisierung wirklich der Kreativität? Kreativität kann definiert werden als „the production of novel and useful ideas" [Ama88]. Sie ist ein wichtiger Bestandteil des Innovationsprozesses eines Unternehmens. In der Literatur finden sich zwei gegensätzliche Ansichten: (i) Routinisierung hemmt Kreativität auf der Ebene des Individuums [FG00] und des Unternehmens [PD77], (ii) Routinisierung fördert Kreativität [OSP06]. Wir vertreten die Ansicht, dass Routinisierung Kreativität fördern kann, indem es Ressourcen freisetzt, die für die Entwicklung von kreativen Lösungsansätzen verwendet werden können. „(N)o conscious decision about what to do (in routinized taks) is needed any more; so, employees are able to think about other aspects of work. In this way, problems at work might be discovered and new ways of solving these problems can be thought through" [OSP06:259]. Dennoch können Routinen mit Eintönigkeit verbunden sein. "(P)eople do the same limited tasks over and over without knowing how they fit into the larger undertaking" [Kra79:149]. Somit bietet die Routinisierung Möglichkeiten, die Kreativität zu fördern, kann sich aber gleichzeitig auch negativ auf die Kreativität auswirken. Es ist die Aufgabe des Managements und jedes einzelnen Mitarbeiters proaktiv die kreativen Potentiale der Routinisierung zu nutzen und die negativen Auswirkungen zu limitieren. Wie im nächsten Abschnitt ersichtlich, stellen Routinen nicht unbedingt starre Abläufe („dead routines") dar, die keine Änderungen herbeiführen können.

2.4 Routinen und Innovation

Das Unternehmen kann als eine Ansammlung von Routinen verstanden werden [NW82]. Innovation wird von Routinen geschaffen und bringt ihrerseits neue Routinen hervor. „(Routines in this context) refer to a repetitive pattern of activity in an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational or individual performance" [NW82:97]. Cohen e.a. haben diese Definition präzisiert: "(the) principal focus is on action patterns that can be called "routines"" [Coh96].

In letzter Zeit wird das Verhältnis zwischen Routinen und Veränderungsprozesse im Unternehmen hervorgehoben. Zum Beispiel können „dynamic capabilities" (zumindest teilweise) als routinisierte Ansätze angesehen werden, Wandel hervorzubringen. Wir betrachten Routinen als wichtige Bestandteile eines Unternehmens. Sie haben in ihrer statischen Dimension gewisse stabilisierende Effekte, die jedoch die Gefahr der Trägheit beinhalten. In ihrer dynamischen Dimension können Routinen Wandel herbeiführen und sind somit auch kreativ.

3 Entscheidende Voraussetzungen der Routinisierung der Innovation

Eine entscheidende Voraussetzung für die Routinisierung der Innovation ist die ***Miniaturisierung***. Sie eröffnet den Unternehmen neue Innovationsmöglichkeiten, indem sie die Ressourcen Raum und Material in oft spektakulärer Weise „erweitert". So benötigte man beispielsweise im Jahre 1891 ganze 88 Kilogramm Material, um einen Elektromotor mit einer Leistung von einem Kilowatt zu produzieren. Bereits 70 Jahre später waren es nur noch 7.5 Kilogramm für die gleiche Leistung. Im Bereich der Speicherkapazität manifestiert sich die Miniaturisierung in einer Steigerung der Speicherdichte. So wurde der Festplattenspeicher für Computer zwischen 1976 und 1989 verzwanzigfacht. Bereits 1965 sah Gordon Moore, einer der Gründer von Intel, die Zukunft voraus. Seine Vorhersage, die als Mooresches Gesetz bekannt wurde, besagt, dass sich die Anzahl der Transistoren auf einem Chip etwa alle zwei Jahre verdoppelt. Diese Beobachtung zur Halbleitertechnologie, die Intel Realität werden liess, hat die technologische Revolution weltweit in Bewegung gebracht. So ist die Prozessorleistung, gemessen in MIPS (Millionen Befehle pro Sekunde), aufgrund der höheren Anzahl von Transistoren gestiegen. Agie SA, der weltführende Hersteller von Schneid- und Senkerodiermaschinen, war in der Lage aufgrund der Miniaturisierung das Gewicht und Volumen der Senkgeneratoren mit 60 A Impulsstrom wesentlich zu verringern.

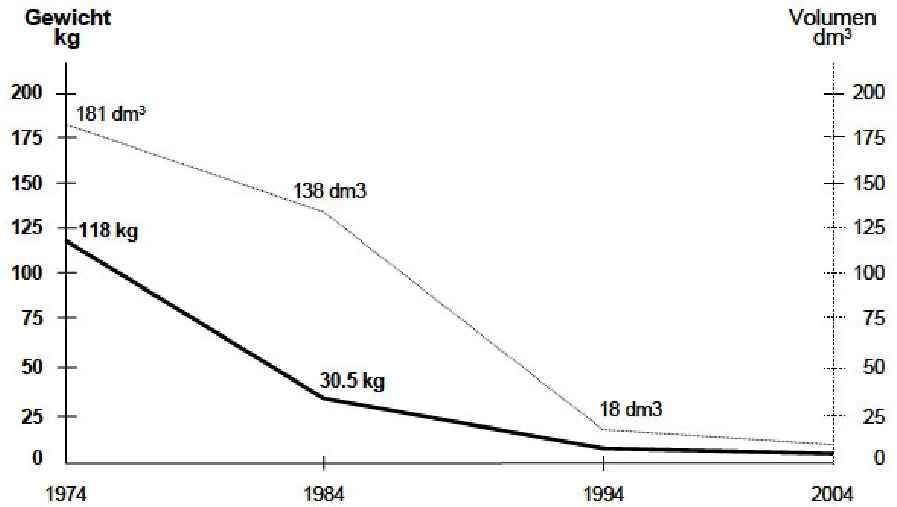


Bild 2: Miniaturisierung in der Funkenerosion [DD06]

Tabbelle 1: Miniaturisierung in der Funkenerosion: Zusatz zu Bild 2 [DD06]

Senkgenerator Leistungsteile (60A Impulsstrom-Mittelwert)		
Jahr	Gewicht kg	Volumen dm³
1974	118	181
1984	30,5	138
1994	8	18
2004	6	10,5

Eine weitere entscheidende Voraussetzung für die Routinisierung der Innovation ist die ***Modularisierung***. Modulare Produktstrukturen verknüpfen durch standardisierte Schnittstellen einzelne Module. Die Modularisierung führt dazu, dass Entwicklungstätigkeiten auf Modul-Ebene als weitgehend entkoppelte Prozesse betrachtet werden können. Dies führt zu einer Spezialisierung auf Modul-Ebene und dadurch zu einer Steigerung der Innovationsintensität. Die Vielfalt der entwickelten Modulvarianten steigt signifikant an.

In der Automobilindustrie werden die Komponentenspezialisten zukünftig noch verstärkt die Rolle der Innovationstreiber einnehmen. Obwohl die Automobilhersteller ihre Produktionstiefe weiterhin verringern, wird nach der Studie „Automobilbranche 2010" (HypoVereinsbank und Mercer, 2006) die Anzahl der Zulieferer bis 2010 von aktuell 5.500 auf ca. 3.500 sinken. Gleichzeitig wird der Anteil der Top 20 Zulieferer von heute 27% auf ca. 50% des Zulieferervolumens steigen. Die Zulieferer profilieren sich also verstärkt aufgrund ihrer Modul- Führerschaft, welche im Wesentlichen in einer überlegenen Innovationsfähigkeit gründet. Innovationen werden in der Automobilbranche vor allem durch den Einsatz von Elektronik, von neuen Werkstoffen und Fertigungstechnologien realisiert. Die erwähnte Studie identifiziert und bewertet über 250 Neuerungen: Pre-Crash-Sensorik, Seitenwandtorsionssensoren für Reifen, Nightvision in den Windschutzscheiben, Steer-by-Wire, Fussgängerschutzsensorik und vieles mehr. Im jüngsten BMW-Modell aus der 7er Reihe wurden beispielsweise über 90 Innovationen gezählt.

In der Finanzindustrie ist der Boom der strukturierten Produkte durch die innovativen „derivatives" ausgelöst worden. Die derivativen Finanzprodukte haben die Anzahl der Modulvarianten, aus denen strukturierte Finanzprodukte zusammengesetzt sind, wesentlich erweitert. Dies führte zu einer signifikanten Ausweitung der Kombinationsmöglichkeiten, welche die grosse Produktevielfalt erst zuliess. Rohner, Geschäftsleitungsmitglied der UBS, vertritt die Ansicht von P.F. Drucker, dass die „derivatives" neben dem „Asset based lending" die einzigen eigentlichen Innovationen in der Geschichte der Banken sind. Man könnte daraus schliessen, dass Innovation – zumindest für strukturierte Finanzprodukte – keine grundsätzlich strategische Bedeutung mehr hat. Sie ist zur „Routine" geworden, welche für das Überleben eines Unternehmens unerlässlich ist.

Die Phänomene der „Miniaturisierung" und der „Modularisierung" sind entscheidende Treiber für die Entwicklung von Produktarchitekturen nicht nur in der Automobilindustrie, sondern in fast allen Industrien. Sie führen zu einer stetig wachsenden Anzahl von Kombinationsmöglichkeiten von vorhandenen und neu entwickelten Modulen, welche fast beliebig miteinander kombiniert werden können. Die Innovationstätigkeit vieler Unternehmen beschäftigt sich auf Systemebene mit der Realisierung von Kombinationsmöglichkeiten. Es geht im Wesentlichen darum, mit einer exponentiell wachsenden Anzahl von technisch realisierbaren Produktvarianten Kundenbedürfnisse immer stärker differenziert zu befriedigen. Beispielsweise können heute allein beim VW Golf mehr als eine Million Varianten konfiguriert werden. Wir stehen vor einem Innovationsschub, welcher weniger das Ergebnis einer unternehmerischen „Kreativitätsleistung" ist, als vielmehr einer systematischen und strukturierten „Fleissleistung". Die Herausforderung der Unternehmen besteht darin, diese „Fleissleistung" möglichst effizient und rasch zu erbringen. Die Rentabilisierung von Innovation muss in vielen Bereichen rascher erfolgen als früher.

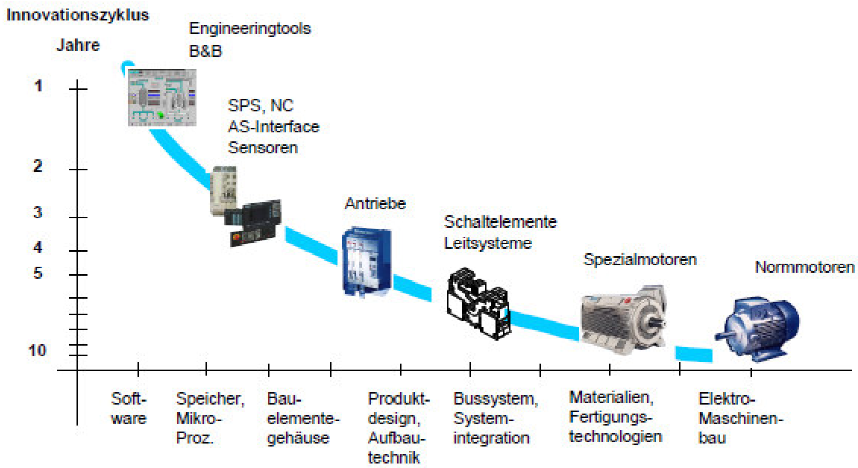


Bild 3: Innovationszyklen. Produkte und Systeme im Bereich Automation & Drives [Mir06]

Analog zur Produktionstätigkeit kann auch ein grosser Teil der Innovationstätigkeit des Unternehmens systematisch abgewickelt werden - das heisst gemäss einer strukturierten und wiederholbaren Abfolge von bestimmten Aktivitäten. Diese „Routinisierung" der Innovationstätigkeit ist eine wesentliche Voraussetzung dafür, dass ein möglichst planbarer und kontinuierlicher Innovationsausfluss entstehen kann.

4 Strukturierung der Innovationstätigkeit

Die Strukturierung der Innovationstätigkeit ist ein fortschreitender Prozess, der zu einer Steigerung des Routinisierungsgrades führt. In der Praxis gehen die Unternehmen vermehrt weg von projektorientierten ad-hoc Organisationen (Sekundärorganisationen) hin zu prozessbasierten permanenten Innovationsorganisationen. Je nach Routinisierungsgrad unterscheiden wir grob drei Ausprägungen:

1. Die auf dem Lean Management beruhenden Methoden des ***Projektmanagements*** betrachten ein Entwicklungsprojekt als ein zeitlich befristetes Vorhaben mit einem definierten Ziel. Für jedes einzelne Projekt wird eine spezifische Projektplanung vorgenommen, in welcher die Projektorganisation aufgesetzt und die Projektphasen bestimmt werden. Die Projektorganisation ist wie das Projekt selbst zeitlich befristet. Die Projektplanung folgt meist einem generischen Muster, ist aber im allgemeinen nicht direkt auf weitere Projekte übertragbar. Es findet bestenfalls eine implizite Übertragung von früheren Erfahrungen auf neu anstehende Projekte statt. Dieses Phänomen wird „carryover" genannt und unterscheidet sich

von der Standardisierung. Man kann noch nicht von einer übertragbaren „Standard Operations Procedure“ sprechen.

2. Die Ansätze des ***Multi-Project Managements*** berücksichtigen die projektübergreifende Sicht des Gesamtunternehmens – das Projektportfolio. Es geht darum, zahlreiche komplexe Innovationsvorhaben mit unterschiedlichen Zielen, Fristen und Entwicklungsstadien so zu koordinieren, dass man diese zeit- und strategiegerecht und mit minimalem F&E Aufwand abwickeln kann. Dies geschieht vor allem durch die Verwendung von gleichen Schlüsselkomponenten in verschiedenen neuen Produkten und durch Entwicklungskonzepte wie platform management, component reuse und object technologies (im Software Engineering). „Ähnliche“ Projekte werden in Clusters gruppiert und teilen einige Funktionen und Technologien. Im Wesentlichen geht es um die Frage, welche Funktionen projektübergreifend zentralisiert werden können und welche Funktionen projektspezifisch ausgeführt werden sollen. Im ersten Fall dominiert die Realisierung von Skalen- und Synergieeffekten und im letzteren die Sicherstellung von Einzigartigkeit und Geschwindigkeit des einzelnen neuen Produktes.

3. Neuere Ansätze entwickeln das Grundprinzip des traditionellen Multi-Project Managements weiter und sprechen von „***Innovationsfabriken***“. Die Anforderung ist, einen planbaren, kontinuierlichen Innovationsausfluss sicherzustellen. Schlüssel dazu ist, den Innovationsprozess – analog zum Produktionsprozess - bezüglich marktentscheidender Leistungsgrössen steuer- und beherrschbar zu machen.

5 Innovationsfabriken

Das Konzept der „Innovationsfabrik“ bezieht sich nicht auf ein einzelnes Projekt oder auf das Projektportfolio des Unternehmens, sondern auf die in der Unternehmensstrategie festgelegte Innovationstätigkeit. Die Innovationsfabrik basiert auf einem systemischen Modellierungsansatz zur ***Gestaltung der Innovationstätigkeit des Unternehmens***. Es gelten folgende Organisationsprinzipien:

5.1 Vertikale Strukturierung

Die teilweise hoch komplexen Produktentwicklungsaufgaben werden aufgrund der Modularisierung beherrschbar gemacht: Einerseits wird die technische Komplexität durch eine modulare Produktstrukturierung reduziert. Andererseits wird die Entwicklungsorganisation ebenfalls modular gestaltet und auf die Produktstrukturierung abgestimmt. Dadurch entstehen modular entkoppelte Aufgabenbereiche mit unterschiedlichen Teilvorhaben und Kompetenz-Anforderungen.

Der Gesamtentwicklungsprozess wird also in modulare, durchgängige Aufgabenbereiche geteilt, welche wie modulare und „steckbare“ Plattformen zueinander stehen. Jeder Aufgabenbereich verfügt über unterschiedliche Kompetenzen und ist für ein Modul des Innovationsvorhabens verantwortlich.

Die Gesamtintegration der Entwicklungsergebnisse auf Modul-Ebene wird durch die Produktarchitektur sichergestellt. Dabei spielt es – ganz im Sinne von „open innovation“ – kaum eine Rolle, ob diese innovativen Erkenntnisse intern erarbeitet oder extern beschafft wurden.

5.2 Horizontale Strukturierung

Die Innovationsvorhaben von jedem Aufgabenbereich werden in einem definierten Innovationsprozess ausgeführt. Dieser Prozess ist – wie jeder andere Geschäftsprozess – eine definierte und wiederholbare Abfolge von definierten Teilschritten mit einem spezifizierten Input und planbaren Output.

Innovationsfabriken funktionieren also aufgrund von „Standard Operating Procedures“. Der Ablauf für Innovationsvorhaben ist allgemein geregelt, gilt für alle Innovationsvorhaben und erfolgt als Teil der Primärorganisation – im Gegensatz zu den weit verbreiteten ad-hoc Projektorganisationen.

5.3 Zeitliche Entkopplung

Die Abwicklung der Innovationsvorhaben in den modularen Aufgabenbereichen erfolgt innerhalb von unterschiedlichen Zeithorizonten. Traditionell wird versucht, dies mit parallelen Entwicklungsansätzen abzufangen: Im „multi-tasking“ werden Projekte in kompakte Arbeitspakete so unterteilt, dass kritische Ressourcen abwechslungsweise an verschiedenen Projekten arbeiten können. Der Ansatz des klassischen „simultaneous engineering“ dagegen, definiert Teilaufgaben aufgrund ihrer zeitlichen Abhängigkeiten. Diese Teilaufgaben werden dann nicht mehr sequentiell, sondern möglichst parallel erledigt. Dadurch wird eine gewisse Verkürzung des Time-to-market erreicht.

Der Ansatz der „Innovationsfabrik“ geht aber über die Parallelität in der Abwicklung der Teilaufgaben hinaus und entkoppelt diese zeitlich voneinander. Die Prozesse in den modularen Aufgabenbereichen laufen zueinander asynchron ab. Die unterschiedlichen zeitlichen Horizonte und der damit verbundene unterschiedliche Grad der Beherrschbarkeit werden durch eine zyklische Betrachtung der Innovationstätigkeit abgefangen.

Auch diese zyklische Betrachtung wurde dem Produktions- und Beschaffungsmanagement entlehnt: Beschaffungsaufträge werden grundsätzlich aufgrund der Beschaffungszeiten zum spätmöglichsten Zeitpunkt ausgelöst. So werden Langläufer zum Beispiel aufgrund der Jahresplanung beschafft, „Mittelläufer“ aufgrund der rollierenden Monatsplanung und Kurzläufer erst aufgrund des Kundenauftrages oder des unmittelbaren Verbrauchs.

Analog dazu werden in der Innovationsfabrik Teilvorhaben nicht mehr aufgrund eines konkreten Gesamtprojektes ausgelöst. Je nach Zeithorizont startet das Unternehmen diese Entwicklungen aufgrund der langfristig ausgerichteten Masterplanung, der mittelfristigen Entwicklungsplanung oder der kurzfristigen Einführungsplanung.

In der Innovationsfabrik kooperieren die modularen Prozessbereiche also miteinander, obwohl sie zeitlich voneinander entkoppelt sind. Die zeitliche Integration derer Ergebnisse wird durch die übergeordnete Innovationsplanung (Master-, Entwicklungs- und Einführungsplanung) sichergestellt.

Die Strukturierung der Innovationstätigkeit des Unternehmens erfolgt ***horizontal*** mit einer Aufteilung eines Innovationsvorhabens in eine Abfolge von überschaubaren Teilschritten und ***vertikal*** mit einer Aufteilung in modular entkoppelte Teilvorhaben gemäss der zugrunde liegenden Produktarchitektur. Zusätzlich erlaubt die ***zyklische Betrachtung*** der Innovationstätigkeit die zeitliche Entkoppelung der modularen Bereiche aufgrund derer unterschiedlichen Zeithorizonte. Dadurch entsteht ein Zusammenspiel von modularen Prozessbereichen mit dedizierten, durchgängigen, aufeinander abgestimmten und zeitlich entkoppelten Innovationsroutinen – die „Innovationsfabrik“.

Die Zeiten, in denen Produktinnovationen einen Wettbewerbsvorteil darstellten, neigen sich in einigen Branchen ihrem Ende zu. Durch die fortschreitende Routinisierung der Innovation wird Innovationsfähigkeit zur unabdingbaren Voraussetzung, um auf einem Markt überhaupt bestehen zu können. Unsichere Innovationstrefferquoten, lange Entwicklungszeiten, Innovationspipelines mit zahlreichen parallelen Innovationsvorhaben, aufwändiges Projektportfolio-Management und Brainstorming-Innovation werden vermehrt durch routinisierte „Innovationsfabriken“ abgelöst. Deren Aufgabe ist es, die als Folge der Miniaturisierung und Modularisierung neu entstandenen Möglichkeiten systematisch zu realisieren und einen kontinuierlichen Innovationsfluss sicherzustellen.

Routinisiertes Innovationsmanagement entwickelt sich damit immer mehr zu einem Standard, der in Zukunft weder Differenzierung noch Wettbewerbsvorteile bietet: So werden viele Nahrungsmittel leicht anders verpackt, Skis erhalten jedes Jahr ein wenig Redesign und manche Autos unterscheiden sich nur noch durch die Marke … Um sich jedoch im Wettbewerb von der Konkurrenz differenzieren zu können, gewinnen „radikale“ Innovationen an Bedeutung. Viele Unternehmen sind auf der Suche nach solchen Innovationen und wollen Ansätze entwickeln, wie man diese auch gleich routinisieren kann. Es gibt weiterhin Arbeit für kreative Genies!

Literatur

[AG01] Agarwal, Rashree, und Gort, Michael (2001): First Mover Advantage and the Speed of Competitive Entry, 1887-1986. Journal of Law and Economics 2001/44(April): 161-171.

[Ama88] Amabile, Teresa M. (1988): A Model of Creativity and Innovation in Organizations. Research in Organizational Behavior, 10:123-167.

[Bau93] Baumol, William J. (1993): Entrepreneurship, Management and Structure of Payoffs. MIT Press, Cambridge, Mass.

[Bau04] Baumol, William J. (2004): The Free-Market Innovation Machine. Analyzing the Growth Miracle of Capitalism. Princeton University Press, Princeton and Oxford.

[Coh96] Cohen, Michael D. e.a. (1996): Routines and Other Recurring Action Patterns of Organizations: Contemporary Research Issues, Industrial and Corporate Change, 5(3), 653-98.

[DD06] Deplazes, Ursula, und Deplazes, Wolfgang (2006): unveröffentlichte Unterlagen von F&E AGIE SA, Losone, Schweiz.

[FG00] Ford, C.M., und Gioia, D.A. (2000): Factors influencing creativity in the domain of managerial decision making, Journal of Management, 26(4):705-32.

[Kra79] Kraft, P. (1979): The routinization of computer programming, Sociology of Work and Occupations, 6(2):139-155.

[Mir06] Mirow, Michael (2006): Wertsteigerung durch Innovation (Vortrag), München, 2006:Folie 9. (http://www.e-berger.de/Innovation_Mirow_2006-04-04.pdf)

[NW82] Nelson, Richard R., and Winter, Sindney G. (1982): Organizational Capabilities and Behavior, in *An Evolutionary Theory of Economic Change,* ch. 5, Belknap Press of Harvard University Press, Cambridge, Mass. 96-103.

[OSP06] Ohly, S, Sonnentag, S., und Pluntke, F. (2006): Routinization, work characteristics, and the relationship with creative and proactive behaviours, Journal of Organizational Behavior, 27, 257-279.

[PD77] Pierce, J.L., und Delbecq, A.L. (1977): Organisational Structure, Individual Attitudes and Innovation. Academy of Management Review, 1(2), 27-33.

[Whi91] Whitehead, Alfred North (1991): An Introduction to Mathematics, Oxford University Press, ch. 5.

Autoren

M.Sc. LSE, M.Sc. HEC, HLH Ursula Deplazes ist externe Doktorandin bei Prof. Dr. Roman Boutellier und schreibt ihre Dissertation zum Thema „Routinisierung der Innovation“ am Lehrstuhl für Innovations- und Technologiemanagement. Ursula Deplazes studierte Betriebswirtschaft an der Universität Lausanne (HEC) und Finance and Accounting an der London School of Econcs. Sie hat mehrjährige Berufserfahrung in International Banking, International Marketing und Begleitung von Start-ups.

M.Sc. HEC Wolfgang Deplazes ist externer Doktorand bei Prof. Dr. Roman Boutellier an der Eidgenössischen Technischen Hochschule (ETH) in Zürich. Thema seiner Dissertation ist Business Design. Wolfgang Deplazes studierte Betriebswirtschaft und Politologie an den Universitäten Lausanne (HEC), St. Petersburg, Beijing und St. Gallen. Er hat langjährige General Management-Erfahrung im internationalen Konsumgüterbereich und ist seit mehreren Jahren als Berater für Restrukturierungen und Re-Engineering tätig.

Prof. Dr. sc. math. Roman Boutellier ist seit 2004 ordentlicher Professor für Technologie und Ökonomie (D-MTEC) der Eidgenössischen Technischen Hochschule (ETH) in Zürich. Seit 1999 ist Herr Boutellier Titularprofessor an der Universität St. Gallen. Nach dem Studium in Mathematik promovierte er 1979 im gleichen Fach und war als Postdoc am Imperial College in London tätig. Seine Industrietätigkeit begann Dr. Boutellier 1981 als wissenschaftlicher Mitarbeiter bei KERN, Aarau und wurde dort Entwicklungs- und Produktionsleiter. Anschliessend war er Mitglied der Geschäftsleitung von Leica, Heerbrugg sowie CEO und Delegierter des Verwaltungsrates der SIG Holding AG, Neuhausen. In der Zeit von 1993 bis 1998 war er Professor an der Universität St. Gallen und Direktionsvorsitzender am dortigen Institut für Technologiemanagement, wo er die Abteilung Innovationsmanagement und Logistik leitete. Herr Boutellier ist Mitglied der Verwaltungsräte mehrerer Schweizer Grossunternehmen.

12.3 Business Design for 'Routinized Innovation'

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Innovation Factory and Innovation Atelier Business Design for 'Routinized Innovation'

W. Deplazes, U. Deplazes, R. Boutellier
Department of Technology and Innovation Management, ETH Zürich, Switzerland
(udeplazes@ethz.ch)

Abstract - **The importance of 'routinized innovation' as a major driver of economic growth, the need for 'ambidextrous organizations' in an uncertain and disruptive business environment, and the importance of contingency for organizations have been widely discussed in management literature. From a business design perspective, practitioners are facing a three-fold challenge to design Innovation structures which meet the requirements of 'designing for routinized Innovation', 'designing for ambidexterity', and 'designing for contingency'. The authors aim at addressing this challenge by introducing the complementary concepts of 'Innovation Factory' and 'Innovation Atelier'. The argument is discussed conceptually and supported by a case study.**

Index Terms - **Innovation management; Business design; Organization management; Process management; R&D management; Ambidexterity.**

I. Introduction

The paper aims at addressing the challenge how to design the firm's Innovation System combining the design imperatives of 'design for ambidexterity' (among others [2], [3]), design for routinized Innovation' (for a detailed discussion [1]), and 'design for contingency' (among others [4]). It adopts a perspective of business design and introduces the complementary concepts of 'Innovation Factory' (referred to as I-Factory) and 'Innovation Atelier' (referred to as I-Atelier). The approach builds on insights stemming from systems theory, economic theories of growth, process philosophy, theories of business design, and theories of contingency of organizations as well as a series of case studies of business design.

The authors present a conceptual discussion supported by a case study of a Fast Moving Consumer Goods manufacturer. We set out by discussing the company's Innovation System and its sub-systems 'I-Factory' and 'I-Atelier' (ch. II). We then proceed by differentiating these concepts with regard to their innovation scopes (ch. III), approaches to structure their innovation scopes (ch. IV), and innovation processes (ch. V). Subsequently, the matching of the Innovation scopes and the Innovation processes is presented (ch. VI). As the concepts are presented, we gradually introduce the case study of an FMCG manufacturer. The paper concludes with a discussion of the I-Factory of the FMCG manufacturer (ch. VII).

II. Innovation System (I-Factory and I-Atelier)

We view the firm's innovation activities as a complex adaptive system aimed at generating a continuous flow of innovations to secure the firm's current and future strategic positions. The 'Innovation System' can be structured into an 'exploitative' and an 'explorative' sub-system. This is supported by theories of ambidexterity and systems theory.

From an organizational perspective, various authors of theories on ambidexterity argue that organizations develop explorative and exploitative innovations simultaneously in different organizational units (among others [5], [6]).

From a business design perspective, it is key to adopt a holistic view of the firm's Innovation activities and embed the two sub-units into the parent Innovation System of the company. This calls for a clear differentiation between the two units with regard to their Innovation scopes, structures and processes. We start our considerations at the level of the firm's overall innovation activities, i.e. its 'Innovation System' (in the following referred to as I-System). It is defined a 'system of processes', that is hierarchically structured into an 'exploitative sub-system' and an 'explorative sub-system'. We refer to the former as the I-Factory and the latter as the I-Atelier.

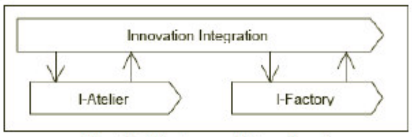

Chart I: I-System and its sub-units

A. Case study - company presentation and issue set-up

Cocoa Ltd. produces and distributes branded packaged chocolate goods. Increased competition and price pressure eroded Cocoa Ltd.'s market share and margins. In a news-driven market, the company repeatedly failed to establish new initiatives, either because it missed out on consumer trends or because initiatives were late. Promotions based on price appeared as the main means to fight the erosion of current market positions. The principal driver behind this was the insufficient Innovation capability of the company as evidenced by its long time-to-market, 24 months versus 6 months for leading competitors, and the lack of systematic capability-building in the company. Top management revised the company strategy. Besides aggressive internationalization the following Innovation objectives were defined: (i) establish sustainable innovation leadership in current product categories by generating a continuous flow of upgrades, line extensions, promotional and seasonal offerings; and (ii) exploit the convergence trend in the food sector by leveraging current capabilities into new product categories and market segments.

The product development organization had undertaken substantial efforts to increase the efficiency of its project-based development process by introducing lean techniques such as cross-functional project teams, multi-tasking, and concurrent development. In the face of the new Innovation objectives, it became however clear that a major organizational re-shuffle was needed to allow for the generation of a continuous flow of product news.

III. Innovation Scope (I-Factory and I-Atelier)

The scope of the I-System is to generate a continuous flow of streams of heterogeneous innovative outputs, including 'incremental' and 'more disruptive' innovations. From a business design perspective, this heterogeneous scope of the I-System needs to be structured into sub-scopes that are attributed to the I-Factory and the I-Atelier respectively. Typologies of Innovation have to be identified, which allow for a clear allocation of the company's Innovation activities either to the scope of the I-Factory or of the I-Atelier.

A. Typology based on 'value delivery system'

Combining insights from Innovation literature and literature on marketing and business strategy, we define a typology of Innovation activities based on the concept of 'value delivery system' (in the following referred to as VD-system). Innovation activities can thus be differentiated based on whether they aim at generating incremental changes *within* the current 'VD-system' of the company ('exploitative Innovations' associated with I-Factory), or whether they aim at more disruptive changes *of* the 'VD-system' (i.e. 'explorative Innovations' associated with I-Atelier). This typology is also confirmed by analogy with the pragmatic view shared by many R&D practitioners. They differentiate Innovation activities based on whether they are associated with generating changes *within* the product architecture or changes *of* the architecture.

B. Scope of the I-Factory

The I-Factory's innovation scope thus covers the company's current VD-system. Exploitative Innovation activities are about scrutinizing all elements of the company's VD-system for incremental innovations, product upgrades, product and module variants, line extensions and new combinations of existing modules. The aim is to generate a continuous flow of incremental innovations. This flow enables the company to adapt to immediate and mediate environment changes and exploit the opportunities presented by these changes.

C. Scope of the I-Atelier

The I-Atelier's Innovation scope covers the company's future VD-system. It deals with the 'creative destruction' associated with a corporation's long-term competitiveness and performance [8]. Explorative Innovation activities aim at replacing the company's current VD-system or significant parts of it with new VD-systems. This includes fundamental changes of some key component of the business, architectural changes, new platforms, new technologies and new business models. The scope of the I-Atelier is a 'landscape of projects'. Its outputs are completed development projects (either single-projects or portfolios of projects) ready for diffusion and adoption internally or externally.

D. Case study - Defining the scopes of I-Factory & I-Atelier

The innovation activities associated with the I-Factory of Cocoa Ltd. include a continuous flow of news in terms of product variants, upgrades, line extensions, seasonal collections, promotional sizes, fillings and ingredients (chart II). They are associated with an exploitative process.

Innovation activities associated with the I-Atelier are radical from a company perspective and require an explorative process. They include: the development of new product formats such as chocolate candies, moulded chocolate products, functional food products, leveraging capabilities (e.g. brands and distribution) into new product categories such as biscuits, exploring new distribution possibilities (e.g. Web-based and alliances) and entering new markets (specifically Central and Eastern Europe). Historically, the company had not made the distinction between 'exploitative innovations' and 'explorative innovations' and handled all innovation activities as single-projects based on an new product development process (NPD) .

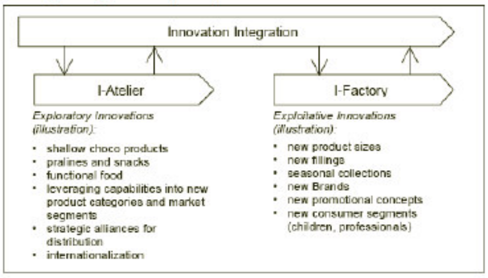

Chart II: I-System of Cocoa Ltd.

IV. Structuring the Innovation Scopes

A. VD-architecture for I-Factory

The scope of the I-Factory is the company's current VD-system. In analogy with the concept of 'product architecture' that has been used as a basis to structure R&D activities, we introduce the concept of 'VD-architecture' as a base to structure the Innovation scope of the I-Factory. The concept of 'product architecture' is well documented in literature of engineering and product development .

The current VD-system is structured into a VD-architecture composed of modular parts. Being a 'nested system' composed of 'parts-within-parts' [7], the architecture can be decomposed until modular sub-scopes of a manageable size are reached. Establishing a VD-architecture is highly contingent upon the company's context and has a series of strategic implications, since it defines the way a company structures its VD-system. For further illustration of the concept of VD-architecture and its applicability we have documented case studies including a service company [9] [10], a distribution company [11], and a FMCG company [12]. It also appears to be relevant for traditional manufacturers facing increased pressure for non-product innovation, such as establishing brands, internationalizing their business, and developing new distribution opportunities. In some cases the VD-architecture can also be used as a framework to develop company strategy or to delimit business divisions [13].

B. *'Project architecture' for I-Atelier*

The I-Atelier specifies projects in line with the company's exploration strategy and generates a set of completed development projects (either single-projects or portfolios of projects) ready for diffusion and adoption internally or externally. The scope of the I-Atelier covers the company's future VD-system and is in most cases a 'landscape' of more or less pre-defined projects. This was also the case for Cocoa Ltd.'s I-Atelier (chart II). Concepts associated with the 'project architecture' can be used to structure the scope of the I-Atelier. The basic idea is to structure Innovation projects into modular and manageable portions. Highly heterogeneous and unique projects are usually structured based on their dedicated project architecture. More homogeneous projects are clustered into portfolios of projects for which consolidated portfolio architectures are designed. Such techniques are also referred to as strategic project mapping. A variety of tools are proposed by the burgeoning literature on project, lean project, and multi-project management (for a comparative discussion of project management, lean project management and multi-project management, and the concept adopted here, refer to [14]). In the case of a maintenance company, the I-Atelier was structured into 'Innovation Fields' that are explored systematically to generate ideas and broadly defined projects. They are closely associated with strategic business development [8], [12].

C. *Case study - Cocoa Ltd.'s VD-architecture*

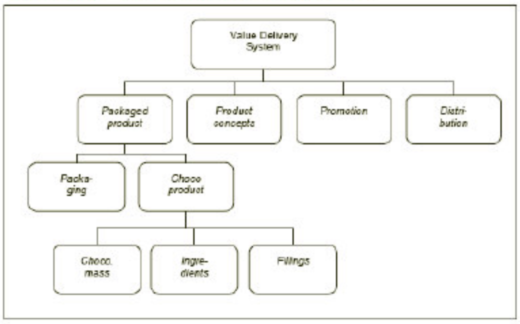

Chart III: VD-architecture of Cocoa Ltd

After defining the Innovation scopes of its I-Factory and I-Atelier in line with company strategy, Cocoa Ltd. proceeded by structuring these Innovation scopes. It adopted the VD-architecture and the 'project architecture' to structure the scopes of the I-Factory and the I-Atelier respectively. Importantly, Innovation areas not related to the physical product were systematically introduced into the scope of the I-Factory to account for the specific FMCG context. Thus, the VD-architecture underlying the I-Factory provides a framework integrating all areas of Cocoa Ltd.'s activities prone to incremental Innovation: product, marketing, promotion, and distribution. The VD-architecture for the I-Factory is illustrated in chart III.

V. Innovation Processes (I-Factory and I-Atelier)

Having structured the Innovation scopes of I-Factory and I-Atelier into architectures, the processes best suited to handle these Innovation scopes need to be designed. Conventional models of Innovation processes adopt a broad view covering the entire Innovation cycle from a unitary perspective. We advocate that this perspective does not meet the requirements of the business design perspective adopted here. It appears that the exploitative process of the I-Factory is significantly different from the explorative process of the I-Atelier and that these processes need to be tailored contingent upon the Innovation scopes they will be associated with.

A. *Process for I-Factory*

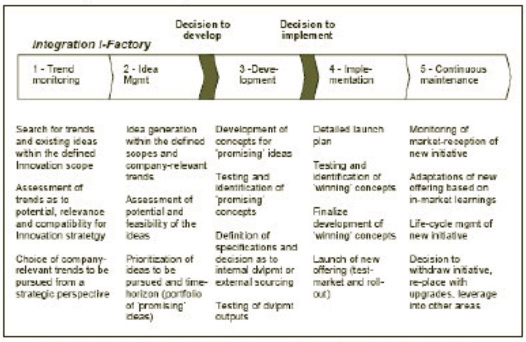

Chart IV: Exploitative process of I-Factory (Cocao Ltd.)

To secure the generation of a sustained flow of incremental innovations, the I-Factory continuously searches its dedicated Innovation scope for 'existing' ideas and assimilates them to address recognized needs. The exploitation process is characterized by "selection, refinement, choice and execution" [15]. It is about routinizable "problem-solving", "information-processing" [16] and not about creating 'new' ideas. Exploitative processes adopt the perspective of continuous and efficient exploitation of defined Innovation scopes or sub-scopes for new variants, upgrades, alternatives, and elsewhere available solutions. The developed ideas are stocked for assembly. The process of integrating the outputs of the exploitative processes is of secondary importance, since the associated Innovation sub-scopes are modularly linked in the VD-architecture and integrated in the overarching integration process at the level of the I-Factory.

B. Process for I-Atelier

The I-Atelier's explorative process generates a highly heterogeneous set of completed development projects. The process is about creating new ideas, making them work and preparing them for diffusion, internally or externally. As mentioned above, the exploration process is characterized by variation and discovery. It is a creative process in which new and existing ideas are combined in a novel way to produce an invention or a configuration that was previously unknown [2]. In the context considered here, the explorative process of the I-Atelier adopts an 'object-based' perspective of 'structuring and integrating tasks for the completion of complex projects' (single-projects or portfolios of projects). The explorative process is managed based on approaches described in project management literature (project, lean project, and multi-project management) [17].

C. Case study - Process design (I-Factory)

Having defined the scope of its I-Factory and its underlying VD-architecture, Cocoa Ltd. proceeded by designing the exploitative process of the I-Factory and the explorative process of the I-Atelier. The processes were designed accounting for their differences and to systematically reap the benefits associated with 'routinized Innovation'. We limit our discussion to Cocoa Ltd.'s I-Factory, whose exploitative process is illustrated in chart IV.

VI. I-FACTORY OF COCOA LTD.

The following discusses the process architecture and the organizational set-up of the I-Factory of Cocoa Ltd.. The process architecture is established by matching the Innovation sub-scopes and the Innovation process (chart V). Further, Cocoa Ltd. decided to adopt a process-based organization in line with the process architecture (chart VI).

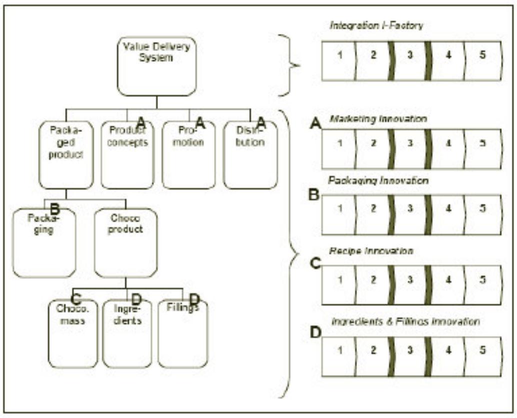

Chart V: Matching Innovation scopes and processes (I-Factory)

A. Process architecture (I-Factory)

Based on an analysis of the capabilities and resources required to exploit the Innovation sub-scopes of the I-Factory, Cocoa Ltd. proceeded by grouping these sub-scopes into manageable and coherent clusters to be allocated to core processes of the I-Factory. The matching of scopes and processes thus produced the process architecture of the I-Factory shown in chart V. It consists of the core processes of Marketing Innovation, Packaging Innovation, Recipe Innovation and Ingredients & Fillings Innovation. These are integrated by the overarching Integration process of the I-Factory.

B. Organizational set-up (I-Factory)

Literature on Business Process Re-engineering (BPR) (a.o. [18]) documents the advantages of the congruency between formal organizational set-ups and business processes. It is associated with lower levels of complexity in the organization, as evidenced by fewer interfaces among organizational units and less conflictual objectives. The formal organizational structure thus reflects the way in which the overall scope of the I-Factory is decomposed into modular sub-scopes. Based on the same principle, organizational units can be re-composed into their higher-level organizational unit, the I-Factory.

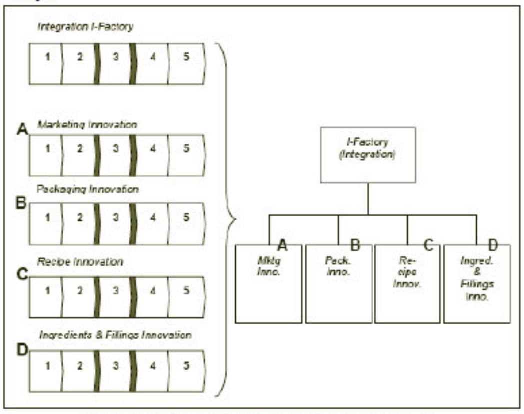

Chart VI: Process-based organizational set-up

Cocoa Ltd. thus designed its formal organizational set-up based on the underlying process architecture. Organizational units are allocated a defined 'Innovation sub-scope' and integrate into the I-Factory. The organizational units exploit their Innovation scope based on an Innovation process which they can further detail based on their specific requirements in terms of process detail, capabilities, resources (such as human, technological, infrastructure) and other organizational requirements.

VII. MECHANICS OF THE I-FACTORY OF COCOA LTD.

The following proceeds with a discussion of the mechanics of Cocoa Ltd.'s I-Factory. The integration of the core processes of the I-Factory is based on its Integration process, whose Innovation scope is the company's current 'VD-system'. The Integration process has a dual function: it contributes to company strategy and ensures the compatibility of the I-Factory's activities with company strategy. To achieve this, the Integration process oversees and integrates the core processes of the I-Factory based on (1.) Innovation cycles and (2.) portfolios of pre-, semi-, and final development outputs.

A. Innovation cycles and portfolios

The Integration process of the I-Factory is in charge of steering and integrating the core processes to deliver a continuous flow of market-relevant Innovations. Specifically, it details their Innovation scopes in line with company strategy and keeps their development activities in line with company strategy. This is achieved through a series of Innovation cycles with associated portfolios (chart VII):

1) Cycle 1 - Trend monitoring

Within their dedicated Innovation scopes, the core processes systematically identify and qualify the key trends. These collectively constitute the I-Factory's portfolio of 'qualified trends'. The Integration process then consolidates these trends from its perspective of the 'VD-system' and scrutinizes them for compatibility with company strategy, relevance and feasibility. Subsequently, it identifies among the 'qualified trends' a series of 'promising trends'.

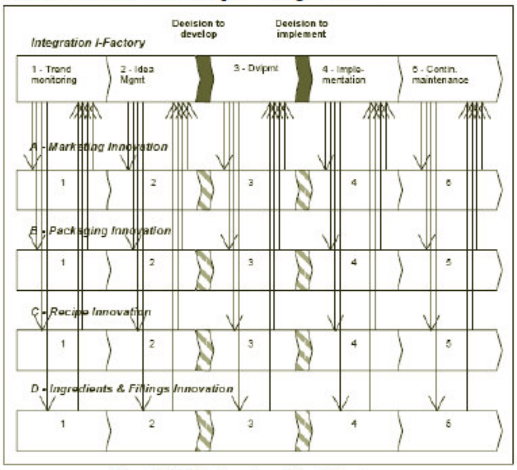

Chart VII: Mechanics of the I-Factory

2) Cycle 2 - Idea management

The core processes (A to D in chart VII) develop and qualify ideas against the 'promising trends'. These constitute the I-Factory's portfolio of 'qualified ideas'. The Integration process combines these ideas from its perspective of the 'VD-system' into the I-Factory's portfolio of 'qualified ideas' and scrutinizes them based on medium-term market developments and company strategy. 'Promising ideas' are selected and a decision to develop is made.

3) Cycle 3 - Development: Development

Subsequently, the core processes develop 'qualified concepts' against these 'promising ideas' and feed the I-Factory's portfolio of 'qualified concepts'. From a combined 'VD-system' perspective, the Integration process qualifies the potential of these concepts in the view of specific short- and mid-term market opportunities and defines a selection of 'promising concepts', for which final development is undertaken.

4) Cycle 4 - Implementation

A launch plan is then established at the I-Factory level and further detailed at the level of each core process. After final development and integration of the 'promising concepts', these are tested against the specific market opportunity to identify the 'winning concepts' that are subsequently launched. For the first 6 months after their launch, initiatives are considered as part of the portfolio of 'new initiatives'. Based on the initiative's reception by the market, they are scrutinized by the core processes to identify areas for improvement to be made to the new initiatives. As part of the management of the portfolio of 'new initiatives', the Integration process reviews the identified 'areas for improvement' and decides how to proceed, i.e. either silently make the adjustments, plan for the subsequent launch of an upgrade, or in the extreme case withdraw the initiative from the market.

5) Cycle 5 - Continuous maintenance

An initiative is considered as part of the 'portfolio of in-market initiatives' beyond 6 months after launch. The core processes scrutinize these initiatives for maintenance and life-cycle requirements. This includes replacing and/or upgrading some elements that approach the end of their lifecycle (e.g. for regulatory reasons), and extending proven concepts to other brands or product variants. Importantly, the portfolio of 'in-market initiatives' is managed by the Integration process of the I-Factory from a 'VD-system' perspective. This includes decisions regarding product upgrades, new product variants, and discontinuation of a product.

B. De-coupled Innovation processes

The following will present the concept of 'de-coupled Innovation' as adopted in our I-Factory and subsequently highlight the differences between these concepts and the widely adopted concepts of 'multi-tasking' and 'parallel development' and its various forms.

1) De-coupled Innovation at Cocoa Ltd.

The design of Cocoa's Ltd.'s I-Factory accounts for the different time horizons of the core processes by de-coupling these processes. In fact, processes follow each their own time horizon and generate innovative outputs for stock (i.e. the various portfolios at I-Factory level). Thus each of the core processes develops within its Innovation scope a variety of 'qualified trends' and 'qualified concepts' for stock. For perspective, Marketing Innovation develops and tests concepts for brands, upgrades, flankers and line extensions. Recipe Innovation develops and qualifies a variety of partial or integral chocolate recipes. The qualified concepts are stocked for further reference. Similarly, nutritional engineers in charge of Ingredients Innovation continuously define technical specifications for a variety of ingredients, i.e. they define their technical specifications (e.g. compatibility, tolerance, consistence, durability). Similarly, 'qualified concepts' for a variety of fillings (e.g. alcohol-based liquids, fruit-based liquids, vegetable pastes) are developed. These include the definition of their technical specifications. Cocoa Ltd. thus created a stock of readily available 'qualified ingredients' and 'qualified fillings' that can be referred to and quickly inserted into new offerings. The introduction of the I-Factory and the concept of 'de-coupled' Innovation, allowed Cocoa Ltd. to reduce lead-times significantly from 24 months to 6 months on average.

2) De-coupled Innovation vs. parallel engineering

Historically, Cocoa Ltd. adopted a 'unitary' project-based NPD process (see ch. V) to undertake its Innovation activities. The product development organization had introduced lean concepts such as multi-tasking and simultaneous development, however, its lead-times remained far off competitive benchmarks. The concept of 'de-coupled Innovation' is different from the various concepts of parallel engineering. In 'multi-tasking' complex projects are structured into tasks, which are scheduled to allow critical resources to work on different projects alternately. Classical 'simultaneous engineering' defines tasks based on their time-dependence and aims at executing these tasks not in a sequential, but in a partially parallel manner.

The I-Factory, however, goes beyond making a variety of tasks in parallel and de-couples its Innovation activities. Innovation processes are not sequential and not even parallel, they are asynchronous to each other. Its core processes develop pre-, semi-, and final development outputs for 'stock'. These are combined by the Integration process in line with the underlying 'VD-architecture'. We define this as 'de-coupled Innovation' or 'asynchronous Innovation'. In a variety of industries the de-coupling of Innovation activities has produced significant reductions of lead-times. In the pharmaceutical industry molecule-concepts are qualified (i.e. qualification of physical characteristics and synthesis) and developed for the library (i.e. for stock). When product development needs a molecule, it refers to this library to select target-molecules that are subsequently tested based on the specific product concept.

C. *Planning of the I-Factory: "Keeping the beat"*

Cocoa Ltd. adopted a cyclical approach to planning the activities of the I-Factory. This is based on the analogy with planning in manufacturing and sourcing management, where items are ordered at the latest possible time based on their sourcing lead-times. Longer lead-time items need to be sourced based on a forecast of 12 months or beyond, mid-term items can be sourced based on the rolling monthly forecast. The procurement of short-term items can be delayed until receipt of the actual customer order. Similarly, the activities of the core processes are not planned and initiated based on a defined project, but based on their allocated Innovation scopes and their specific time horizons. In line with company planning, Cocoa Ltd. adopted also for its I-Factory the Master Planning (established once a year for the following 5 years), the rolling Development Planning (established every 3 months for the following 24 months), and the Launch Planning (established once a month for the following 12 months).

D. *Benefits of the I-Factory at Cocoa Ltd.*

A variety of benefits were associated with the introduction of the I-Factory at Cocoa Ltd. Within 36 months of introduction, the company had reduced its time-to-market from 24 months to 6 months and increased share of turnover of product news (less than 12 months) by 25 percentage pts. Importantly, awareness studies among users rated the company's brands highly for their innovativeness and suggested that Cocoa Ltd. succeeded in conquering back lapsed users. In some markets, the company achieved market leadership and innovation leadership. This was mainly driven by the seasonal collections the I-Factory allowed the company to launch every quarter, each including 12 new product variants. The increased innovative capacity translated into higher market share, higher price levels, and higher margins. Separately, the I-Factory is seen today as a major contributor to the successful internationalization of the company's activities. In fact, in a Food context driven by national and regional concepts, the I-Factory was able to develop a variety of new product concepts within very short lead-times.

REFERENCES

[1] U. Deplazes, W. Deplazes and R. Boutellier, The Importance of Routine Innovation Activities for Economic Growth, Proceedings ICMIT 2008.

[2] R. B. Duncan, "The Ambidextrous Organization: Designing Dual Structures for Innovation," In: R.H. Kilmann, L. R. Pondy, and D. P. Slevin (Editors), *The Management of Organizational Design: Strategy Implementation*, vol. 1. North-Holland, New York, 1976, pp. 167-188.

[3] C. A. O'Reilly and M. L. Tushman, "The ambidextrous organization," *Harvard Business Review*, May-June 2000: pp. 157-166.

[4] J. D. Thompson, "*Organizations in Action: Social Science Bases of Administrative Theory*", Transaction Publishers, New Jersey, 2003.

[5] M. L. Tushman and Ch. A. O'Reilly, "Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change," *California Management Review*. 1996, 38(4), pp. 8-30.

[6] M. J. Benner and M. L. Tushman, "Exploitation, Exploration, and Process Management: The Productivity Dilemma revisited". *Academy of Management Review*, 2003 (28); pp. 238-256.

[7] H. A. Simon, *The science of the Artificial*, Cambridge, MIT Press, 1996.

[8] R. Foster and S. Kaplan, "Creative Destruction," *The McKinsey Quarterly*, 2001 (3): pp. 41-51.

[9] W. Deplazes, U. Deplazes, and R. Boutellier, *Case Study: A Service Company*, forthcoming.

[10] W. Deplazes, U. Deplazes, and R. Boutellier, *Case Study: A Service Company in the Banking Sector*, forthcoming.

[11] W. Deplazes, U. Deplazes and R. Boutellier, *Case Study: A Distribution Company*, forthcoming.

[12] W. Deplazes, U. Deplazes, and R. Boutellier, *Case Study: Fast Moving Consumer Goods*, forthcoming.

[13] W. Deplazes, U. Deplazes, and R. Boutellier, *The concept of Business Units*, forthcoming.

[14] F. Damanpour and J. D. Wischnevsky, „Research on Innovation in Organizations: Distinguishing Innovation-Generating from Innovation-Adopting organizations," *Journal of Engineering Technology Management*, 2006 (23), pp. 269-291.

[15] J. G. March, "Exploration and Exploitation in Organizational Learning," *Organization Science*, 1991 (2), pp. 71-87.

[16] I. Nonaka, "Redundant, Overlapping Organizations: A Japanese Approach to Managing the Innovation Process," *California Management Review*, spring 1990, pp. 27-38.

[17] M. A. Cusumano and K. Nobeoka, *Thinking Beyond Lean: How Multi-Project Management Is Transforming Product Development at Toyota and Other Companies*, Free Press, New York, 1998.

[18] M. Hammer and J. Champy, *Reengineering the Corporation. A manifesto for business Revolution*, Nicholas Brealey, London, 1994.

12.4 Design of Engines of Growth based on 'Routine Innovation Activities'

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The Importance of Routine Innovation Activities for Economic Growth

Ursula Deplazes, Wolfgang Deplazes, Roman Boutellier
Department of Technology and Innovation Management, ETH Zürich, Switzerland
(udeplazes@ethz.ch)

Abstract—**This paper analyzes the importance of routine innovation activities for economic growth. After discussing the drivers of growth in the free-market economy, we focus on the concept of routine innovation activities as a major source of economic growth. Based on several economic theories we conceptualize routine innovation activities. This concept is the foundation of a holistic approach to organizational design discussed in an additional paper presented at the ICMIT 2008 [1]. Business organizations can thus capitalize on the phenomenon of routine innovation activities by proactively routinizing innovation.**

Index Terms—**Innovation management; Routines; Routinization of innovation; Economic growth.**

I. Introduction

STUDIES contemplating past decades show that a vast majority of companies was not able to generate above-average growth rates in the mid- and long-term and developed more slowly than financial markets. About 90% of companies were not able to generate sustained growth over a decade and simultaneously generate above-average shareholder returns [2]. This is confirmed by the fact that only 26% of companies appearing in the Fortune Top 100 ranking of 1980 still appear in 2001. A more recent research concludes that less than 1% of companies achieved both, above average growth and above-average profitability, over the period from 1994 to 2004 [3]. A variety of authors attribute this to the inability of companies to overcome discontinuous environmental developments [4]. On the far side, successful companies were associated with sustained organic growth and high market-to-book ratios. These reveal a systematic accumulation of valuable 'intangible assets' [3] directly associated with a firm's innovative capacity.

We adopt an economic perspective analyzing the drivers of the extraordinary growth of free-market economies with a view to determining the main elements on which business organizations have to focus in order to generate above average growth in the mid- and long-term. The question being addressed is: "What is the main driver of the extraordinary growth of free-market economies?"

The article commences with an illustration of the unprecedented economic growth associated with the free-market economy (chapter II). We then proceed with a review of economic theories considering innovation as an endogenous factor for economic growth and define characteristics of innovation associated with economic growth. Special focus is on the concept of 'routine innovation activities' as described in micro-economic theories of authors such as Schumpeter and Baumol (chapter III).

II. Superior Growth in Free-Market Economies

This chapter illustrates the extraordinary growth achieved in free-market systems as compared to other economic systems. Subsequently, it briefly introduces a variety of scientific approaches to growth. Based on the evolution of GDP per capita in Western Europe and the comparison of GDP per capita between Western Europe and China, we illustrate in section (A) the undisputed fact that the free-market system has generated unprecedented economic growth. Section (B) introduces multi-disciplinary explanations of the historical economic and technological dominance of Western society, including well-publicized approaches by Diamond [5] and Landes [6]. In line with [6] we set aside the "pseudo-scholarship that tries to deny the phenomenon as a Eurocentric myth and the polemics that regard it as simply the result of some form of pillage and robbery". From the perspective adopted in this paper, we need to understand the drivers of growth in free-market systems to derive learnings for practitioners aiming at leveraging this phenomenon.

A. Growth record of free-market economies

Western European economies experienced extraordinary growth from the early 19th century onward. GDP per capita (measured in 2002 dollars) rallied spectacularly in Western European countries with the onset of the industrial revolution. It increased exponentially from the late 18^{th} century through the end of the 20^{th} century (Fig. 1).

Despite all the insufficiencies of measuring economic growth based on real GDP per capita, the effect of industrialization and free-market economy on economic growth is undeniable. Thus, "average growth rates for about one and a half *millennia* before the Industrial Revolution are estimated to have been approximately *zero*, and, although there was undoubtedly some growth starting around the tenth century, it proceeded at a snail's pace by modern standards" [7].

A comparative analysis of the evolution of per capita GDP in Western Europe and China reveals a widening gap between the early 19^{th} and the 1970s (Fig. 2). In fact, economic growth (as measured based on per capita GDP) tends to develop exponentially in the free-market economy, while in other economic systems it appears to develop in a more linear fashion or stagnate altogether.

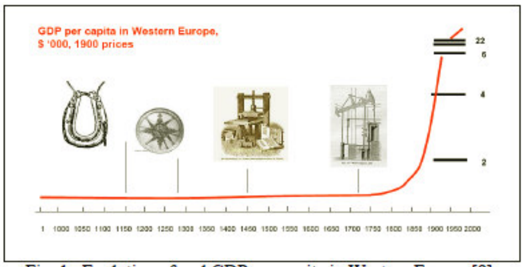

Fig. 1. Evolution of real GDP per capita in Western Europe [8].

The following observations support the argument in favor of the importance of free-market mechanisms in generating economic growth: (i) the explosion of GDP growth in Western Europe with the onset of the industrial revolution, (ii) the decline of China's per capita GDP to lowest-ever levels after its gradual withdrawal into isolationism in the 15th century, and (iii) the spectacular per capita GDP growth since 1978 when Deng Xiaoping became de facto leader of the People's Republic of China and gradually opened the country to market forces as part of his attempt to introduce 'socialist market economy'. "In 1978, China had the world's ninth largest economy, with a GDP just one-eighth that of the United States and a third that of Japan. But by 2001, China had grown to the world's second largest economy" [9].

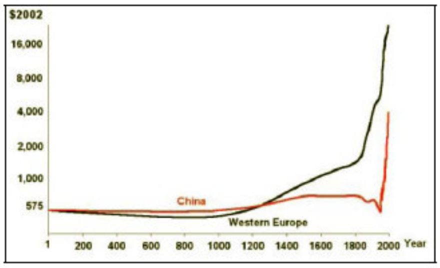

Fig. 2. Comparison real GDP per Capita: China and Western Europe. 1-1998 AD [9].

It is undisputed that free-market system has been associated with extraordinary economic growth as compared to other economic systems. From the perspective adopted in this paper, it is important to understand the drivers of this extraordinary growth. From these insights, we will derive a set of learnings to be used by practitioners of organizational design in innovation management.

B. Multi-disciplinary view of free-market performance

Scientists from disciplines other than economics have been debating the question of the rise of Western Civilization to economic and technological domination. Prominent contributors to this debate are [6] [10] [11] [12] [13] [5] [14]. Economics, politics, sociology, psychology, and geography all play a role in explaining the historical fact of Western economic and technological predominance [15]. However, there is no consensus view of the relative importance of each contributing factor. While historians tend to agree on Western economic and technological predominance, they disagree as to when the divergence between West and East began and how to explain it.

The historical record of economic growth indicates without any doubt that, historically, European technology and institutions moved from Europe elsewhere until WWII. This diffusion, coupled with continuing advances in the West, constitutes the central dynamic force of modern times [15]. While it is undisputed that Europeans ended up knowing more than non-Europeans, Europeans did by far not invent everything they used. Several authors maintain that, historically, Europeans were better than any other society at adopting and assimilating knowledge and disseminating it as well as transmitting it from one generation to the next. By 1600, for example, Europeans were leading in sailing, making clocks, and pumping water from mines. Along these lines Diamond advocates that "The fate of societies is determined by their adoption of innovations" [6]. Pinker defines culture as "a pool of adopted technical and social innovations" [16] and several authors see the propensity to adopt innovations as a key differentiator among different cultures. *In line with these findings, it can be concluded that innovation (as opposed to invention) and more specifically its adoption is a key factor explaining the unprecedented growth in free-market economies.*

This paper aims at deriving 'organizational' learnings from the free-market system that is associated with extraordinary performance as compared to other economic systems. Further research is therefore focused on economic growth theories viewing innovation as an endogenous driver of growth.

III. Innovation-Based Growth Theories

In this chapter, we review growth theories and micro-economic models where innovation is an explanatory variable of growth. The objective is to derive learnings as to which characteristics of innovation are associated with extraordinary growth in free-market economy. Specifically, we base our findings on theories by Marx and Engels, Schumpeter and Baumol. To account for a wider economic understanding of the role of innovation in economic growth, we complement the micro-economic models by Schumpeter and Baumol with insights from Romer's macro-economic growth model of endogenous innovation. Romer is a prominent proponent of New Growth Theory and views knowledge as the main driver of growth.

A. Marx and Engels

Conventional understanding of economic growth in the 19th century was deterministic. In "An Essay on the Principle of Population" [17] Malthus discusses his 'theory of economic growth'. He states that "population, when unchecked, (increases) in a geometrical ratio, and subsistence for man in an arithmetical ratio" [17]. Such an evolution inevitably results in poverty, as population grows much faster than production. This inevitability theory was the standard explanation of poverty offered in the 19th century.

Marx and Engels opposed Malthus' growth theory and maintained that it underestimates production increase. They were among the earliest scientists to write about the unprecedented growth of capitalism and underlined the importance of innovation to boost production growth. "The bourgeoisie (i.e. capitalism), during its rule of scarce one hundred years, has created more massive and more colossal productive forces than have all preceding generations together" [18]. The main sources of growth are related to "constantly revolutionizing the instruments of production" [18]. Innovation thus becomes an explanatory variable of growth. This clearly contrasts with Malthus' perspective where means of production were kept unaltered. However, while Marx and Engels emphasized that the capitalist system was particularly apt at creating growth through innovation, they also highlighted that the very same system was prone to recurrent crises. The capitalist "society that has conjured up such gigantic means of production and of exchange, is like the sorcerer, who is no longer able to control the powers of the nether world whom he has called up by his spells" [18].

B. Schumpeter

Schumpeter is best known for his original economic concepts, such as 'creative destruction', 'routinization of innovation', and the role of the 'entrepreneur' in innovation management. Witt mentions, that "(d)espite the enormous prominence of the work of Joseph A. Schumpeter in terms of citations there is nothing like a Schumpeterian school in economics" [18]. His ideas, even though very influential, remain eclectic and thus tend to be integrated in often rather contradictory theories.

Some researchers (among others [20], [21], [22], [23], [24], [19]) divide Schumpeter's contribution to innovation theory into an 'early' and a 'late' theory – also referred to as Schumpeter I and II. They maintain that these theories - as dealt with in "The Theory of Economic Development" [30] (first published in German in 1911) and in "Capitalism, Socialism and Democracy" [25] (first published in 1942) respectively - reflect different economic visions.

In line with scientists such as Langlois [26], and Becker & Knudsen [27], we adopt the view that Schumpeter I and II stress two aspects of the same theory (for a detailed discussion of this issue refer to [26]). The former theory focuses on entrepreneurs (i.e. the independent innovator), the latter underlines the rising importance of routinized innovation activities. Schumpeter II does, however, not negate the contribution of entrepreneurs. The difference between the early and the late theory reflects the effects of progressive rationalization on innovation management. This concept refers to the fact that understanding of innovation activities advances in time. This allows for activities to be progressively rationalized and routinized. Large corporations take over an increasing number of innovation activities formerly executed by entrepreneurs. This reflects historical evolution of capitalism with its rise of large corporations that Schumpeter was able to observe especially during his research years at Harvard University (1932 – 1950), where he published "Capitalism, Socialism and Democracy" in 1942.

1) Specialization in Innovation activities

Schumpeter, whose theories on innovation regained great popularity in the last 20 years, views capitalism as an "engine of growth" [28] based on innovation. He maintains that there are two sources of innovation: (i) the entrepreneur: "Unternehmergeist" as he is called in the original German edition and (ii) large corporations. The entrepreneur is the "*independent innovator*, (…) the bold and imaginative deviator from established business patterns and practices, who constantly seeks the opportunity to introduce new products and new procedures, to invade new markets, and to create new organizational forms" [29]. Large corporations are dealing with innovation activities that are routinized. This means activities can be "planned" and "calculated" and thus executed by "trained specialists" [25] following known and pre-determined standard procedures. This division of labor between entrepreneurs and large corporations is based on specialization. All innovation activities requiring some "flash of genius" [25] are assigned to entrepreneurs, as this "flash of genius" cannot be seized in a routine and thus implemented by large corporations. Organizations deal with routinized innovation activities aiming at efficiency in producing a predictable stream of innovation output. Schumpeter describes the division of labor between entrepreneurs and large corporations as follows: "(c)arrying out a new plan and acting according to a customary one are things as different as making a road and working along it" [30]. Both types of activities are interrelated and imply different types of knowledge and capabilities. Thus entrepreneurs generate radically new innovations which form the basis of routine innovations executed in large corporations. Capitalism, through routinization of innovation, "can stamp out innovation with all the efficiency that it brings to bear on stamping out mass-produced goods" [26].

⇒ *Finding 1: Specialization in innovation activities is associated with division of labor between entrepreneurs and large corporations. The former for radical innovation, the latter for routinized innovation.*

2) Self-transforming innovation system

Schumpeter opposes "classical" economic theories as promoted by e.g. Walras – even though Schumpeter was a great admirer of Walras [26] - that are based on static, equilibrium-based models where the sources of economic change are exogenous. He considered it to be "his mission to provide a theoretical approach that could account for the features of a self-transforming system, based on its internal dynamics rather than seeking change through external changes or stimuli" [19]. Schumpeter distinguishes between 'development' and 'growth'. As Becker et al. [31] write, the former is associated with more fundamental discontinuous changes and the latter with incremental innovation. This distinction reflects the division of labor between entrepreneurs and corporations mentioned above. Schumpeter is concerned with viewing both types of innovation as being interrelated and underlines that they are both necessary for economic growth. They are part of a self-transforming system where innovation is an endogenous factor. "Development (is defined as) a change from one vector norm to another in such a way that it cannot be decomposed into infinitesimal steps" [31] and incremental changes are improvements along the same vector norm. Development is related to what Schumpeter calls "novelty", knowledge that is qualitatively new to the system. Incremental changes capitalize on knowledge that is already in the system and exploit its innovation potential. It is particularly this exploitation of available knowledge according to pre-determined routines that represents the engine of capitalist growth. Generally speaking, routine innovation activity makes an important contribution to economic growth.

⇒ *Finding 2: Routine innovation activities drive growth.*

3) Progressive rationalization

More and more innovation activities are increasingly routinized. They are seized in a routine and become bureaucratically controlled. This is what Schumpeter calls "routinization of innovation" [25]. "(P)rogressive rationalization of economic activity" [30] is the underlying mechanism driving routinization. It is a concept based on Weber's theory of progressive rationalization [32]. "For Weber, rationalization is "the disenchantment of the world", that is, the disappearance of the supernatural and the metaphysical in favor of a hard-headed concern with the here-and-now" [26]. It is a process whereby innovation activity becomes increasingly rule-governed in order to better meet the requirements of the particular economic situation faced by the firm. The "flash of genius" - which was originally thought to be the sole source of innovation - is progressively replaced by bureaucratically controlled processes generating innovation. Intuition is gradually replaced by routines. Uncertainty is replaced by plans and predictability. "Because the unknown can be increasingly calculated rationally, the "extra-logical" function of the entrepreneur becomes increasingly unnecessary, and so the importance of the entrepreneurial type must diminish" [26]. However, the entrepreneur doesn't lose his importance for innovation generation completely. He remains important for innovation activity that cannot be seized in a routine. Rationalization of innovation activities and as a consequence also routinization of the corresponding activities is thus a dynamic concept. It covers an increasing number of innovation activities as time passes by.

⇒ *Finding 3: "Progressive rationalization" of innovation activities is consistent with progressive routinization.*

⇒ *Finding 4: Degrees of routinization of innovation activities tend to increase over time.*

4) Degrees of routinization

Specialization in innovation activities leads to division of labor: "entrepreneurs" generating "novelty" and "large organizations" dealing with "routine innovation". However, there is no strict dichotomy between the two types of innovation, as the transition between the two extremes is continuous. Most innovation activities are positioned somewhere between routine and non-routine behaviour. Schumpeter's process of "progressive rationalization" implying a progressive routinization of innovation activities means that the degree of routinization of innovation activities tends to increase in time. Taking this progressive evolution of innovation activity into account is essential for understanding the concept of routinization. It is thus misleading to talk about routine versus non-routine activities as most activities are at least a bit routinized and always require some non-routinized behaviour from the people executing them. Winter mentions in his neo-Schumpeterian theory of the firm: "(t)here is (…) a quite continuous gradation from highly routine behavior to highly innovative behavior" [33]. In this paper it is understood that when we write about routinized and non-routinized activities, we refer to highly-routinized (i.e. with a high degree of routinization) and "poorly"-routinized (i.e. with a low degree of routinization) activities respectively.

The individual employee executing a routinized activity retains some element of discretion. He has to make decisions while following established patterns of behavior. He thus introduces small variations into the system. "(O)nly small variations at the margins, such as every individual can accomplish by adapting himself, to changes in his economic environment, without materially deviating from familiar lines" [30] are possible while executing routinized activities. People executing these activities are called "mere managers" [33], "bureaucrats" [34] and employees of "large corporations" [25]. "As Schumpeter points out, there is not much of fundamental economic interest in the distinction between such managers (bureaucrats) and the people whose activities they direct" [33]. They are contrasted with the "entrepreneur", the leader who guides the firm to novelty, radically new innovation areas.

⇒ *Finding 5: There is a continuum from highly routinized to highly innovative behavior.*

C. Baumol

Baumol ([7], [28], [39], [35]) attempts to explain the extraordinary growth of capitalist economies with a micro-economic theory strongly influenced by Schumpeter. From the perspective adopted in this paper, Baumol's main contribution is the more specific discussion of the "capitalist innovation machine" and the related concept of routinization of innovation.

1) Competitive innovation arms race

The main source of economic growth of free-market economies is their ability to generate continuous flows of innovations. "(W)hat differentiates the prototype capitalist economy most sharply from all other economic systems is free-market pressures that force firms into a continuing process of innovation, *because it becomes a matter of life and death for many of them*" [7]. Firms are dragged into a "competitive innovation arms race" [35], where none wants to lag behind. Baumol considers this element the most important attribute leading to economic growth. Large and growing resources are allocated to innovation activities in firms. This pushes understanding and thus routinization of innovation activities. Entrepreneurs (used in the Schumpeterian sense) lose some of their importance to large corporations as innovation increasingly becomes a routine. However, both entrepreneurs and large corporations remain important for growth. They are "complementary rather rivalarous. More than that, there is a tendency toward serendipity between the two, with each facilitating and supplementing the work of the other" [34]. Entrepreneurs are specializing in "radical departures from then-current products and processes (…), the big novel idea, the unprecedented way of thinking, the heterodox approach". Firms specializing in routine innovations "transform the breakthrough models into more easily usable, more powerful and more marketable products, raising them from infancy into mature products with substantial markets and massive outputs". The global result has been "superadditive, with the total contribution to the economy's productive powers greater than the sum of the contributions for which each was individually responsible" [34]. However, the incremental contributions of routinized innovation activities outperform the growth contribution of the original breakthrough ideas.

⇒ *Finding 6: A "competitive innovation arms race" drives routinization of innovation and thus economic growth.*

D. Romer

Romer presents a new macro-economic theory of growth known as "endogenous growth". He stresses the crucial role that knowledge and ideas play in driving growth. His model underlines the importance of combinatorial innovation in creating an almost unlimited potential for economic growth. "On any conceivable horizon – I'll say until about 5 billion years from now, when the sun explodes – we're not going to run out of discoveries. (…) There is (thus) absolutely no reason why we cannot have persistent growth as far into the future as you can imagine" [36].

1) Combinatorial innovations

Romer compares ideas with kitchen recipes. "To create valuable final products, we mix inexpensive ingredients together according to a recipe" [37]. Ideas create growth when resources are mixed according to a new recipe so that the output is more valuable. "Human history teaches us (…) that economic growth springs from better recipes, not just from more cooking" [37]. The quality of the recipe is the main source of value and thus of growth. Already Schumpeter referred to the possibility of "new combinations of productive means" [30].

⇒ *Finding 7: Ideas are often combinatorial innovations creating value.*

2) Combinatorial explosion

The potential for finding new ideas is almost unlimited as "the possibilities (to combine ingredients into new recipes) do not merely add up; they multiply" [37]. The resulting growth potential is exponential. Romer states that this vast area of combinatorial exploration is in general underestimated and so is the potential outcome. Just as nature was able to create in millions of years through trial and error the multitude of species, thus should combinatorial innovation allow forever newer and more different ideas to be developed. Also the scarcity of resources – an important limitation of "traditional growth theories" based on producing more in order to grow – is essentially overcome as ideas are neither a conventional good nor a public good; it is a non-rival, partially excludable good" [38]. They can be shared by everybody at the same time without there being unpleasant side effects related to the tragedy of the commons. There is thus no good reason why economic growth should be limited in the future.

⇒ *Finding 8: Combinatorial explosion of ideas is an important source of growth.*

3) Importance of small innovations

"(M)any small applied ideas (were) needed to transform basic ideas such as the transistor or web search into valuable products and services" [37]. These recipes (i.e. ideas) also reduce costs due to the fact that everybody can integrate transistors into their recipe. Parallel development of ideas may offer economies of scale and scope. It also greatly improves the value offered to customers. This is what Kuhn [39] describes as problem solving. In his model these activities follow revolutions and are based on paradigms, basic assumptions that are no more questioned. These paradigms thus ensure efficiency.

⇒ *Finding 9: Small innovations are significantly contributing to economic growth by ensuring efficient innovation activities.*

This paper started by asking the question "What is the driver of the extraordinary growth of free-market economies?" The findings can now be applied in business organizations to create above-average growth in the mid- and long-term. The holistic approach to organizational design discussed in the paper entitled "Innovation Factory and Innovation Atelier. Business Design for 'Routinized Innovation'" [1] (also presented at the ICMIT 2008) is based on the concept of routine innovation activities developed in this paper.

References

[1] W. Deplazes, U. Deplazes & R. Boutellier, *Innovation Factory and Innovation Atelier. Business Design for 'Routinized Innovation'*. Proceedings ICMIT 2008.

[2] C. M. Christensen & M. E. Raynor, *The Innovator's solution. Creating and sustaining successful growth*. Harvard Business School Publishing Corporation, Boston, MA, 2003, p. 7.

[3] J. Devan, M. Klusas & T. Ruefli, The Elusive Goal of Corporate Outperformance, *The McKinsey Quarterly*, web exclusive, April 2007. Available: www.mckinseyquarterly.com

[4] M. Hamori & P. Capelli, "*Work-based Organizational Routines and Franchise Operations*", Wharton School Working Paper, 2005.

[5] J. Diamond, *Guns, Germs and Steel: A Short History of Everybody for the Last 13,000 Years*, Vintage, London, 1998.

[6] D. S. Landes, *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor*, Abacus, London, 2002.

[7] W. J. Baumol, *The Free-Market Innovation Machine. Analyzing the Growth Miracle of Capitalism*, Princeton University Press, Princeton and Oxford, 2004.

[8] R. Boutellier, *Discovering Entrepreneurship: Technology and Innovation*, Lecture slides, slide 31648e. Available: http://www.tmu.ethz.ch/education/lectures/previous/ss07/discoveringentrepreneurship/Vorlesung4
[9] W. M. Cox & J. Koo, *China : Awakening Giant*, Sept 2003. Available: http://www.dallasfed.org/research/pubs/china.pdf
[10] E. L. Jones, *The European Miracle: Environments, Economies, and Geopolitics in the History of Europe and Asia*, Cambridge University Press, Cambridge (UK) & New York, 1981.
[11] M. Olson, *Rise and Decline of Nations:Economic Growth, Stagflation, and Social Rigidities*, Courier, Yale University, 1982.
[12] N. Rosenberg and L. E. Birdzell, Jr., *How the West Grew Rich: The Eonomic Transformation of the Industrial World*, Basic Books, New York, 1986.
[13] C. Kindleberger (1996), *World Economic Primacy: 1500-1990*, Oxford University Press, New York, 1996.
[14] T. Sowell, *Conquests and Cultures: An International History*, Basic Books, New York, 1998.
[15] J. Mokyr, "Eurocentricity Triumphant", *The American Historical Review*, 104 (4), pp. 1241-1246, 1999. Available: http://www.riseofthewest.net/thinkers/landes05.htm#start
[16] S. Pinker, *The Blank Slate. The Modern Denial of Human Nature*, Penguin, London, 2002.
[17] Th. Malthus, *An Essay on the Principle of Population*, London, 1798. Available: http://www.ac.wwu.edu/~stephan/malthus/malthus.0.html
[18] F. Engels and K. Marx: *The Communist Manifesto*, 1888. Available: http://www.gutenberg.org/etext/61
[19] U. Witt, "How Evolutionary is Schumpeter's Theory of Economic Development?", *Industry and Innovation*, 9 (1/2), pp. 7-22, 2002.
[20] M. L. Tushman & R. R. Nelson, "Introduction: Technology, Organizations, and Innovation", *Administrative Science Quarterly*, 35, pp. 1-8, 1990.
[21] A. Phillips, *Technology and Market Structure: A Study of the Aircraft Industry*, D. C. Heath, Lexington MA, 1971.
[22] C. Freeman, *The Economics of Industrial Innovation*, MIT Press, Cambridge, 1982.
[23] R. R. Nelson, *The Moon and the Ghetto*, Norton, New York, 1977.
[24] B. H. Klein, *Dynamic Economics*, Harvard University Press, Cambridge, 1977.
[25] J. A. Schumpeter, *Capitalism, Socialism and Democracy*, Harper & Row, New York, 1950.
[26] R. N. Langlois, *The Dynamics of Industrial Capitalism. Schumpeter, Chandler, and The New Economy*, Routledge, London & New York, 2007. Available: http://web.uconn.edu/ciom/Graz.pdf
[27] M. C. Becker & Th. Knudsen, "The Entrepreneur at a Crucial Juncture in Schumpeter's Work: Schumpeter's 1928 Handbook Entry Entrepreneur", *Advances in Austrian Economics*, 6, pp. 199-234, 2003.
[28] W. J. Baumol, *Entrepreneurship, Management and Structure of Payoffs*, MIT Press, Cambridge MA, 1993.
[29] W. J. Baumol, *Entrepreneurship, Innovation and Growth: The David-Goliath Symbiosis*, Presentation at New York University, 2002. Available: http://www.econ.nyu.edu/user/baumolw/sfg.pdf
[30] J. A. Schumpeter, *The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, Harvard University Press, Cambridge MA, 1955.
[31] J. A. Schumpeter, "Development", *Journal of Economic Literature*, XLIII, pp. 108-120.
[32] M. Weber, *The Theory of Social and Economic Organization*, Oxford University Press, New York, 1947.
[33] S. G. Winter, "*Toward a neo-Schumpeterian theory of the firm*", Industrial and Corporate Change, 15 (1), pp. 125-141, 2006.
[34] W. J. Baumol, "On Entrepreneurship, Growth and Rent-Seeking: Henry George Updated", *American Economist*, March 22, 2004.
[35] W. J. Baumol, *"Towards Microeconomics of Innovation: Growth Engine Hallmark of Market Economics"*, Presentation at New York and Princeton University, 2004. Available: http://www.iaes.org/journal/aej/march_02/baumol.pdf
[36] R. Bailey, "Post-Scarcity Prophet. Economist Paul Romer on growth, technological change, and an unlimited human future.", *Reason Science*, Dec, 2001. Available: http://www.reason.com/news/show/28243.html
[37] P. M. Romer, *Economic Growth*, in: the Concise Encyclopedia of Economics, D. R. Henderson, 2007. Available: http://www.stanford.edu/~promer/EconomicGrowth.pdf
[38] P. M. Romer, "Endogenous Technological Change", *Journal of Political Economy*, 98 (5), pp. 71-102, 1990.
[39] T. Kuhn, "*The Structure of Scientific Revolutions*", University of Chicago Press, Chicago, 1970.

12.5 Model of Technology Foresight

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Model of Technology Foresight: An innovative Approach

Roman Boutellier, Ursula Deplazes, Karin Löffler

Abstract—**Companies are looking for Technology Foresight (TF) models to focus strategy and innovation management. This paper establishes an "implementation" gap in TF practices based on empirical research in multinational companies in Europe and Japan. The "implementation" gap refers to the neglected use of TF results in strategy and innovation management. Thus the paper suggests a TF model focusing on guiding ideas for a structured approach to eliminate this "implementation" gap. Concepts of "backcasting", "functionalities" and "bottleneck technologies" are introduced to set priorities in the foresight process.**

Index Terms—**Technology foresight; technology management; strategy management; innovation management; back casting; functionalities; bottleneck technologies.**

I. Introduction

STRATEGIC relevance of TF systems is widely accepted by business organizations as TF contributes to reducing uncertainty in managerial decisions. However, few have adopted a structured approach to TF. Explorative research conducted over the last three years shows that only about a fourth of the multinational companies considered have some kind of structure in their TF system. Most companies apply an unstructured and often intuitive approach to TF because of a lack in appropriate procedures. In this paper, we would like to determine which TF procedures are not available to practitioners and suggest some solutions. Thus, in part II empirical research is undertaken to determine the needs of practitioners. First, explorative research referring to 40 interviews in multinational companies based in Europe and Japan provides some needs expressed by the companies. These findings are then verified based on 10 case-studies from literature. The paper focuses on one main need of organizations and offers in section III a model to meet this need. The model is illustrated with the example "SmartStation" of Leica Geosystems AG.

The paper contributes to covering the gap in TF practice and literature referring to making systematic use of TF results for strategy and innovation management.

The main findings of our studies point to a "flexibility" and an "implementation" gap. The "flexibility" gap refers to a lack of structured approaches to take unpredicted changes into account within the TF system. As this problem is approached in literature by the concept of "wild cards" [1], [2], the paper focuses on the "implementation" gap. This gap leads to the companies not using their TF results in a systematic way and thus actually not capitalizing on their investments in TF systems. Eliminating this gap is essential for improving the effectivity of TF systems. The paper offers hints for managers on how to implement TF systems.

The paper contributes to covering the gap in TF practice and literature referring to making systematic use of TF results for strategy and innovation management.

II. Background on Technology Foresight

The aim of this section is to establish the main needs of practitioners regarding TF. An approach in two phases is adopted. First the main quality criteria that have to be met by TF systems used in organizations are determined. This is done based on a classification of TF systems in three generations. Then, in a second step, empirical evidence based on interviews is analyzed to assess some aspects of TF practices in firms. The results are compared to the quality criteria of good TF systems and gaps in TF practice are determined. Then the results are validated with an analysis of TF practices from literature. The main gaps in TF practices are established and a solution will be suggested in section III of this paper.

A. Concept of Technology Foresight

Literature on TF may roughly be divided into two main groups: (i) literature on national and industry programs and (ii) research on TF in firms. (i) National and industry approaches to TF have been amply documented (see: [3], [4], [5], [6] to state a few). "During the early 1990s, technology foresight has become much more widespread. First pioneered in the United States (since the 1950s) and later in Japan (since the 1970s), it has then spread to Continental Europe. One of the first engagements in modern national foresight (in Europe) occurred in the Netherlands" [4]. (ii) Scientific research on TF in firms has assumed a more important role as globalization intensified and environments became more dynamic. Literature focuses on issues such as: models and methods of

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R. Boutellier, Prof Dr, is Professor for Technology and Innovation Management, Chair of Technology and Innovation Management at The Swiss Federal Institute of Technology (ETH) in Zurich.

U. Deplazes, MSc. LSE, MSc. HEC, HLH, is an IEEE member, PhD student and researcher at the Department of Management, Technology and Economics, member of Prof. Boutellier's team in Technology and Innovation Management at The Swiss Federal Institute of Technology (ETH) in Zurich (e-mail: kloeffler@ethz.ch) (e-mail: udeplazes@ethz.ch).

K. Löffler, MSc. E&M, is a PhD student and researcher at the Department of Management, Technology and Economics, member of Prof. Boutellier's team in Technology and Innovation Management at The Swiss Federal Institute of Technology (ETH) in Zurich (e-mail: kloeffler@ethz.ch).

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TF (such as [7], [8], [9], [10], [11]), best practices and empirical studies (such as [12], [13]). This paper deals with the second group, specifically, TF applied in firms.

Reger [7] gives an overview of the concept of TF as it is applied in firms (Fig. 1). His main statement is that there have been in the past fifty years "fundamental changes in the definition and understanding of the technology foresight process itself" [7]. Based on these changes he determines three generations of TF. In the first generation, around the 1960s, TF was an isolated task within organizations focusing on data gathering and analysis. It consisted of forecasting tools based on trend extrapolation and prediction. In the 1970s and 1980s, the second generation, TF remained a forecasting activity focused on technology data. It remained technology-driven and was executed by isolated, specialized foresight units such as corporate staff functions. Thus, the first two generations were very similar with respect to their strong focus on technology-driven forecasting activities where predicting was more important than foresight. Most of these activities remained isolated within the corporation.

From the 1990s onwards, a new trend manifested itself and gave rise to the third generation of foresight activities. TF became an integral part of strategic management and of decision-making at all managerial levels. It is now need- and value-driven and monitors technology evolution not only in its narrow sense but in a wider context, e.g. economic, social, environmental and legal trends, potentially relevant to technology evolution.

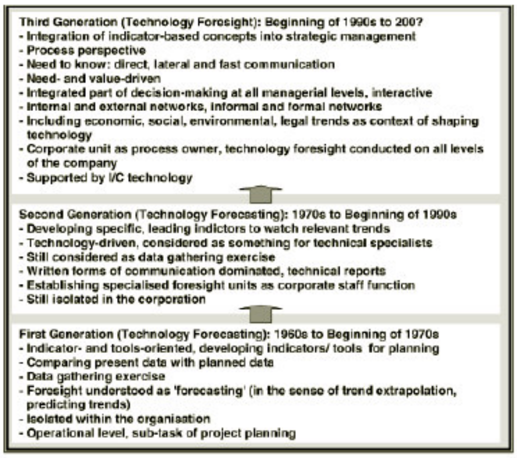

Fig. 1 Three generations of TF [7]

In this paper the third generation of TF is dealt with. Thus, the model suggested in section B. is based on foresight activities being an integral part of strategy and future-oriented innovation systems. Foresight is on the one hand guided by strategy and innovation goals, on the other hand it provides important inputs for the formulation of strategy and innovation programs. This reciprocal relationship manifests itself for instance when discontinuous innovation areas are discovered in foresight activities: The mini-computer disrupted mainframes in computer hardware industry and lead to a redefinition of many strategy and innovation objectives.

The perspectives of our model are future needs of our future customers. Prahalad and Hamel [14] underline the positive impact of this view on the firm's ability to vision its future and create new markets. This future value orientation conditions the appropriate actions to be taken in the present. Thus TF should provide areas of broad future technology trends and of future customer needs and then determine appropriate actions to be implemented by the organization to meet these trends. Foresight fosters a proactive culture in the organization and helps business organizations to shape their future. Thus, there are two broad phases in the FT-process. The first phase, determining future trends, involves monitoring the wide context of future scenarios having the potential of influencing the customer needs. This context might include for instance legal, technological and social trends that from a current perspective are relevant to future customers of the firm. For instance, the automobile industry, for a long time concerned with power and safety, materials and design, faced in the 1980s the challenge to detect a future new trend toward ecologically friendly automobiles. This new trend had some precursors in general social movements toward a more responsible relationship with our ecological environment. For instance, building houses with energy-saving heating systems was an early trend in Europe already before the 1980s. This could have been a hint for managers in the automobile industry that ecologically relevant issues were becoming more important to customers. Thus customers would most likely show an ecological attitude also toward their cars at some point in the future. Foresight of this trend in the 1980s allowed companies to have the time to develop new technologies to meet the future needs of their customers.

Based on literature review, four quality criteria of TF systems are retained for this paper:

--Integration in strategy and innovation management,

--A proactive perspective aiming at shaping the future of the organization,

--Future customer need orientation,

--Flexibility to adapt to unpredicted events.

B. *Empirical Evidence*

Having established the quality criteria of a good TF model, TF practice is analyzed in section B. The objective is to determine the needs of practitioners with respect to TF. First, an exploitative empirical study based on 40 informal interviews, each in a different multinational organization, is presented and then validated with case-studies from literature. The results point to shortcomings of today's TF practice. These shortcomings indicate challenges business organizations are facing today with respect to TF. The model suggested in section III of the paper will provide an approach how to meet these challenges.

1) Objective of empirical study: The aim of this empirical study is to determine the main needs of organizations regarding TF by assessing the extent to which our quality criteria of foresight approaches are met. This extent will be expressed in two states: "structured" and "unstructured" approaches. The "structured" approach being the more elaborate implementation of the quality criteria.

2) Structured and unstructured approaches: The two approaches "structured" and "unstructured" refer to the way in which important elements of the TF system are implemented. We define an approach as "structured", if there is, on the one hand, a specific procedure with a corresponding responsibility for implementing the TF system. On the other hand, there has to be a clear assessment of the outcomes of the implementation. The term "structured" approach in this context refers thus to "disciplined imagination" according to Szulanski and Amin [15]. Intuitive approaches belong to the group of "unstructured approaches". All companies in our sample of empirical studies try to develop a TF system with a structured approach. This does not imply that all companies should adopt a structured approach to TF. In this paper the issue which companies should adopt a structured approach is not dealt with, except for the general statement that multinational companies with business in dynamic environments are likely to profit from a structured TF process.

3) Research methodology: Research conducted in this section is inductive based on a qualitative case study approach with multiple sources of empirical evidence. There are two steps in the research process: (i) exploitative research based on 40 semi-structured interviews and (ii) validation of these findings based on case-studies from literature.

In the first phase of our empirical research, 40 semi-structured interviews were conducted with multinational companies headquartered in Europe (some of them in Switzerland) and in Japan. Focus of the interviews was TF practices and experiences of the organizations with their foresight systems. The companies represent a broad variety of industries such as machinery, manufacturing, electronics & semiconductors, medical technology, automotive, process industry and consumer goods. The interviewed partners were heads of R&D, of technology management or of corporate development.

In the second phase of our empirical research, findings from the first phase are complemented by 10 foresight cases from literature ([16], [17], [18], [19]). These case studies refer to organizations with focus on manufacturing, electronics, automotive, petrol and telecommunications. In this paper the multinational corporation Siemens is chosen as an illustration of a company with a structured approach to TF. Siemens is a company with an advanced TF system having gained significant experience in the TF area. Nevertheless, there are still important gaps in Siemens' TF approach.

4) Quality criteria of TF: Quality criteria of TF are the benchmark for the analysis of our empirical data. Procedures considered by the company as TF will thus be measured against the quality criteria of a good TF system. As mentioned above in section IIA. TF models should satisfy the requirements of third generation foresight models according to Reger [7]. The following criteria are considered in this paper: (i) integration into strategy and innovation management; (ii) proactive perspective aiming at shaping the future of the organization; (iii) future customer need orientation, and (iv) flexibility to adapt to unpredicted changes. Each of these criteria is measured as follows:

i The first criterion "integration in strategy and innovation management" refers to TF as an integral part of "decision-making at all managerial levels and as a core activity for corporate strategy formulation" [7]. This criterion is thus assessed with two indicators: (i) the existence of some kind of link between the TF system and corporate strategy formulation. If there is a link, the type of approach ("structured" or "unstructured") creating this link is determined; (ii) the combination of bottom-up and top-down procedures referring to TF as a mix of top management goals and ideas created on the lower employee level.

ii The proactive perspective measures whether actions result from TF efforts and if so, what type of approach leads to actions.

iii Future customer need orientation is assessed by whether or not foresight addresses the issue of future customers and their future needs. If future customer needs are considered, it will be determined whether a "structured" or an "unstructured" approach leads to these needs. In order to determine the future customer needs a wide context orientation is required. This is another indicator considered in the analysis of the 40 interviews.

iv Strategic flexibility [20] is measured by the ability of a system to integrate surprises. Thus effective TF systems must be flexible in order to adapt to unforeseeable happenings. It will be determined if the adaptation follows a "structured" or "unstructured" approach.

5) Findings of interview-based research: This section presents the findings of the first phase of empirical research. Specifically, the analysis of 40 multinational companies based on interviews. The analysis refers to the quality criteria of good TF models established above. If they meet the set criteria the type of approach ("structured" or "unstructured") will be determined. The specific findings of the interview-based research are summarized in Figure 2.

Generally speaking, relatively few companies adopt a structured approach to at least some of the measured aspects of TF. This is shown in the low numbers figuring in the "Structured Approach" column. The main reasons stated by the companies are: (i) appropriate foresight procedures are not available and (ii) structure kills creativity. This paper would like to offer a model based on a simplified approach to TF and thus suggest suitable foresight procedures for practitioners.

	Quality Criteria of Technology Foresight	Structured Approach	Unstructured Approach
Integration in Strategy & Innovation Management	Link between strategy formulation and TF	10	6
	Combination of bottom-up and top-down procedures	5	16
Proactive Perspec-tive	Practical actions based on FT results	0	11
Orientation	Future customer need orientation	10	16
	Wide context orientation	8	7
Flexi-bility	Measures to adapt to unpredicted changes	0	11

Fig. 2: Results of empirical study based on 40 interviews

95% of companies interviewed have some kind of foresight approach. However, not a single company has a TF system that meets all our quality criteria. The two main gaps are flexibility and implementation requirements. One of the important reasons is the unavailability of appropriate structured procedures. Thus intuition often supplants this lack of procedures. However, there are flexible foresight models integrating surprises as "wild cards" [1], [2]. Even though these foresight models have their limitations, they offer a structured approach to fill the flexibility gap. This paper thus focuses on the second established gap, the implementation gap in TF practices.

6) Comparison with case-studies from literature: The main finding of the interview-based research, the missing implementation, is supported by 10 case-studies from literature. In this paper only Siemens is presented in more detail, as it is a company with a sophisticated approach to TF.

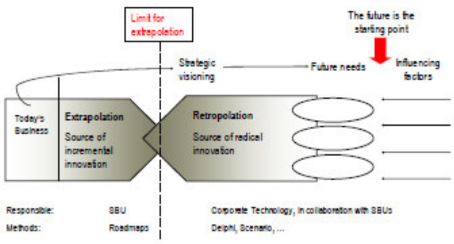

Fig. 3: Strategic foresight process (based on [22])

The foresight system of the Siemens organization has been widely dealt with in literature [16], [21], [18], [19], [22]. The corporate technology unit of Siemens played a central role in developing the system. Figure 3 provides an overview of the overall foresight process.

The main idea of the system is to combine extrapolation of current situations with what the company calls "retropolation" based on future needs of the customers. Extrapolation is based on roadmaps and is a source of incremental innovation. Extrapolation is done by the strategic business units and follows well-known and widely adopted procedures. "Retropolation" is a Siemens-specific concept. The starting point is strategic visioning aiming at determining possible future scenarios. This procedure is in use at Siemens since 1990. To communicate their visions of the future and innovation topics to customers and partners, Siemens publishes the Journal "Pictures of the Future" [21], [19], [16]. Based on the possible future scenarios, future customer needs are determined. The time horizon of this visioning process is three to seven years depending on the industry. Based on future states and future customer needs the company determines "innovation aims".

Retropolation takes place on the basis of scenarios and is supposed to lead from future needs to actions to be taken by the company. This is the critical link determining the proactive dimension of TF. Unfortunately, information on how retropolation is actually implemented is unavailable as the company does not make it public. It is suspected that in many organizations retropolation only exists as a concept that is not yet ready for implementation. Whatever the truth, Siemens and all the other case-studies of our research support the main finding of the interview-based research: There is an implementation gap in TF practice.

Empirical research based on interviews and case-studies from literature shows that there is a multitude of TF practices. However, all structured approaches to TF had at least one main gap in common: the implementation gap. Literature underlines the implementation gap of foresight approaches [23], [24], [25], [14], [15]. Thus there is a need to better make use of future planning and technology foresight results. In this paper a TF framework is defined offering a systematic approach to guiding practitioners in establishing an institutionalized TF process in their companies. We focus on the core idea of the model, namely the "backcasting" phase (which fulfills the same objective as "retropolation" at Siemens). The paper will suggest to focus on "bottleneck technologies" (a concept introduced in section III.A) to set priorities in the "backcasting" process.

III. Proactive Technology Foresight

In this section a model of TF is presented focusing on innovation actions resulting from TF findings. Thus priority is given to a systematic process linking determined areas of future customer needs to specific actions enabling the company to shape its future and remain flexible to meet unpredicted happenings. In order to simplify the process efforts are focused on bottleneck technologies, that limit the company's capabilities to meet future customer needs. The model thus covers the "implementation" gap established in section II.

As stated above, the TF model suggested in this section belongs to the third generation category (see: [7]) in section II.A) of foresight models used in companies. It abides the quality criteria stated in section II.B. The model is based on two general phases. Specifically, (i) foresight activities determining future areas of customer needs and (ii) "backcasting" where actions are determined based on the future customer needs. As TF literature deals extensively with foresight methods and processes belonging to the first phase (see for instance: [26], [27], [28]), we focus on the second phase. The generic method for the second phase is called 'backcasting' [29]. The method has its origin in energy policy in the 1970s [30] and can be represented as a chain scenario in reverse [25]. The aim of backcasting is to relate future states to the present with focus on how desirable future situations can be attained. The starting point is a desired or possible outcome. From this point the backcaster works backwards in time to determine what events should take place in order to reach the desired future state. The steps how to reach the desired states do not follow a formal plan. Instead, Costanzo describes them a "probing and learning process" [23]. The institution can deduce which actions are required to enact the desired future [31]. Backcasting is wellknown in project scheduling and operations research. For instance scheduling methods such as CriticalPathMethod and PERT planning apply this approach [24]. Although backcasting is used in various contexts [25], a methodology applicable for practical innovation planning in companies is missing. In this research work, we apply elements of the method described and extend it to meet the specific needs of an innovation planning project.

A. The Model "Innovation Backcasting"

With the model of "innovation backcasting" we provide a structure for systematically deducing possible innovation steps, covering future customer needs with possible innovation activities.

The backcasting approach is applied according to Robinson [29], and modified according to company requirements. Important elements of the model are the links between customer needs, functionalities and technologies, and bottlenecks in the system. Having defined desired future states, the method starts with searching for a logical sequence of possible realizations of these customer needs in functionalities. The functionalities are analyzed according to their role in context and differentiated according to primary, secondary and support functionalities. Critical bottleneck technologies are identified. After bottleneck analysis, the bottleneck solution process starts on component level, continues on module and finally on system level. Our main idea on the one hand relates future customers' needs to functional requirements and on the other hand focuses on bottleneck technologies.

1) Function and Functionality: Based on future customer needs, functionalities that have to be met by the company in the future are determined. In this section the notions function and functionality are specified capitalizing on schools of product design.

The terms function and functionality are closely related. They refer, generally speaking, to "the benefit" of a product or service that a company offers to its customers. As Chiang, Pennathur and Mital [32] mention in their literature review of functionality in product design and manufacturing, "there is no clear, uniform, objective and widely accepted definition of functionality" [32]. They found three types of representations of functions in design: (i) verb-noun pairs [33], (ii) input-output flow transformation [34] and (iii) transformation between input-output situations and states [35], [36]. This paper describes function and functionality in line with the first group. Specifically, a function is expressed with a verb and some addition (e.g. a noun). Thus the function of for instance a bus would be "to transport passengers to a pre-defined destination". Additionally, [33] develops a function hierarchy based on the importance of the functions. He differentiates between primary and secondary functions. The primary function of sunglasses for example would be "to protect the eyes from the sun". Two of the several secondary functions might be "to be fashionable" and "to resist breaking when falling to the ground".

For the purpose of this research, we introduce an additional type of functionalities: 'support' functionalities. They are defined as being non-core [37] but nevertheless important for the overall innovation ecosystem. An example for a support functionality would be the power supply for notebooks. It is a necessary functionality, but not the core functionality of the notebook. Another example is the disinfection functionality of medical implants. The core functionality is to support the healing process by providing fixation for broken bones, and the support functionality is to prevent inflammation.

2) Bottleneck technologies: Bottleneck technologies are defined as technologies limiting the performance of a system. Examples for recent bottleneck technologies are the battery in hybrid cars or security systems for mobile banking. A characterization of bottleneck technologies has been worked out based on case studies [38].

In existing technology typologies, interdependencies between product modules are neglected. The new perspective, "bottleneck technology", completes the existing typology by considering limitations, trade-offs and coupling.

A bottleneck technology can be an emerging technology [40] and a disruptive technology [41], [42], [43] at the same time. In addition it is not necessarily the core technology in a company. Because bottleneck technologies limit at least one function of a system, they are usually pushed to their limits.

	Classification by..	Definition	Counter-part	Literature
Core	Role in application context	Supporting core functions of a product	Support	Barney (1991)
Critical	Importance, used in industry context	Strategic relevance	uncritical	Popper (2003)
Bottleneck	Role in system context	Limiting at least one function of the system	Non-bottleneck	

Fig. 4: Classification of technologies [37], [38], [39]

B. Illustration of 'Backcasting' methodology - the Leica Geosystems 'SmartStation' Model

Do increasing land prices impact on precision requirements of distance measurement devices? An intuitive answer would be yes, as customers will require more precise measurement results to avoid overpayment. In Figure 5, the measurement device "SmartStation" for determining spatial distances is represented. It is manufactured by the Swiss based company Leica Geosystems AG.

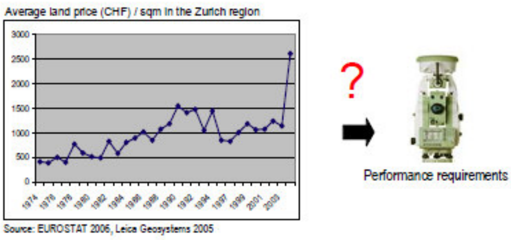

Fig. 5: Challenge of TF

Leica Geosystems AG is a company based in Switzerland belonging to the Hexagon Group (Sweden). It provides technology and service solutions for capturing, analyzing and presenting spatial distances to various industries, such as building construction, mining and aerospace. With more than 2400 employees and being active in dynamic business environments, the company can take advantage from a structured TF approach. In this section the specific case-study "SmartStation" is presented to illustrate the backcasting phase based mainly on bottleneck technologies. This case-study is based on interviews with senior researchers of Leica Geosystems AG.

1) Problem setting: Leica Geosystems AG had been faced with customers asking for convenient, fast and flexible measurement solutions offering consistently high measurement quality. Like the whole industry of spatial measurement solutions, Leica Geosystems AG had for decades only measuring techniques based on theodolites and measurement reference points on the surface of the earth to meet customers' needs. This approach however was time-consuming and lead to, as was generally suspected, inaccurate measurement results.

On the technology side, since the mid 1990s Global Positioning System (GPS) allowed fast, but inaccurate, positioning solutions. Thus Leica Geosystems AG was faced with future customer needs it could not meet, just like any other organization in the same industry. This starting point is comparable to the backcasting phase in TF where, based on future customer needs, actions to be taken by the company to meet these needs have to be determined. Leica Geosystems AG followed an approach intuitively that we would like to systematize. Thus the case study is a good illustration of backcasting in technology management.

The first step in the backcasting procedure is to determine the functionalities that the company has to offer to its customers in the future. The second step is to identify the bottleneck technologies on which innovation management can focus.

2) Bottleneck identification: The idea of combining the traditional measurement devices with a global positioning system (GPS) in order to simplify and accelerate measurement processes is not new. In 1983, a researcher named Stansell predicted, that by the year 2000 conventional systems would be combined with a GPS unit [44], [45]. By the mid-1990s, the GPS system was fully operational with 24 satellites in space, developed for defence purposes at a budget of USD12 billion. Even though there was GPS infrastructure in place in 1997, two major bottlenecks emerged in the search for a combined measurement instrument at Leica Geosystems:

i In the 1990s the bottleneck of GPS positioning purely based on satellites turned out to be the measurement accuracy for civilian use. Viewed form the perspective of Leica Geosystems, this bottleneck is outside of its own strategic scope. a missing co-innovation [46].

ii The second bottleneck was the data transfer between the two modules, the theodolite and the GPS unit. This internal bottleneck functionality is called "transfer data between modules" (see Fig. 7).

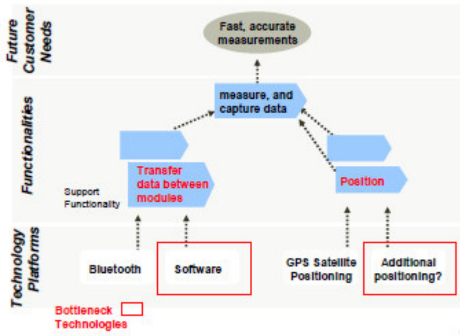

Fig. 6: Backcasting, illustrated with example 'SmartStation', Leica Geosystems [44]

Figure 6 illustrates the backcasting procedure applied to the SmartStation example. The customer need is improved measurement speed and accuracy. Walking backwards in time, the functionality to be provided is determined: 'measure and capture data'. The functionalities are arranged in hierarchy, on top level the functionality: 'measure, and capture data', further detailed in core and support functionalities: 'Position' and 'Transfer data between modules'.

3) Bottleneck solution: The bottleneck solution process covers three levels of analysis: component, module and system level. Thus, solutions for both established bottlenecks mentioned above are looked for on these three levels. Neither bottleneck could be solved on component level nor on module level. The bottleneck 'insufficient measurement accuracy', was solved externally, by including fixed GPS reference points. The 'missing data transfer' could be solved internally. As there were two modules involved, the bottleneck needed to be solved on the system level (see Fig. 7).

i Measurement accuracy of GPS technology from satellite signals only is not sufficient, but GPS technology offers fast measurement in comparison to the theodolite. As positioning signals are provided by the US government the solution is expected to be supported by public agencies. The generic options for problem solving are 'optimize', 'substitute' or 'compensate' [38]. As optimization is not possible due to the given data quality and as substitution of signals is far too expensive, supplementary technologies remain: In Switzerland, a GPS reference station network has been installed with 17 fixed GPS points. Thus, remote improvement is enabled [44]. In Europe, many government agencies now favour this solution as it is more economical than maintaining the old structures on the ground. Leica Geosystems developed reference station software, e.g. enabling RTK (real time kinematic functionality) corrections.

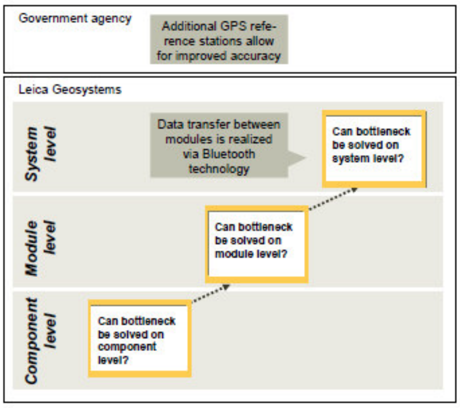

Fig. 7: Bottleneck solution process, example 'SmartStation'

ii Seamless data transfer between the module theodolite and the module GPS required a new software solution and the use of a new transfer protocol. The software solution for analyzing and converting data from the GPS module to be used in the total station had to be developed. In addition, communication protocols, such as GSM, GPRS, TDMA, CDMA or Bluetooth™ wireless connections [44] had to be applied. The bottleneck of data transfer was not solved at module, but at system level by introducing a new software protocol used by the system.

Having both bottlenecks solved in 2004, Leica launched "System 1200", called the 'worlds first universal GPS/TPS surveying system' in the same year [45]. In 2005, the company presented the world's first Total Station with integrated GPS module. The time for positioning and orientation was reduced by 80 %, measurement is done by pressing a single button (Leica 2006).

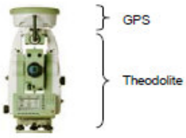

Fig. 8: Leica SmartStation [44]

3) Interpretation of the example SmartStation: The example illustrates how backcasting can bridge the gap between future customer needs and innovation actions in firms. Concerning general foresight, the example shows how the identification of new needs can be triggered by new technologies, such as the GPS. Concerning the focus of our research, the backcasting stage, the example points out major aspects of the backcasting approach:

i Identify future needs of customers.

ii Evaluate possible general solutions including alternatives for these needs.

iii Set priorities in technology planning by explicitly defining the bottlenecks in the system.

iv Separate problem identification and problem solution, by determining two distinctive phases 'bottleneck identification' and 'bottleneck solution'. Although the value of separating these two steps is evident to most practitioners [47], the concept is often not implemented.

v Evaluate different possible solution spaces: The example underlines that future planning should be more discovery-driven than anticipative [48]. Specifically, it provides possible innovation paths instead of one solution.

IV. CONCLUSION

This paper presents a model of Technology Foresight with focus on the backcasting phase. The 'implementation gap' in technology foresight which has been identified in an empirical study on practices in multinational companies, can partly be eliminated with the model of innovation backcasting. An interdisciplinary approach is adopted based on the backcasting methodology, including a definition of product functionalities and an identification of bottleneck technologies. The approach tries to capitalize on the experience gathered in various disciplines, such as operations research, energy policy and future science. It contributes to reducing the uncertainty of technology planning and to increasing the value of TF results. Setting priorities on bottleneck technologies also improves the efficiency in Technology Foresight.

Even though this model has had some good results in practice, there are few empirical data on the direct effects of the backcasting model on innovation and strategy management. To provide further empirical validation of the backcasting concept multiple case studies are planned. In addition, conceptual details, as conditions for implementing the suggested model, and the role of bottleneck technologies in backcasting, will be elaborated in an action research case.

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REFERENCES

[1] J. L. Petersen, Out of the Blue: *Wild Cards and Other Big Surprises.* Arlington: Arlington Institute, 1997.

[2] J. D. Rockfellow, "Wild Cards - Preparing for 'The Big One'." *The Futurist*, Jan-Feb., pp. 14-19, 1994.

[3] D. Schlossstein and B. Park, „Comparing recent technology foresight studies in Korea and China: towards foresight-minded governments?" *Foresight*, 8(6), pp. 48-70, 2006.

[4] K. Blind, K. Cuhls and H. Grupp, „Current Foresight Activities in Central Europe." *Technological Forecasting and Social Change*, 60, pp. 15-35, 1998.

[5] O. Saritas, E. Taymaz and T. Tumer, (2006) "Vision 2023: Turkey's national Technology Foresight Program: A contextualist analysis and discussion". *Technology Forecasting & Social Change*. Available: doi:10.1016/j.techfore.2006.07.005.

[6] L. V. Tavares, "Development policies in the EU and technology foresight: an experiment in Portugal." *Foresight*, 4(2), pp. 33-45, 2002.

[7] S. Reger, "Technology Foresight in Companies: From an Indicator to a Network and Process Perspective." *Technology Analysis & Strategic Management*, 13(4), pp. 533-553, 2001.

[8] A. Salo, T. Gustafsson and R. Ramanathan, "Multicriteria methods for Technology Foresight". *Journal of Forecasting*, 22, pp. 235-255, 2003.

[9] F. J. Coates, "Scenario Planning". *Technological Forecasting and Social Change*, 65, pp. 115-123, 2000.

[10] D. W. Bunn and A. Salo, "Forecasting with scenarios." *European Journal of Operational Research*, 69, pp. 291-303, 1993.

[11] F. Lizasco and G. Reger, "*Scenario-based Roadmapping – A Conceptual View*". Paper accepted at the EU-US Seminar "New Technology Foresight, Forecasting & Assessment Methods", Seville, 2004. Available: liz-re-roadmap 120504.pdf.

[12] D. Barker and J. H. Smith, "Technology Foresight Using Roadmaps." *Long Range Planning*, 28(2), pp. 21-28, 1995.

[13] G. Reger et al., "*Technology Foresight in Enterprises*." Main Results of an International Study by the Frauenhofer Institute for Systems and Innovations Research and the Department of R&D Management, University of Stuttgart. Karlsruhe/ Stuttgart, 1998.

[14] C. K. Prahalad and G. Hamel, "Strategy as a field of study: why search for a new paradigm?" *Strategic Management Journal*, 15, pp. 5-16, 1994.

[15] G. Szulanski and K. Amin, "*Disciplined Imagination: Strategy Making in Uncertain Environments*." Wharton on Managing Emerging Technologies, G. S. S. Day, Paul J.H. & Gunther, Robert E., ed., John Wiley & Sons, Inc., New York, pp. 189-205, 2000.

[16] M. Gruber, B. W. Kolpatzik, J. Schönhut and C. Venter, "*Die Rolle des Corporate Foresight im Innovationsprozess*." zfo praxis, 5/2003, pp. 285-290, 2003.

[17] G. S. Lynn, J. G. Morone and A. S. Paulson, "Marketing and Discontinuous Innovation." *California Management Review*, 38(3), pp. 8-37, 1996.

[18] G. Trauffler, "*Disruptive technologies and radical innovation*" Dissertation, ETH Zürich, 2005.

[19] C. Weyrich, "*Pictures of the Future*." Presentation, Technopark Zürich, Switzerland, 2003.

[20] R. Pitkethly, "*Analysing the Environment*." The Oxford Handbook of Strategy, Oxford University Press, New York, pp. 225-260, 2003.

[21] SiemensAG. "*Pictures of the Future*." München, 2006.

[22] C. Weyrich and H. Brodbeck, "*Innovation durch industrielle Forschung und Entwicklung*." Technologie-Management, Idee und Praxis, H. Tschirky and S. Koruna, eds., Verlag Industrielle Organisation, Zürich, pp. 721-726, 1998.

[23] L. A. Costanzo, "Strategic foresight in a high-speed environment." *Futures*, 36, pp. 219-235, 2004.

[24] D. List, "Multiple pasts, converging presents, and alternative futures." *Futures*, 36, pp. 23-43, 2004.

[25] G. C. O'Connor and R. W. Veryzer, "The nature of market visioning for technology-based radical innovation." *The Journal of Product Innovation Management*, 18, pp. 231-246, 2001.

[26] S. Makridakis, S. C. Wheelwright and R. J. Hyndman, R. J., "*Forecasting – methods and Applications*." Wiley, Chichester, 1998.

[27] A. W. Drew, "Building technology foresight: using scenarios to embrace innovation." *European Journal of Innovation Management*, 9(3), pp. 241-257, 2006.

[28] R. Loo, "The Delphi method: a powerful tool for strategic management." *An International Journal of Police Strategies & Management*, 25(4), pp. 762-769, 2002.

[29] Robinson, "Futures under glass, A recipe for people who hate to predict." *Futures*, 22(8), pp. 820-842, 1990.

[30] H. Noori, H. Munro, G. Deszca and B. McWilliams, "Developing the 'right' breakthrough product/service: an umbrella methodology - Part A." *International Journal Technology Management*, 17(5), pp. 544-562, 1999.

[31] J. B. Robinson, "Energy backcasting - A proposed method of policy analysis." *Energy Policy*, pp. 337-344, 1982.

[32] W. Ch. Chiang, A. Pennathur and A. Mital, "Designing and manufacturing consumer products for functionality: a literature review of current function definitions and design support tools." *Integrated Manufacturing Systems*, 12 (6), pp. 430-448, 2000.

[33] L. D. Miles, "*Techniques of Value Analysis and Engineering*", New York: Mc Graw-Hill, 1961.

[34] W. Rodenacker, "*Methodisches Konstruieren*." Berlin, Heidelberg, New York: Springer, 1971.

[35] A. Goel and E. Stroulia, "Functional device models and model-based diagnosis in adaptive design." *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*, 10(4), pp. 355-70, 1996.

[36] V. Hubka and W. E. Eder, "*Design Science*." New York: Springer, 1992.

[37] J. B. Barney, "Firm Resources and Sustained Competitive Advantage." *Journal of Management*, 17, pp. 99-120, 1991.

[38] R. Boutellier and K. Loeffler, "*Bottleneck technologies. Applying the constraints approach to technology management. A concept and its applications.*" PICMET, Istanbul, 2006.

[39] S. W. Popper, C. S. Wagner and E. V. Larson, "*New Forces at Work, Industry views Critical Technologies*", RAND Corporation, 2003.

[40] P. A. Roussel, "Technological Maturity Proves a Valid and Important Concept." *Research Management*, 27, pp. 29-34, 1984.

[41] C. M. Christensen, "*The Innovators Dilemma, When New Technologies Cause Great Firms to Fail*", Harvard Business School Press, Boston, Massachusetts, 1997.

[42] C. M Christensen and M. E. Raynor, "*The innovator's solution. Creating and sustaining successful growth*". Harvard Business School Publishing Corporation, Boston, 2003.

[43] M. L. Tushman, P. C. Anderson and C. O'Reilly, "Technology Cycles, Innovation Streams, and ambidextrous Organizations: Organization Renewal through Innovation Streams and Strategic Change." *Managing Strategic Innovation and Change*, Oxford University Press, New York, pp. 3-23, 1997.

[44] C. D. Hill, "*Leica SmartStation. The integration of GPS & total station technologies*." Publication of Leica Geosystems AG, Heerbruck, 2005.

[45] T. Stansell, "*GPS in the Year 2000*." presentation at The Special DOD Sysposium on the Global Positioning System (GPS), Arlington, USA.

[46] A. M. Brandenburger and B. J. Nalebuff, *Co-opetition, Currency-Doubleday*, 1996.

[47] P. Checkland and J. Poulter, *A Short Definitive Account of Soft Systems Methodology, and Its Use Practitioners, Teachers and Students*, Wiley & Sons, 2006.

[48] D. F. Abell, "*Competing Today While Preparing for Tomorrow*." Sloan Management Review, Spring 1999, pp. 73-81, 1999.

12.6 Systematic approach to superior innovation structures

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Systematic approach to superior innovation structures

Roman Boutellier, Ursula Deplazes, Wolfgang Deplazes

Abstract—**Business organizations are aware of the new challenges arising from disruptive business environments and 'routinization' of innovation. However, their track-record in successfully encompassing both, incremental and radical change, has been relatively poor. This paper proposes a systematic approach to design innovation structures and process architectures and thus establish consistent organizations. The approach is based on strategies of modularity, complexity reduction and a process-based organizational view. A case study illustrates the approach.**

Index Terms—**Innovation management; Modularity; Complexity; Organization management; Process management; R&D management; Complex systems.**

I. INTRODUCTION

THE combined effect of discontinuous business environments and 'routinization' of innovation make traditionally established business models rapidly become obsolete. Classical approaches to organizational design have to be revised to account for the fact that in the future a company's survival will as much depend on its ability to pre-empt disruptive change as on its ability to continuously optimize its fit to a given environmental framework. This challenge has been recognized for some time and literature abounds with suggestions ranging from venture capital models to approaches based on project management and, more recently, organizational ambidexterity. Nevertheless, the track record of companies succeeding at generating breakthrough innovations while continuing to implement incremental changes on its current products and services is quite poor. This paper aims at contributing towards closing this gap by outlining a framework for a systematic and pragmatic approach to the design of innovation structures, process architectures and organizations. It builds on insights of the systems theory, the theory of complexity, modularity and process-based organizations.

The paper starts by explaining forces driving volatility of traditional business models (chapter II) and the resulting challenges for business practitioners. Despite the fact that literature abounds with suggestions, companies have difficulty in coming to terms with these challenges (chapter III). In chapter IV we outline a systemic framework for the design of innovation structures, process architectures and organizations. The key building blocks of the approach are: modularity, complexity reduction and a process-based organizational set-up. The closing chapter describes a case study where the approach proposed is currently being implemented by the authors.

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R. Boutellier, Prof Dr, is Professor for Technology and Innovation Management, Chair of Technology and Innovation Management at The Swiss Federal Institute of Technology (ETH) in Zurich.

U. Deplazes, MSc. LSE, MSc. HEC, HLH, is an IEEE member and an external PhD student at the Department of Technology and Innovation Management of the ETH in Zurich, Switzerland (e-mail: udeplazes@ethz.ch).

W. Deplazes, MSc. HEC is an external PhD student at the Department of Technology and Innovation Management of the ETH in Zurich, Switzerland (e-mail: wolfgang.deplazes@mac.com).

II. RAPIDLY CHANGING BUSINESS LANDSCAPE

Environmental changes that characterize the early 21st century business landscape seem unprecedented in terms of scale, pace, complexity and uncertainty (among others [1], [2], [3], [4], [5], [6], [7]). Increasingly global markets and competition, fundamental changes in the economic and political landscape, progressing deregulation, and ecological restrictions are some of the underlying forces driving complexity and rapid change in most business environments.

A. Discontinuous Environment

Environmental discontinuity appears to be in contradiction to the traditional approaches of organizational design. These are based on strategies aiming at optimizing the company's fit with its existing (or imminent) environment. For perspective, the pre-dominant strategy schools of the 1980s and 1990s identify sources of competitive advantage based on market positioning ('strategic positioning') or the firm's resources and capabilities ('resource-based view'). The former school adopts an 'outside-in' view and strives to align the company's organization and resources to the existing industry structure and market requirements. The latter school, however, adopts an 'inside-out' view seeking market opportunities that match the company's resources and capabilities. Both approaches (and their combinations) strive to continuously optimize the fit between the organization and its environment. However, in an increasingly discontinuous business environment, these continuity-based approaches have shown inherent limitations. 'Organizations that have become accustomed to successful business practices and the established 'way of doing business' in attaining a 'fit' often find themselves unable to cope with the complexities and uncertainties of most business environments' [5]. This phenomenon is also referred to as the 'conundrum – that established companies simply lack the flexibility to explore new territory' [8].

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B. Routinization of Innovation

Miniaturization, modularization, and standardization drive the evolution of product architectures in most industries and eventually enlarge the number of possible module variants and their potential combinations. For individual firms, the innovative challenge is to satisfy increasingly differentiated customer needs with a continuous flow of differentiated product variants. For perspective, in 2006 Volkswagen's most popular model, the VW Golf, was made available in more than one million different configurations. In order to secure this indispensable continuous stream of 'incremental' innovations, successful companies establish systems of structured, reproducible and efficiency-oriented innovation routines. This 'routinization' of innovation is the basis for generating a manageable, predictable and continuous flow of innovative outputs. Investments in 'incremental innovation' become transparent and are more easily compared to investments in other areas such as manufacturing, sales and marketing.

Routinized innovation systems have 'everything to do with organization and attitude and very little to do with nurturing solitary genius' [9]. They can easily be replicated outside the company and thus offer only temporary and short-lived competitive advantage. By analogy to the fate of other prominent management practices such as 'TQM', 'project management' and 'lean management', we advocate that 'routinized' innovation will soon be widely adopted. It will lose its importance as a source of noteworthy competitive advantage and simply become a must for long-term survival.

The combined effects of environmental discontinuity and 'routinized' innovation significantly reduce the lifespan and sustainability of traditional business models and organizational architectures. *We conclude from this that innovation structures need to have the systemic breadth to pre-empt discontinuous changes and sufficient standardization to realize economies of scale and scope in areas of 'routinized' of innovation.*

III. CHALLENGE FOR BUSINESS ORGANIZATIONS

Companies facing environmental discontinuity and 'routinized' innovation need to design innovation strategies, innovation systems, process architectures and organizations which allow them to pre-empt discontinuous change without jeopardizing their base business. The challenge is to design innovation structures able to simultaneously pursue different types of innovation streams generating incremental (small improvements in the existing products), architectural (fundamental changes of some component of the business) and discontinuous (radical advances) innovations. Literature offers theoretical and practical illustrations how organizations cope with this challenge - among those are venture capital models, cross-functional teams, shifting back and forth between different organizational models. We would like to briefly discuss the following approaches, as they seem relevant to understanding the approach we propose for modeling innovation structures:

A. Project Management

Methods of project management usually apply to an individual innovation project which is limited in time and scope. Each project is allocated its specific resources, organization, teams and sometimes even infrastructure. While the innovation process applied in a given project usually follows a generic pattern, it is essentially project-specific and not a routine (or 'standard operations procedure') directly transferable or applicable to other projects. *Thus, innovation structures based on project management will not secure the systematic realization of learning effects and economies of scale or scope, which are indispensable in an environment of 'routinized' innovation.*

B. Multi-Project Management

Multi-project management practices take a cross-project view and aim at coordinating a large number of complex innovation projects with varying objectives, lead-times and maturities. Projects of 'similar' nature share similar functions, technologies and key components. A key lever is to identify functions and functionalities that can be shared among several projects versus those that are project-specific. In the former case the realization of synergies and economies of scale predominate. In the latter the uniqueness of the individual projects is significant. Multi-project management allows for economies of scale while securing the uniqueness of individual projects. *However, the breadth of an innovation structure based on multi-project management is usually insufficient to account for disruptive innovations.*

C. Approaches based on Ambidexterity

More recent approaches are based on the concept of 'ambidexterity'. They build on the duality of innovation strategy encompassing its exploitative and explorative dimensions: the former focuses on exploiting existing capabilities for profit (incremental innovation) and the latter focuses on exploring new opportunities for growth (disruptive innovation). Only the combination of both will yield the sustainable continuous flow of innovations necessary for a company to remain successful over long periods.

Our literature review showed that there is ample documentation (including illustrations of case studies and quantitative research) supporting the advantages of ambidexterity. Nevertheless, in line with some of the leading authors on ambidexterity, we conclude that companies have not been very successful at implementing ambidextrous organizations (see also [10], [8]). In fact, we are not aware of any comprehensive, systematic and easy-to-implement guidelines for practitioners wishing to cope with the challenge of sustainable continuous innovation. *The aim of this paper is therefore to propose a systematic approach to the design of innovation structures, process architectures and organizations guiding practitioners seeking to cope with the dual challenge of exploitative and explorative innovation.*

IV. A SYSTEMIC FRAMEWORK FOR MODELLING INNOVATION STRUCTURES

We base our model on a systemic framework viewing innovation as a complex social adaptive system. Using the strategies of modularity and complexity reduction and the principle of process-based organizational design, we attempt to structure the innovation system into modular sub-systems which can be further modeled. Subsequently, we show that while all sub-systems contribute as a whole to pursuing the realization of the dual innovation strategy, each sub-system has its specific and clearly-defined contribution to value creation, and its dedicated structure, processes, and culture.

It is not surprising that implementing modular structures alone (see Fig. 1 and Fig. 2) does not eliminate all complexity of a system. In order to tackle this residuary complexity we apply a domain-based design approach (see Fig. 3) drawn from Suh's theory of complexity, and more specifically the 'zigzagging' technique (see Fig. 4) to decompose domains into hierarchies. After structuring the system, we link the innovation structure to the process architecture and, eventually, deduct from this latter the process-based organization (see Fig. 5). In the following sections of this chapter we will further explain the basic concepts underlying our approach to the design of innovation structures, more specifically modularity, complexity and process-based organizational design. In Chapter V, we will discuss a case study, in which the approach outlined in this paper is implemented.

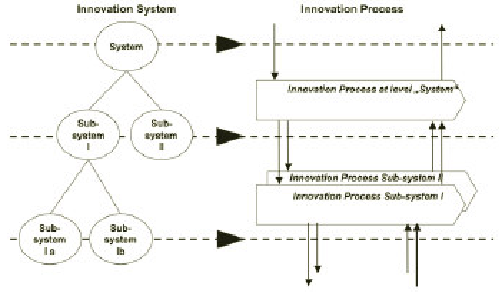

Fig. 1: *Linking the Structure of the Innovation System to the Innovation Process – Part I (adapted from [18]). The structure of the innovation system defines the structure of the architecture of the innovation process and thus determines the scope of the modular innovation sub-processes.*

A. Modularity

We adopt a systemic approach viewing innovation organizations as complex social systems. According to Simon [11] these systems are artefacts (i.e. human-made) adaptive to the environment in which they live. They are nearly decomposable and hierarchical in their structure. Even though Simon does 'not undertake a formal definition of 'complex systems'' [11], his notion of complexity used in the context of complex social systems is structural and more specifically hierarchical in nature. Baldwin and Clark [12] refer to modularity as the building of a complex system from smaller sub-systems that can be designed independently yet function together as a whole. From this definition, it follows that modularity consists in dividing a large system into smaller sub-systems that can be designed and carried out independently while still ensuring that the whole system fulfills its objectives. We therefore proceed to structuring the innovation system into sub-systems, and the innovation process into sub-processes. The sub-units are clearly delimited and can therefore be designed independently (with specific organizational, structural and cultural mechanisms). However, they function together via clearly defined interfaces. We chose modularity as the preponderant strategy in our approach to structure innovation systems.

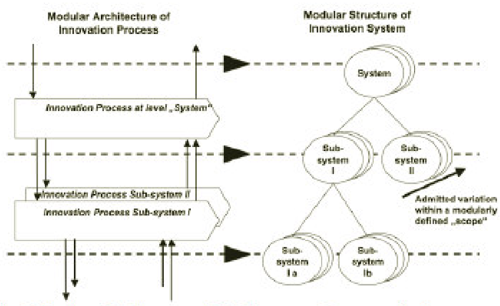

Fig. 2: *Linking the Structure of the Innovation System to the Innovation Process – Part II (adapted from [18]). A defined process architecture inherently limits radical and architectural innovation, but fuels incremental innovation in each innovation sub-process.*

B. Complexity

The application of modularity alone is not sufficient to tackle the complexity of systems. In fact, 'some complexity problems will still arise, in spite of the implementation of modular structures' [13]. Inherent complexity tends to limit growth of the system by making it less efficient or even ineffective. Indeed, the main costs of complexity appear to be the opportunity costs of the organization's reduced efficiency. Revenues, for example, might fall as sales opportunities are missed due to longer development cycles. Or a company's business model might even become obsolete driven by its inability to pre-empt radical innovations that would allow it to overcome disruptive environmental changes. For perspective, the fact that 'only 26% of the 100 companies listed in Fortune's 1980 ranking remained on the list in 2001' can be linked to the difficulty most firms experience in overcoming discontinuous change [14]. According to Suh's theory [15], [16], complexity is an indicator of the ability of the designed system to achieve pre-defined goals. From this perspective, the aforementioned example suggests that a vast majority of companies are unable to control the inherent complexity of their innovation systems. This seems even more alarming, since complexity belongs to those factors that 'appear to be 'self-potentiating': the more of them there are, the more powerful the impetus to the production of yet more' [17].

Behind this, the relevancy of complexity reduction when structuring innovation systems seems unquestionable.

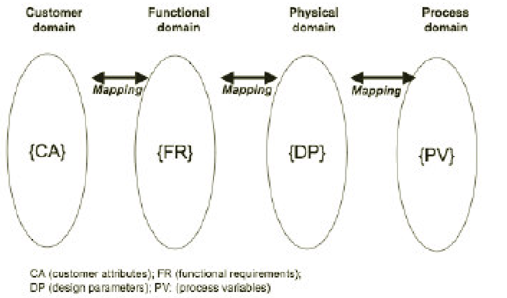

Fig. 3: *Four Domains of the Design World. During the design process we map from a left domain (i.e. the "what" we want to know or achieve) to a domain on its right (i.e. how we hope to satisfy the "what"). The process is iterative in the sense that the designer can go back to the domain on the left based on the ideas generated in the right domain [16].*

Suh's complexity theory is based on a systematic approach to design. As illustrated in Fig. 3, the axiomatic design guides designers through the four domains of the design world – step by step from customer attributes {CA} to functional requirements {FR} to design parameters {DP} to product variables {PV}. Fig. 4 illustrates what happens between two adjacent pairs of domains: First, a designer decomposes customer attributes {CA} into a hierarchy of higher- and lower-level attributes. In parallel, he uses a technique called "zigzagging" to iteratively map between the adjacent design domains of customer attributes {CA} and functional requirements {FR}. Then he gradually proceeds decomposing and zigzagging between the next adjacent pairs of domains, i.e. {FR} and {DP}, and subsequently {DP} and {PV}. In this way, the design will ultimately be reduced to a set of hierarchies. This process helps the designer to identify independent, uncoupled (or at least decoupled) design parameters and thus reduce design specifications to their simplest components. This is how one could qualify 'good' designs. *In the proposed approach to design innovation structures, we adopt principles of Suh's theory of complexity management as a complementary strategy to modularity. This complexity-based view contrasts with traditional managerial approaches that counter complexity with a series of 'ad hoc' devices (such as teams, projects, ventures, groups, relationships). With the model of "innovation backcasting" we provide a structure for systematically deducing possible innovation steps, covering future customer needs with possible innovation activities (Ref. DEU & Karin).*

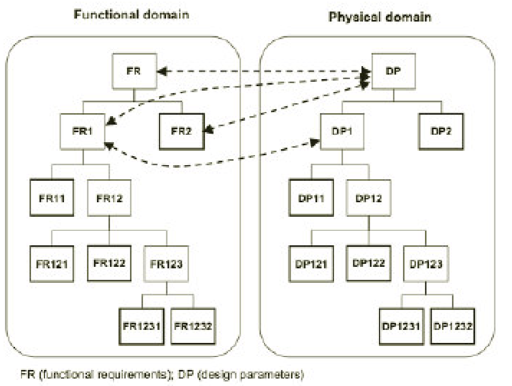

Fig. 4: *Decomposition, Zigzagging and Hierarchy. Zigzagging to decompose FRs and DPs in the functional and the physical domains to create the FR and DP hierarchies. Boxes with thick lines represent "leaves" that do not require further decomposition [16].*

C. Process-based Organizational Design

In process-based organizations, the organizational units and sub-units coincide with the processes and sub-processes of the process architecture. In fact, the process owner is responsible for the entirety of a modular process or sub-process.

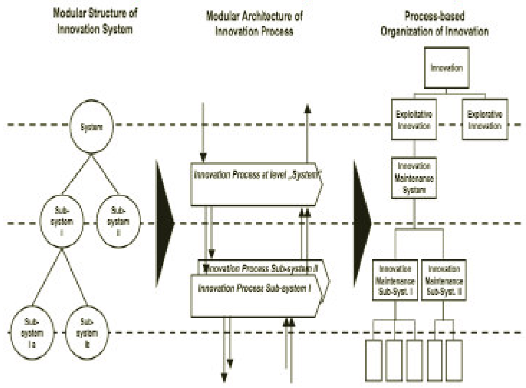

Fig. 5: *Process-based Organization of Innovation. The modular structure of the innovation system defines the architecture of the innovation process, which in turn determines the organizational structure of a company's innovation activity. This ensures the consistency among innovation strategy, process architecture and organization.*

The process is triggered by a clearly defined input and is liable to deliver a clearly defined output – with no interruptions in responsibility to account for superfluous and complexity-driving interfaces among organizational units. The overall number of interfaces in the organization is limited to the optimum required based on the modular structure of the underlying process architecture. This congruency is key to secure the realization of systematic learning effects. Each process forms a consistent area of responsibility and is expected to deliver a modularly defined 'portion' of the total value proposition delivered by the company. Since modularity groups similar elements while separating non-similar elements, a modular (sub-) process can be designed, planned, and steered independently – within the scope determined by the modular structure. This channeling function of a modular process is directly associated with economies of scale and scope. Process-based organizational design is a key element in the approach proposed, since it anchors the consistency between innovation strategy, processes and organization and is a pre-requisite for systematic learning and economies of scale.

V. CASE STUDY

The company Main Ltd. was founded in 2002 after the National Army outsourced its maintenance operations including three factories and a network of 60 workshops across the national territory. Today, it has around 2000 employees and its turnover amounts to the equivalent of USD 400 MM. The fundamental mission of Main Ltd. is to offer full-service maintenance support to the National Army for a specified portfolio of weapon systems. The service-level-agreement includes full-service maintenance support, guaranteed levels of availability of the weapons systems at regional and national levels, as well as other services such as breakdown and training support.

Right from the outset, management recognized that the disintegration from the National Army's operations would result in a dramatic change of the company's business landscape. The inherited business model rapidly became obsolete and was a liability to the realization of the company's mission. Availability of weapon systems was decreasing dramatically, pass-through times were increasing, spare-parts availability levels dropped and customer satisfaction decreased. After validating the inherited business model, management decided to initiate a major restructuring exercise to achieve the following objectives: (i) securing availability levels at optimal cost, (ii) achieving best practice in maintenance operations, (iii) restructuring the supply chain to secure availability of spare parts, and (iv) developing an inherent ability to tackle the challenge of systematically and continuously developing not only improvements of the current value proposition, but also new value propositions allowing the company to expand into new markets and industries.

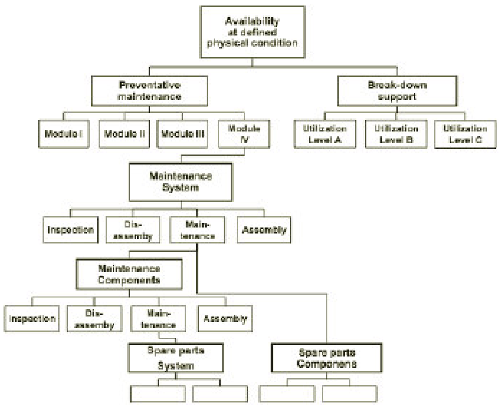

Fig. 6: *Structuring the Company's Value Proposition.*

The approach adopted consists of 5 phases: First, the client's requirements had to be identified as a basis to re-assess the company's value proposition (phase 1). Then, based on the structured value proposition, the company's process architectures were designed, for both the operative (phase 2) and the exploitative innovation business (phase 3). Subsequently the organizational design was defined and implemented (phase 4).

1) Phase 1 - Identifying and Structuring Main Ltd.'s Value Proposition: A thorough an assessment showed that – for historical reasons – the boundaries between the company and the customer had become so blurred that there was no clear understanding as to who exactly was the customer and what exactly were his requirements (existing or imminent). This unstructured interface to the client was identified as a major driver for complexity in the current business model. Main Ltd. started by identifying and then decomposing these customer requirements, while – in parallel - "zigzagging" to decompose the functional requirements. This approach became instrumental to structure the interface between Main Ltd. and its client. It eventually enabled the company to identify and then reduce, rather than absorb, the huge complexity emanating from the client.

2) Phase 2 - Process Architecture for the Operative Business: The modular structure of the Value Proposition (see Fig. 6) is used as the basis for the design of the underlying process architecture of the operative business (see Fig. 7).

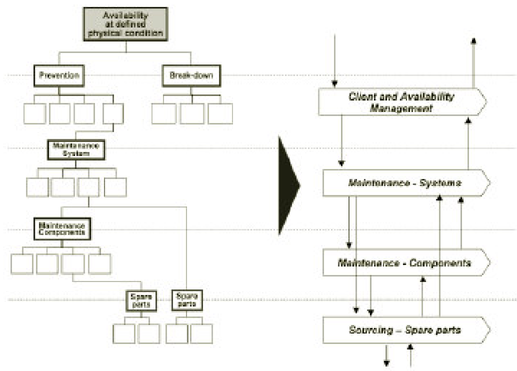

Fig. 7: *Linking Company's Value Proposition and Process Architecture.*

Significant levers identified when structuring the value proposition were for example: (i) Separating the maintenance of entire systems from the maintenance of its components based on their different periodicity and capabilities and (ii) Separating the responsibility for delivering the agreed levels of availability of weapon systems from the responsibility to meet agreed-upon maintenance lead-times. Both these levers are directly reflected in the process architecture: (i) The maintenance process has been divided into two processes encompassing the maintenance of systems and the maintenance of components respectively. This separation at process level had obvious implications in terms of factory infrastructure, warehousing, workshop floor design and qualification of human resources. (ii) The historically collective responsibility of maintaining agreed levels of availability of weapons systems has been assigned to the client management process, while the achievement of maintenance lead-times has been assigned to the maintenance processes.

3) Phase 3 - Process architecture for the incremental innovation business: Main Ltd. is aware that to outperform its potential competitors it must continuously improve its value proposition and the way it is structured. This is accounted for in their exploitative Innovation activities (see Fig. 8) and implies, for example: (i) The regular adjustment of the contents of the preventive maintenance packages and their periodicity based on the continuous evaluation of observed damages and utilization. The objective is to balance the need to prevent breakdowns with the need to meet availability objectives while avoiding the economic drawbacks associated with over- and under-maintenance. This is accounted for in the process "development of maintenance modules". (ii) The continuous monitoring of customer needs to identify opportunities for new services based on the actual value proposition. Or, alternatively, to identify new markets for the actual value proposition. This is accounted for in the process "strategic marketing/client management".

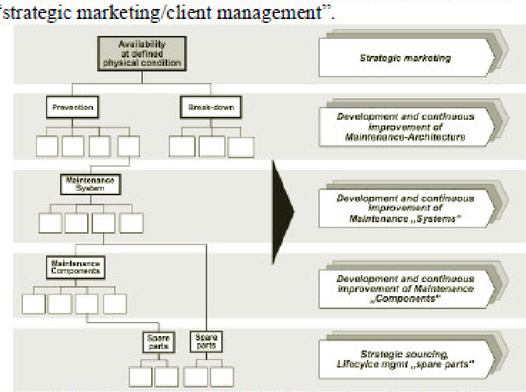

Fig. 8: *Identifying the Process Architecture for Exploitative Innovation.*

4) Phase 4 - Establishing Process-Based Organizations: The organization is deducted from the process architectures respecting the principle of congruity to avoid complexity driven by superfluous interfaces. Like the sub-processes, the sub-units are also clearly delimited and can therefore be designed independently pending on their requirements as to structural, organizational and cultural mechanisms. The same principles were applied to the exploitative innovation business (see Fig. 7 and 8 for the process architectures of the operative business and the exploitative Innovation respectively).

5) Phase 5 - Accommodating for the Development of Future Value Propositions: Developing future value propositions beyond the current offerings is associated with radical innovation. A variety of strategic fields of knowledge that have to be systematically covered have been identified. For example, the technical understanding of the interdependences between systems maintenance, systems engineering, and systems construction. Following the same design approach as above, the structuring of the vision for future-value propositions was followed by the definition of the optimal process architecture and eventually also organizational set-up. It is not surprising that the degree of structure, formalization and standardization is much lower in the explorative innovation business than in the exploitative innovation business.

6) Organizational set-up: The operative business, the exploitative Innovation and the explorative Innovation are linked via clearly defined interfaces. This is also reflected in the process-based organizational set-up chosen by Main Ltd. Fig. 9 illustrates the overall organization encompassing the operative business, the exploitative Innovation and the explorative Innovation. It is clear that in such organizational settings, the role of senior management changes. It faces the challenge of managing the 'co-habitation' of highly differentiated, but still integrated organizations. The design principles applied (modularity, complexity and consistence between process architectures and organization) guarantee simple structures, with clearly defined interfaces, coherent areas of responsibility and minimal redundancies. This is a solid basis facilitating not only the differentiation task, but also the integration task of senior management. Nevertheless, the role of senior management, with the according steering processes allocating resources among the different parts of the business and managing portfolios of activities and initiatives that have a cross-organizational relevance, still has to be modeled.

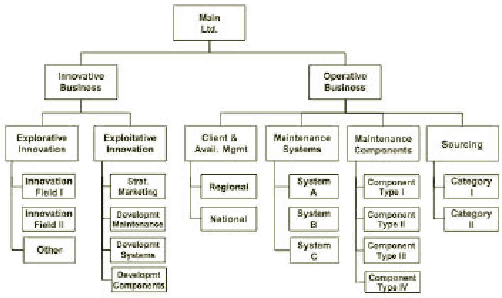

Fig. 9: *Company Organization*

VI. CONCLUSIONS

This paper presents a case study which applies the proposed approach to design business systems, process architectures and organizations in complex business environments. Based on the current status (about 12 months into the exercise), we have reason to believe that the approach proposed is systematic, pragmatic and offers solid guidance to practitioners wishing to come to terms with the challenges of managing complex systems.

To some, the design concept proposed might appear to have some affinity with traditional industrial companies. The case study supports, however, the fact that approaches originally developed in the context of physical products (e.g. modularity) can be easily transferred to immaterial products and services (such as logistics and other services). The applicability of the proposed methodology is supported by this case study.

Company performance has been improving along with progress in the project. The new processes allow the company to pro-actively manage availability and meet its availability targets. The separation of the maintenance process for systems from the maintenance process for components led to a drastic reduction of maintenance time and cost. Additionally, the approach adopted allows the company to continuously monitor and adjust its "service architecture" at all levels. This already yields a continuous improvement of quality and cost of the availability and maintenance service. This gives us an optimistic perspective regarding the achievement of the other objectives the management had defined at the outset of the project. Specifically, the ability to continuously improve the existing services, while also developing new value propositions for different markets and industries will be key to the long-term success of Main Ltd.

References

[1] M. L. Tushman and P. Anderson, "Technological discontinuities and organizational environments," *Administrative Science Quarterly*, 31(3), pp. 439-465, 1986.

[2] D. Tapscott, "Strategy in the new economy," *Strategy and Leadership*, 25(6), pp. 8-14, 1997.

[3] G. Hamel, *Leading the Revolution*, Harvard Business School Press, Boston, MA, 2002.

[4] M. Gibbert et al., "Five styles of customer knowledge management, and how smart companies use them to create value," *European Management Journal*, 20(5), pp. 459 – 469, 2002.

[5] S. C. Voelpel, M. Leibold and B. T. Eden, "Managing purposeful organizational misfit: Exploring the nature of industry and organizational misfit to enable strategic change," *Journal of Change Management*, 6(3), pp. 257-276, 2006.

[6] C. M. Christensen and M. E. Raynor, *The Innovator's dilemma*, Harvard Business School Press, Boston, MA, 2003.

[7] C. M. Christensen and M. E. Raynor, *The Innovator's solution. Creating and sustaining successful growth*, Harvard Business School Publishing Corporation, Boston, MA, 2003.

[8] C. A. O'Reilly and M. L. Tushman, "The ambidextrous organization," *Harvard Business Review*, April 2004, pp. 74-81.

[9] A. Hagardon and R. Sutton, "Building Innovation Factory," *Harvard Business Review*, May June 2000, pp. 157-166.

[10] S. Kaplan and R. Henderson, "Strategic entrepreneurship: Creating competitive advantage through streams of innovation," *Organization Science*, 16(5), pp. 509-521, 2005.

[11] H. A. Simon, *The Sciences of the Artificial*, The MIT Press, Cambridge, MA, 1996.

[12] C. Y. Baldwin and K. B. Clark, *Design rules, Volume 1: The Power of Modularity*, The MIT Press, Cambridge, MA, 2000.

[13] T. Blecker and N. Abdelkafi, "Complexity and variety in mass customization systems: analysis and recommendations," *Management Deicision*, 44(7), pp. 908-929, 2006.

[14] R. D. Ireland and J. W. Webb, "Strategic entrepreneurship: Creating competitive advantage through streams of innovation," *Business Horizons*, 50, pp. 49-59, 2007.

[15] P. S. Suh, *The Principles of Design*, Oxford University Press, New York, 1990.

[16] P. S. Suh, *Complexity Theory and Applications*, Oxford University Press, New York, 2005.

[17] N. Rescher, *Complexity. A philosophical Overview*, Transaction Publishers, New Brunswick, NJ, 1998.

[18] A. Suter, *Die Wertschöpfungsmaschine. Wie Strategien ihre Stosskraft entwickeln*, Orell Füssli Verlag, Zürich, pp. 173-174, 2004.

12.7 Auswirkungen von neuartigen Unternehmensrisiken auf die Versicherer

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▸ **TEXT** Ursula Deplazes, Wolfgang Deplazes, Prof. Roman Boutellier

Ursula Deplazes, M.Sc. LSE, M.Sc. HEC, HLH ist Doktorandin und Mitarbeiterin am Lehrstuhl für Innovations- und Technologiemanagement der Eidgenössischen Technischen Hochschule (ETH) Zürich.

Wolfgang Deplazes M.Sc. HEC ist Doktorand am Lehrstuhl für Innovations- und Technologiemanagement der ETH Zürich. Er ist Vice-President in einem internationalen Beratungsunternehmen.

Roman Boutellier Prof. Dr. Sc. Math. ist ordentlicher Professor für Technologie und Ökonomie an der ETH Zürich und Titularprofessor an der Universität St. Gallen. Er ist Mitglied der Verwaltungsräte mehrerer Schweizer Großunternehmen.

Auswirkungen von neuartigen Unternehmensrisiken auf die Versicherer

Tiefgreifende Veränderungen des Umfelds anfangs des 21. Jh. stellen Unternehmen vor neuartigen Risiken. Der Bedarf der Unternehmen an Risikodeckung ändert sich auch durch die zunehmende Risikoprävention und konsequente Reduzierung der Risikokosten aus gesamtunternehmerischer Sicht. Auf der Seite der Nachfrage setzt sich eine neue Sicht des Versicherungsmarktes durch. Es entsteht eine neue Marktstruktur mit neuen Segmenten und neuen Spielregeln. Traditionelle Erfolgsfaktoren der Versicherer wie Kapitalstärke und Grösse verlieren an Bedeutung zugunsten von Wissen um Risikoprofile, Finanzierungs- und Servicebedürfnisse der individuellen Unternehmen. Versicherer müssen bewährte Erfolgsrezepte hinterfragen und differenzierte Strategien fahren, um die neuen Potentiale auszuschöpfen – bevor neue Wettbewerber, von Systemhäusern bis Investmentbanken, die Überhand gewinnen. Im Artikel werden die neuartigen Unternehmensrisiken und deren Auswirkungen auf den Versicherungsmarkt analysiert. Insbesondere werden drei Handlungsoptionen aufgezeigt, die Versicherungsunternehmen angesichts der grundlegenden Marktveränderungen und deren Chancen und Risiken offen stehen.

1. Innovationsdruck steigt

Das Marktumfeld anfangs des 21. Jahrhunderts ist tiefgreifenden Veränderungen unterworfen. Die wirtschaftliche und politische Neuordnung, die Globalisierung der Märkte und des Wettbewerbs, die zunehmende Deregulierung und das Aufkommen von bisher nicht beachteten ökologischen Risiken leiten einen grundlegenden Wandel in den meisten Industrien ein. Sie treiben die Komplexität und die Unsicherheit, in welchen sich die Unternehmen bewegen. In diesem diskontinuierlichen Umfeld müssen die meisten Unternehmen ihre Strategien grundsätzlich überdenken. Denn die traditionellen Strategieansätze, welche auf der Marktpositionierung (strategic positioning) oder auf Fähigkeiten des Unternehmens (resource-based view) gründen, gehen meist von einer absehbaren Kontinuität des Umfeldes aus. In einem zunehmend komplexen, unsicheren und diskontinuierlichen Umfeld müssen Unternehmen traditionelle Ansätze relativieren. Es gilt, neue Wege zu finden, um mit den neuen Unsicherheiten umzugehen.

Trotz den zunehmenden Unsicherheiten im Umfeld der Unternehmen, verlangen die Kapitalgeber eine immer genauere Plan- und Vorhersehbarkeit über einen mittel- und langfristigen Zeitraum. Unternehmen müssen also Strategien fahren, um die Unsicherheiten systematisch und pro-aktiv in den Griff zu kriegen, den

Unternehmenswert langfristig zu steigern und den Kapitalgebern stabile, überdurchschnittliche Erträge zu verschaffen. Denn die Kapitalmärkte folgen dem einfachen Prinzip der „Creative Destruction[1]“: Unternehmen, welche unterdurchschnittliche Leistung erbringen, werden fallengelassen. Diejenigen aber, welche die Leistung erbringen, werden schnell belohnt. Über die vergangenen Jahrzehnte hat sich gezeigt, dass die große Mehrheit der Unternehmen nicht in der Lage ist, überdurchschnittliche Wachstumsraten aufrechtzuerhalten und sich langsamer als die Finanzmärkte bewegt. Studien belegen, dass etwa 90 Prozent der Unternehmen nicht in der Lage sind, über ein Jahrzehnt hinweg einen Wachstumskurs einzuhalten, der überdurchschnittliche shareholder returns generiert[2]. Dies wird auch durch die Tatsache bestätigt, dass im Fortune Top 100 Ranking nur 26 Prozent der Unternehmen aus dem Jahre 1980 auf der Liste von 2001 wiederzufinden waren. Zu einem großen Anteil ist dies auf das Unvermögen der Unternehmen zurückzuführen, diskontinuierliche Änderungen des Umfeldes zu überwinden[3]. Und eine jüngst veröffentlichte Studie von McKinsey[4] (Devan et al. 2007) kommt gar zum Schluss, dass nicht einmal 1 Prozent der Unternehmen über den Zeitraum von 1994 bis 2004 ein höheres Umsatzwachstum und eine höhere Profitabilität als der Wettbewerb erreichen konnten. Die wenigen nachhaltig erfolgreichen Unternehmen wiesen zwei gemeinsame Merkmale auf: einerseits hatten sie stärker auf organisches Wachstum gesetzt und andererseits wiesen sie überaus hohe market-to-book ratios aus, welche auf das Vorhandensein von hochwertigen „intangible assets“ hinweisen.

Daraus kann man schließen, dass nachhaltig erfolgreiche Unternehmen diese wissensintensiven immateriellen Güter (Urheberrechte, Patente, Brand Franchises, Innovationsfähigkeit) gezielt entwickeln. Sie setzen diese ein, um ihre überdurchschnittliche Leistungsfähigkeit über Jahre hinweg zu sichern. Unternehmen können also nicht mehr „gelegentlich“ Innovationen hervorbringen. Sie müssen pro-aktiv und systematisch mit den Unsicherheiten des Umfeldes umgehen und einen nachhaltigen, möglichst planbaren Ausfluss an Innovationen sicherstellen – trotz der großen Unsicherheiten. Der Hauptmotor ist dabei die Institutionalisierung der Innovationstätigkeit: einerseits wird das aktuelle Angebot systematisch und kontinuierlich verbessert, um kurz- und mittelfristig differenzierende Wettbewerbsvorteile zu zementieren. Andererseits werden diskontinuierliche Potentiale durch radikale Innovationen systematisch vorweggenommen, was langfristig zur pro-aktiven Ablösung der aktuellen Produkte, Technologien oder Geschäftsmodelle führt – sozusagen, bevor es ein anderer tut. So können Unternehmen langfristig überdurchschnittliche Wachstumsraten erzielen und den Unternehmenswert nachhaltig steigern – über die unsicheren und diskontinuierlichen Veränderungen des Umfeldes hinaus.

Der Anteil der Unternehmen, welche ihre Innovationstätigkeit institutionalisieren, ist in den vergangenen Jahren dramatisch gestiegen. Auch die Innovationsvielfalt nimmt in vielen Märkten fast explosionsartig zu. Beispielsweise konnten im Jahre 2006 allein beim VW Golf mehr als eine Million Varianten konfiguriert werden. Zudem haben sich die Imitationszeiten über die vergangenen Jahrzehnte wesentlich stärker verkürzt als die Innovationszeiten. Dies treibt die Routinisierung der Innovation voran: die Gewinnspannen von innovativen Produkten und Dienstleistungen sinken auf ein Preisniveau, das etwa den Kapitalkosten entspricht. Tatsächlich stellen wir fest, dass in vielen Industrien außerordentliche Innovationsrenditen bereits heute die Ausnahme bilden. Innovationen verlieren also an Bedeutung für die Steigerung des Unternehmenswertes, werden aber für dessen Erhaltung unerlässlich.

2. Neuartige unternehmerische Risiken

Die Unternehmensrisiken steigen: Einerseits müssen Unternehmen sich kontinuierlich durch höher- und neuwertige Angebote *differenzieren*, um bestehende Wettbewerbsvorteile zu erhalten. Andererseits müssen sie die *Entwicklungszeiten* drastisch reduzieren, um kurzweilige Potentiale und die damit verbundenen Innovationsprämien vor dem Wettbewerb ausschöpfen zu können. Gleichzeitig müssen Unternehmen *radikale Veränderungen* vorwegnehmen und dadurch aktuelle „strategische Positionen“ ablösen – bevor es der Wettbewerb tut.

Dadurch entstehen besonders in der Produkt- und Technologieentwicklung grundsätzlich neue Risiken für die Unternehmen. Häufig bringt auch eine drastische Zunahme der Investitionen in Innovation den Unternehmen den erhofften Markterfolg nicht. Das Gesetz von Augustine[5] besagt, dass nicht selten Kosten pro Einheit um den Faktor 10 erhöht werden, nur um eine Verschlechterung um den gleichen Faktor zu erzielen. So nahm zum Beispiel bei Airborne Electronic Equipment die Zuverlässigkeit der Produkte (gemessen an der mittleren Betriebsdauer zwischen Ausfällen) mit deren höherem Innovationsgrad und höherer Wertigkeit dramatisch ab. Auch in der Automobilbranche zeigt sich ein ähnliches Phänomen. Trotz der höheren Wertigkeit und des höheren Innovationsgrades hat sich die Anzahl der Einsätze des Pannendienstes des Touring Clubs Schweiz pro 1000 Fahrzeuge seit 1980 wesentlich erhöht. Es scheint, dass die zunehmende Innovationsgeschwindigkeit zulasten der Produktzuverlässigkeit erfolgt. Dadurch entstehen neue Unternehmensrisiken, besonders im Bereich der Produkthaftung und damit neue Versicherungsansprüche für Autofahrer und Automobilproduzenten.

In der Entwicklung von Innovationen werden die Prototyp- und Testphasen zunehmend zum „Bottleneck“. Während die Geschwindigkeit in der Produkt- und Technologie-Entwicklung dramatisch zugenommen hat, konnte die Innovation der Testinstrumente nicht Schritt halten. Gerade im Anlagenbau dauern die Testphasen oft sehr lange und die Testinstrumente sind der zunehmenden Produktkomplexität kaum gewachsen. Die Zunahme der Geschwindigkeit in der Grundlagenforschung und in der Technologieentwicklung generiert neue Technologien, deren Einsatz kaum abschätzbare Risiken in sich bergen. Besonders die „long-tail risks“, die Risiken über den gesamten Lebenszyklus von neuen Technologien, stellen Unternehmen vor bisher unbekannten Herausforderungen. Einerseits sind diese langfristigen Risiken kaum einschätzbar, andererseits werden die schadhaften Auswirkungen der Technologien aber immer genauer messbar und identifizierbar.

1 *Foster, R. und Kaplan, S.* (2001) Creative Destruction. Why Companies That Are Built to Last Unterperform the Market – and How to Successfully Transform Them, New York: Doubleday.

2 *Christensen, C.M. and Raynor, M.E.* (2003) The Innovator's Dilemma, Boston: HBS Press, S. 7.

3 Unter anderen: *Capelli, P. and Hamori, M.* (2005) The New Road to The Top, HB Review, Vol. 83, No 1, pp. 25-33.

4 *Devan, J., Klusas, M. and Reufli, T.* (2007) The Elusive Goal of Corporate Outperformance, The McKinsey Quarterly: www.mckinseyquarterly.com, Web exclusive, April 2007.

5 *Augustine, N.R.* (1983) Augustine's Laws, Reston, Virginia: American Institute of Aeronautics and Astronautics, Inc., S. 56.

wissenschaft aktuell

TEXT Ursula Deplazes, Wolfgang Deplazes, Prof. Roman Boutellier

Wie im Falle von Asbest tritt häufig eine große zeitliche Verzögerung zwischen dem Einsatz dieser Technologien und deren schadhaften Auswirkungen auf. Gemäß der Einschätzung von Standard & Poor's erreicht die gesamte Schadensbelastung durch Asbest bis zu 200 Mrd. USD. Die bislang bekannten versicherten Schadenzahlungen belaufen sich auf etwa 54 Mrd. USD. Es ist unbestritten, dass Unternehmen die Risiken, welche von Asbest ausgehen, unterschätzt haben. Obwohl die langfristigen Risiken von Asbest lange nicht wissenschaftlich nachgewiesen worden waren, stellt sich heute die Frage, ob man – vielleicht geblendet von den enormen Markt- und Innovationspotentialen – „vage" Signale über die Gefahren nicht ignoriert hat. Denn Asbest ist seit dem Altertum bekannt und warnende Signale über potentielle Gesundheitsgefährdungen gibt es fast ebenso lange. Die EU erließ erst 1999 ein allgemeines Asbestverbot.

Ähnliche Gefahren durch Spätfolgen könnten von der Genetik, Robotik oder der Nanotechnologie ausgehen. Die Nanotechnologie macht die Herstellung und Manipulation von Materialien auf molekularem oder atomarem Niveau möglich. Unternehmen in verschiedensten Industrien sehen große Potentiale für die Anwendung von Nanomaterialien. Sie stehen mehr als je zuvor unter Druck, überlebensnotwendige Innovationsgeschwindigkeit gegen Zuverlässigkeit und Sicherheit der Produkte abzuwägen. Die Marktpotentiale sind enorm, die potentiellen gesundheitlichen und wirtschaftlichen Risiken der Nanotechnologie aber äußerst unsicher. Der Druck auf die Unternehmen wächst und damit auch das von innovativen Unternehmen zu tragende Risiko.

3. Umgang mit den neuartigen Risiken

Die ***Wissenschaft*** vertritt keine klare Lehre über die möglichen Folgen und Gesundheitsrisiken der Nanotechnologie. Die Auswirkungen von Nanopartikeln auf die menschliche Gesundheit sind bisher nicht hinreichend untersucht worden. Die Unternehmen sollten aber aus der Vergangenheit lernen und bei ihrer Risikoeinschätzung „frühzeitige Signale" nicht übersehen: einige Studien haben gezeigt, dass Nanopartikel eigenartige biologische Reaktionen hervorrufen und viel toxischer sein können als größere Partikel derselben Chemikalien. Insgesamt betrachtet sind die wissenschaftlichen Ergebnisse aber widersprüchlich und führen zu gegensätzlichen politischen, regulatorischen und unternehmerischen Empfehlungen. Gerade in Situationen großer Unsicherheiten sind wissenschaftliche Ergebnisse aber nicht über jeden Zweifel erhaben. Beispielsweise wurde die östrogenähnliche Wirkung von Bisphenol A seit der ersten Erwähnung in 1936 immer wieder untersucht. Der Toxikologe Frederick vom Saal[6] hat 130 wissenschaftliche Arbeiten untersucht, die sich von 1996 bis 2005 mit den möglichen Wirkungen niedriger Bisphenol A-Konzentrationen befasst hatten. Mehr als 90 Prozent der industrieunabhängigen Untersuchungen wiesen auf Gesundheitsrisiken hin und alle industriegeförderten Forschungen kamen zum gegenteiligen Ergebnis. Die wissenschaftliche Lage bleibt widersprüchlich. Inzwischen ist Bisphenol A eine der meistproduzierten Chemikalien weltweit und wird in der Herstellung von Polycarbonat Kunststoffen, Epoxydharzlacken und Flammschutzmitteln eingesetzt. Es tritt auch in Babyflaschen und Babyspielzeug auf.

Die Akzeptanz von Innovationen in der ***Gesellschaft*** hängt oft von schwer einschätzbaren sozialen Parametern ab und weniger von objektiven Leistungsparametern. Tendenziell wehrt sich die Gesellschaft zunehmend, Unternehmensrisiken zu übernehmen. In Medien und Verbraucherschutzkreisen wird gefordert, dass die Unternehmen gesamthaft für ihre Produkte haftbar gemacht werden und die Risiken in geringerem Maß auf den Staat abwälzen können. Europaweit gewinnen Forderungen nach einer Reform der europäischen Produkthaftungsrichtlinie an Unterstützung. So soll die aktuell rechtlich verankerte Aufhebung der Herstellerhaftung, wenn der vorhandene Fehler nach dem Stand der Wissenschaft nicht erkannt werden konnte, gestrichen werden. Die Beweislast soll zukünftig nicht der Geschädigte, sondern der Verursacher tragen. Die Medien und die Öffentlichkeit allgemein verfolgen diese Thematik sehr kritisch und breit publizierte Schadensfälle heizen diese Diskussion an. In den USA traten im September 2006 E.coli Infektionen nach dem Verzehr von frisch verpacktem Spinat auf. Dies führte zu einer Verzichtempfehlung der Food and Drug Administration und landesweiten, teilweise freiwilligen, Rückrufaktionen. Obwohl die Verunreinigung nicht bei den Spinatproduzenten selbst stattfand, sondern bei der Verpackung, ergaben sich besonders für die ersteren enorme Einbußen: nebst den Umsatzeinbußen, musste aufwändiges Krisenmanagement durchgeführt werden, um die Produkte vom Markt zu nehmen und durch neue zu ersetzen. Die Kosten der Betriebsunterbrechung wurde meist von den Versicherern nicht gedeckt, weil Betriebsunterbrechung im traditionellen Sinn durch Sachschaden verursacht wird. Oft übersteigen aber langfristige Einbußen durch die stark ramponierte Reputation des Unternehmens oder der gesamten Branche die unmittelbaren Kosten des Produktrückrufs und der Betriebsunterbrechung. Dazu kommen Rechtsverfahrenskosten und hohe Schadenersatzleistungen aufgrund der Annahme, dass Unternehmen für Schadensersatzfälle eh versichert sind oder genügend Mittel zur Verfügung haben („deep pockets"). Im Bereich der Konsumgüter, insbesondere der Nahrungsmittel und Bedarfsartikel, geht man auch in Europa von einer Zunahme der Produktrückrufmaßnahmen aus. Dabei müssen die Unternehmen nicht nur mit objektiven, sondern auch mit emotionalen oder gar konstruierten Ursachen rechnen. So wurde das Reinigungsspray „Magic Nano" infolge von Intoxikationen im März 2006 vom deutschen Markt genommen. Obwohl sich herausgestellt hat, dass das Produkt gar keine Nanomaterialien enthielt, wurde eine breite Debatte über die Gefahren der Nanotechnologie ausgelöst. Allgemein kann man feststellen, dass die Unternehmensrisiken im Bereich der Produkthaftung, Produktrückrufe, Betriebsunterbrechungen, Reputationsschädigung, Rechtsverfahren und Schadenersatzleistungen signifikant steigen. Die traditionellen Angebote der Versicherer decken diese teilweise neuartigen Risiken gar nicht oder nur mangelhaft.

Die ***Behörden*** horchen auf. In den meisten Ländern bieten sie den Unternehmen noch kei-

6 University of Missouri-Columbia, Division of Biological Sciences

ne umfassenden regulatorischen Richtlinien hinsichtlich des Umgangs mit Nanopartikeln, beispielsweise im Bereich Arbeitsschutz. Prof. Andreas Hensel, Leiter des deutschen Bundesinstituts für Risikobewertung (BfR), hat zum Beispiel erklärt, dass die Einführung von neuen Technologien in Konsumgütern mit einer Einschätzung der möglichen Risiken verbunden werden muss. Das BfR hat verschiedene Projekte initiiert, um zu untersuchen, ob und in welchem Umfang der Verbraucher mit Nanomaterialien in Kontakt kommt und wie diese Materialien auf den Organismus wirken. Die amerikanische FDA[7] hat mehrere Initiativen lanciert, um die Risiken der Nanotechnologie für Arzneimittel, Nahrungsmittel, Kosmetik und medizinische Instrumente zu untersuchen.

Die ***Versicherer*** verweisen auf die Forschung und Industrie und fordern diese auf, fundierte Erkenntnisse über die Risiken zu erarbeiten. Die Swiss Re[8] vergleicht die möglichen Auswirkungen von Nanotubes auf die menschliche Gesundheit mit denen von Asbest[9]. Es wird den Versicherern empfohlen, die Risiken von Nanotechnologie auf keinen Fall unbegrenzt zu versichern und grundsätzlich maximal abzudeckende Schadenshöhen (Caps) mit den Unternehmen zu vereinbaren. Auch im Bereich der Haftung für Umweltschäden sträuben sich die Versicherer, wenig bekannte Risiken zu übernehmen. Die EU hat bereits im April 2004 die Environmental Liability Directive angenommen, deren Ziel es ist, Umweltschäden durch das sogenannte „polluter pays principle" einzudämmen. Die Umwelt wird als juristische Person betrachtet und die nationalen Regierungen sind gehalten, im Namen der Umwelt Schadensansprüche an den Verursacher zu erheben. Aufgrund des mangelhaften Versicherungsangebotes haben die CEA[10] und die FERMA[11] die Versicherungsgesellschaften aufgefordert, weniger riskavers zu sein. Versicherungsprodukte sollen entwickelt werden, welche die Unternehmen gegen Haftungsrisiken für Umweltschäden schützen. Aber durch die Zeitverzögerung zwischen Inkrafttreten der Direktive und Verfügbarkeit von Versicherungsprodukten werden Unternehmen beträchtliche Risiken in Kauf nehmen müssen.

Die neuen Risiken bleiben also größtenteils an den „innovativen Unternehmen" hängen, welche die enormen Marktpotentiale der Nanotechnologie ausschöpfen wollen. Aufgrund von ähnlich gelagerten Fällen, sind die Unternehmen in ihrer Risikoeinschätzung vorsichtiger geworden. Gerade in Fällen hoher Unsicherheit mit potentiellen Auswirkungen über langfristige Zeiträume, trifft die traditionelle Ansicht, dass der „First Mover" den größten Vorteil einer Innovation für sich beanspruchen kann, immer weniger zu. Unternehmen greifen vermehrt zu Alternativstrategien, um in solchen Fällen langfristig höhere Renditen zu erzielen. Sie warten die Diffusion von neuen Technologien ab und beobachten systematisch „warnende Signale", welche sie dann in der Einschätzung des Risikos eines potentiellen Markteintritts einfließen lassen. So erinnern sich heute die wenigsten an damals radikal innovative Produkte wie die erste Einwegwindel Chux, den ersten Videorekorder Ampex oder etwa den ersten Taschenrechner Berkey. Die heutigen Marktführer haben die Diffusion dieser unsicheren neuen „Technologien" abgewartet, durch systematische Beobachtung „warnende Signale" erfasst und in ihre Entscheidung über den Markteintritt einfließen lassen. Ihr Markteintritt erfolgte im Durchschnitt etwa 13 Jahre nachdem die heute weitgehend unbekannten Pioniere ihre Produkte eingeführt hatten. Man spricht von einem „Fast Follower Advantage".

4. Professionalisierung des Risikomanagements

Aufgrund der veränderten Risikolandschaft gewinnt das Risiko-Management in den Unternehmen an Bedeutung. Im Zentrum stehen nicht mehr die traditionellen Sachrisiken, sondern die zunehmenden Haftungsrisiken (Produkt, Technologie, Reputation, geistiges Eigentum, Umwelt, immaterielle Risiken). Professionelle Risiko-Management Programme nehmen gar die Sicht des Gesamtunternehmens ein. Es werden Strategien entwickelt, um die Risiken, welche die Stabilität von Bilanz, Erfolgsrechnung und Cash Flow gefährden, gesamthaft zu bewältigen. In der Regel werden Kostenvorteile erzielt einerseits durch systematische *Risikoprävention* und andererseits durch die *Reduzierung der Risikokosten*. Diese erfolgt meist durch Selbstversicherung und durch Bündelung von unterschiedlichen Risiken.

Risikomanagement ist nicht mehr ausschließlich der Hoheitsbereich der Finanzmanager und durchdringt sozusagen das gesamte Unternehmen. Die Linienmanager werden vermehrt in die Verantwortung gezogen, ihre unmittelbaren Risiken zu identifizieren und zu reduzieren oder gar systematisch auszumerzen. Wir beobachten bei Unternehmen, dass Prozess-Modellierungen und Re-engineering-Projekte meist nicht nur Effizienz-Gewinne erzielen, sondern auch Risiken in den Kernprozessen des Unternehmens reduzieren. Modellierungen des Innovationsbereichs steigern nicht nur die Innovationsfähigkeit der Unternehmen, sondern beugen auch den systematischen Unternehmensrisiken vor. Die zunehmende Professionalisierung des Risikomanagements und die Risikoprävention in den Unternehmen führen zu einer Reduzierung der Häufigkeit und des Ausmaßes von Forderungen.

Versicherungskosten, und Risikokosten allgemein, machen einen zunehmenden Anteil von Umsatz und Gewinn aus. Sie sind ein wichtiger Hebel, um Kosten zu senken und Erträge zu steigern. Risiko-Manager wägen also vermehrt die zu erwartenden Verluste mit den Prämienkosten ab. Verschiedene Unternehmen haben festgestellt, dass bei *vorhersehbaren* Risiken die Versicherungskosten die erfolgten Auszahlungen auch über einen längeren Zeitraum bei weitem übertreffen. So sind Unternehmen bestrebt, vorhersehbare und quantifizierbare Risiken vermehrt selbst zu übernehmen und aus dem Cash Flow oder über hausinterne Versicherung zu decken („Selbstversicherung"). Im Vergleich zu externen Versicherungsgesellschaften sind die Unternehmen meist in der Lage, ihre traditionellen Risiken besser zu

7 Food and Drug Administration, United States Department of Health and Human Services

8 Die Schweizerische Rückversicherungs-Gesellschaft ist die weltweit größte Rückversicherung mit Hauptsitz in Zürich.

9 *Hett, A.* (2004) Nanotechnologie. Kleine Teile – grosse Zukunft. Zürich: Swiss Reinsurance Company.

10 Comité Européen des Assurances, Brüssel

11 Federation of European Risk Management Associations, Brüssel

▸ TEXT Ursula Deplazes, Wolfgang Deplazes, Prof. Roman Boutellier

quantifizieren und auch häufig auftretende Schadensfälle effizienter intern abzuwickeln. Traditionell hohe Prämienzahlungen sind bei häufig auftretenden, vorhersehbaren Schadensfällen also nicht zu rechtfertigen. So kennen beispielsweise Autovermieter das Schadensaufkommen bei ihren Autos sehr genau und tendieren dazu, dieses vorhersehbare Risiko selbst zu versichern, bzw. direkt aus dem Cash Flow zu bezahlen.

5. Auswirkungen auf die Versicherungsbranche

Die Versicherer kommen also unter Druck, ***vorhersehbare Risiken*** möglichst effizient zu decken, um den Unternehmen eine externe Alternative zur Selbstversicherung und Selbstabwicklung zu bieten. Es gilt, effiziente Abwicklungsprozesse mit tiefen Transaktionskosten zu entwickeln, um Geschwindigkeit und Servicequalität sicherzustellen. Marktvolumina, Preise und Margen für traditionelle Versicherungsleistungen sinken und die Versicherungsgesellschaften können ihren traditionellen Wettbewerbsvorteil der hohen Kapitaldeckung kaum ausspielen. Denn durch das überschüssige Kapitalangebot und die relativ günstigen Rückversicherungsleistungen für vorhersehbare Risiken wird Kapital in diesem Bereich zur Massenware. Dies bereitet den Weg für neue Anbieter mit Prozess-Knowhow und tieferen Transaktionskosten, wie Systembetreiber und andere Dienstleister. Ähnlich wie bei der Abwicklung von Kreditkartengeschäften werden in diesem Bereich effiziente „Prozessfabriken“ Bestand haben.

Bei ***kaum vorhersehbaren*** Risiken ohne statistische Daten bieten die Versicherer oft keinen adäquaten Risikoschutz. Gerade bei den zunehmend bedeutenden Unternehmensrisiken der Produkthaftung, Umwelt und Reputation, können die Versicherer weder die potentiellen Verluste einschätzen noch das Risiko in einem homogenen Kundenpool bündeln. So schließen sie diese Fälle häufig aus *(Abb. 1 „Exclusion“)* oder decken sie nur begrenzt *(Abb. 1 „Caps“)*. Die Unsicherheit treibt auch die Versicherungsprämien in Höhen, welche bereits über wenige Jahre kumuliert die zu erwartenden Schäden übertreffen. Bei fehlender oder ungenügender Risikodeckung durch die Versicherer bevorzugen es die Unternehmen, sich gegen solche Risiken gar nicht zu versichern. Sie halten dagegen mit grundsätzlicher Risikoprävention und der Stärkung ihrer Krisenmanagement- und Rechtsabteilungen. In Fällen großer Unsicherheit greifen Unternehmen auch zu legalen Konstrukten, um das Risiko eingrenzen zu können *(Abb. 1 „Insolvency“)* und ihre Bilanzen zu schützen. Ihnen wird wohl in naher Zukunft auch nicht viel anderes übrigbleiben: beispielsweise steht bereits fest, dass nach der nationalen Umsetzung der EU Richtlinie zur Umwelthaftung aus dem Jahre 2004 die Unternehmen mit großen Unsicherheiten konfrontiert sein werden, da die Versicherer die Entwicklung von entsprechenden Produkten hinauszögern. Obwohl Pharma-Unternehmen das Risiko der Produkthaftung als eines ihrer Hauptrisiken betrachten, decken die Versicherungsgesellschaften diese Risiken nur mangelhaft mit deckungsschwachen Versicherungsprodukten zu exzessiv hohen Prämien. Zahlreiche große pharmazeutische Unternehmen mit mehr als 10 Mrd. USD Umsatz sind heute weitgehend selbstversichert. Dieses brachliegende Potential von unversicherten finanziellen, unternehmerischen oder Sachrisiken wird vermehrt auch von „outside risk takers“ oder dem Kapitalmarkt angegangen. Sie übernehmen Risiken und investieren Mittel, um eine Risikoprämie zu erwirtschaften. Sie machen den Versicherungsgesellschaften ihre Grundfunktion streitig: Unternehmen in Krisenzeiten rasch bedeutende finanzielle Mittel zur Verfügung zu stellen. Investoren federn das Risiko nicht durch Risikobündelung (risk pooling), sondern durch Diversifizierung der Risikopositionen und Reduzierung des Gesamtrisikos ihres Portfolios. „Risikoeinschätzung“ und „rascher Kapitalzugang“ sind wichtige Erfolgsfaktoren im Bereich der schlecht vorhersehbaren Risiken.

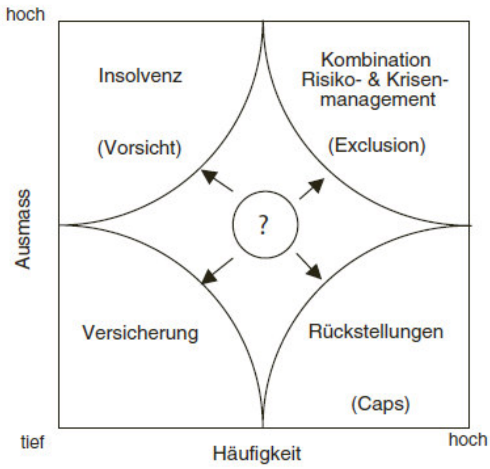


Abb. 1: Unternehmen und Versicherer haben unterschiedliche Auffassungen von Risiko und Risikomanagement

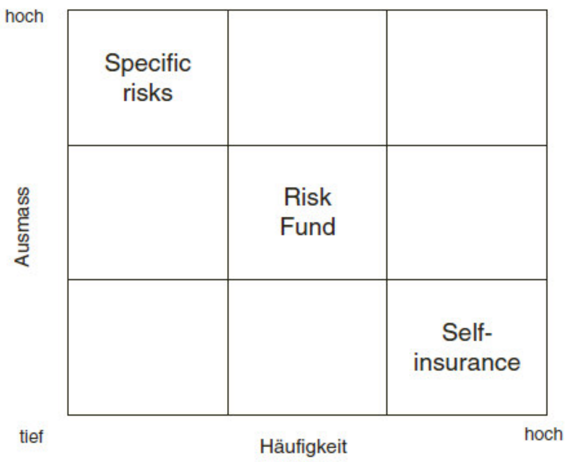


Abb. 2: Unternehmen gruppieren die Risiken in unterschiedliche Segmente

Im Risikomanagement gehen Unternehmen vermehrt weg von einer Einzelbetrachtung der Risiken, welche sie dann durch spezifische Einzelpolicen und Finanzinstrumente abdecken. Sie verfolgen einen gesamthaften Ansatz der Risikobetrachtung: unternehmerische, finanzielle oder Sachrisiken werden in einem Risikoportfolio gebündelt. Das Risikomanagement strebt eine optimale Risikoverteilung zu relativen Kostenvorteilen über das gesamte Risikoportfolio des Unternehmens an. Dadurch entsteht implizit eine differenzierte Betrachtung der Unternehmensrisiken. Grundsätzlich beobachten wir in Unternehmen eine Strukturierung des Risikoportfolios in drei Kategorien: quantifizierbare, häufig auftretende Risiken werden durch *Selbstversicherungslösungen (Abb. 2 „Self-insurance")* abgedeckt. Verschiedenartige Risiken, welche nicht korreliert sind und mittelhäufig auftreten, werden in einem *Risikofonds (Abb. 2 Risk Fund)* gebündelt. Außerordentliche, schwer quantifizierbare Risiken werden zusätzlich durch *spezifischen Risikoschutz (Abb. 2 „Specific risks")* versichert.

6. Herausforderungen für die Versicherer

Diese veränderte Einstellung zu Risiko stellt die Versicherer vor neuen Herausforderungen. Im Bereich der Unternehmensrisiken existiert das Kundenbedürfnis nach spezifischem Schutz von Einzelrisiken kaum mehr. Traditionell bemessen die Versicherer das Risiko aufgrund des Gesetzes der großen Zahlen und der Bildung von Kundenpools mit ähnlichem Risiko. Fälle ohne statistische Daten bewegen sich aber außerhalb dieses Rahmens und werden gar nicht oder nur beschränkt und zu horrenden Prämien gedeckt. Aufgrund von schrumpfenden Märkten, hohem Preis- und Margendruck bei den traditionellen Versicherungsleistungen muss die allgemeine Anwendung dieses traditionellen Ansatzes der Versicherer im Falle von Unternehmensrisiken hinterfragt werden.

Unternehmen betrachten ihre Bedürfnisse nach Risikoschutz gesamthaft und gruppieren diese nach Zeithorizont, Schwere und Häufigkeit des Auftretens in unterschiedliche Segmente. Daraus ergibt sich eine neue Sicht des Marktes auf der Seite der Nachfrage. Dies ändert auch die Spielregeln für die Anbieter. Kritische Erfolgsfaktoren sind weniger die Kapitalstärke und Größe der Versicherer, sondern deren Wissen um Risikoprofile, Finanzierungs- und Servicebedürfnisse der individuellen Unternehmen. Dadurch sehen neue Wettbewerber Potentiale für sich und drängen auf den Markt. Versicherungsgesellschaften stehen grundsätzlich folgende Grundoptionen und deren Kombinationen offen *(Abb. 3)*:

Option I: Prozessfabrik

Häufig auftretende und quantifizierbare Schadensfälle kennt das Unternehmen oft sehr genau über einen kurzfristigen Zeithorizont von etwa 1 Jahr. Um eine Prämie für die Deckung von bekannten Risiken einzufordern, muss das Unternehmen Prozess-Know-how aufbauen und seine Transaktionskosten optimieren. Denn Erfolgsfaktoren in diesem Segment sind optimierte Prozess-, Abwicklungs- und Transaktionskosten bei gleichzeitig optimierter Effizienz, Geschwindigkeit und Qualität. Es geht also darum, Prozessfabriken zu errichten und Skaleneffekte zu erzielen. Wichtigste Wettbewerber der Versicherer in diesem Bereich sind (1.) Selbstversicherung durch die Unternehmen, (2.) neue „Service-Anbieter", welche sich auf Prozesseffizienz in der Abwicklung spezialisiert haben, (3.) Dienstleister für gesamte Service-Lösungen wie zum Beispiel Risk Management, Policen- und Schadensabwicklung.

Option II: Risiko- & Deckungsstrukturierer

Schadensfälle mit mittlerer Häufigkeit und mittleren Verlusten werden über einen Zeitraum

wissenschaft aktuell

▸ TEXT Ursula Deplazes, Wolfgang Deplazes, Prof. Roman Boutellier

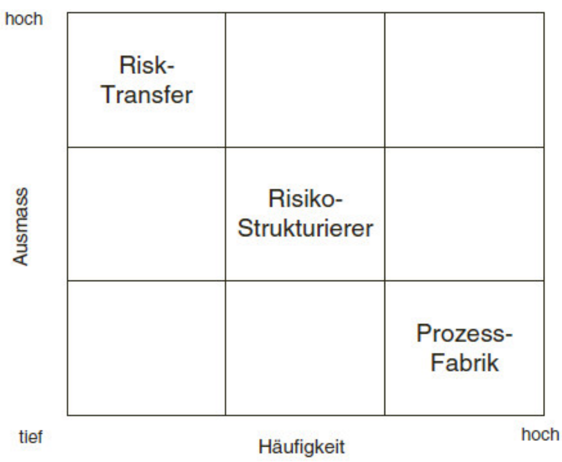


Abb. 3: Versicherer müssen segmentspezifische Angebote entwickeln

von 5 bis 10 Jahren betrachtet. Es geht im wesentlichen darum, den optimalen Mix zwischen Selbstversicherung und traditioneller Deckung für einen individuellen Kunden über einen mittelfristigen Zeitraum zu finden. Dabei werden Risiken und deren Deckung so strukturiert, dass die Volatilität externalisert wird und das Unternehmen über einen längeren Zeitraum einen stabilen Aufwand hat. Erfolgsfaktor in diesem Bereich ist detailliertes und individuelles Kunden-Know-how, etwa über Risikoprofil, Schadenshistorie etc. In den angelsächsischen Ländern ist diese Art von Risiko- und Deckungsstrukturierung weit verbreitet. So konnte Columbia Energy Services ihre Marktstellung stärken, indem sie sich gegen die Volatilität des Gaspreises absicherte. Columbia Energy Services wurde dadurch in die Lage versetzt, ihren Kunden einen stabilen Preisband anzubieten und deren Gewinnprognosen um einen entscheidenden Volatilitätsfaktor sicherer zumachen. Aufgrund von Wetterparametern und Marktpreis von Gas wurden Korridore festgelegt, innerhalb welcher das Unternehmen selbst das Risiko übernimmt. Übersteigen die volatilitätstreibenden Parameter jedoch den festgelegten Korridor, sind Entschädigungen entweder zugunsten oder zulasten des Unternehmens fällig. Ähnliche Konstellationen sind in verschiedenen Industrien möglich. In Zusammenarbeit mit Versicherungsgesellschaften können Unternehmen auf sie zugeschnittene Versicherungen abschliessen, welche ihnen ermöglichen, sich gegen die Volatilität des Unternehmensgewinnes und die Unsicherheiten des Geschäfts zu schützen. Versicherungsgesellschaften bauen Wissen auf, welches sie Unternehmen von verschiedensten Branchen zur Verfügung stellen können. In wetterabhängigen Industrien zum Beispiel besteht großes Potential. So können Anbieter von touristischen Dienstleistungen – wie z.B. Skiorte – ihre Unternehmensgewinne vor dem entscheidenden Volatilitätstreiber „Wetterfaktor“ schützen.

Option III: Risikoumwandler/Risk Transfer

Kaum vorhersehbare Risiken, welche selten auftreten, aber sehr hohe Forderungen zur Folge haben können, werden für die Unternehmen immer akuter – beispielsweise in den Bereichen der Produkthaftung, Katastrophen, Betriebsunterbrechung. Die Deckung der eingetretenen Schadensfälle verlangen kurzfristig die Mobilisierung von großen Kapitalmengen. Erfolgsfaktoren für potentielle Anbieter sind Größe, Kapitalstärke, Wissen um Finanzierungsinstrumente, Risiko-Management. Im Vergleich zu den reiferen Versicherungsmärkten wie den USA, ist dieses Segment in Europa stark unterentwickelt. Risiken, welche von Produkten, aber auch von Computer Systemen und Umwelt ausgehen, gewinnen aber auch in Europa an Aktualität. Anbieter, welche sich in dieses Segment drängen sind die Investmentbanken, welche durch Finanzinstrumente die globalen Kapitalmärkte als Quelle für die Finanzierung von Risiken anzapfen. Beispiele sind Umweltrisiken wie Hurricanes oder vereinzelt auch Terrorismusrisiken. So zum Beispiel die Hurricane Bonds oder vereinzelt Terrorismus und Umwelt.

Veränderungen im Umfeld der Unternehmen führen zu einer Veränderung des Versicherungsmarktes. Es bildet sich eine neue Marktstruktur heraus mit unterschiedlichen Segmenten, welche aufgrund von Zeithorizont, Risikoarten, Key Buying Factors und Erfolgsfaktoren voneinander entkoppelt sind. Versicherer müssen traditionelle gleichmacherische Erfolgsrezepte aufgeben und differenzierte Strategien wählen, um die rasant zunehmenden Potentiale auszuschöpfen. *Die Autoren analysieren die Treiber der neuartigen Unternehmensrisiken anfangs des 21. Jh. und deren Auswirkungen auf die Nachfrage nach Risikodeckung.* Es werden anstehende Veränderungen auf dem Versicherungsmarkt erörtert sowie sich daraus ergebende Herausforderungen für die Versicherer und entsprechende strategische Handlungsoptionen.

12.8 Unternehmensdesign als Herzstück der Firmenstrategie

Deplazes U, Deplazes W and Boutellier R (2007) Unternehmensdesign als Herzstück der Firmenstrategie. io new management. 12:33-37

Unternehmensdesign als Herzstück der Firmenstrategie

Die Unternehmensstrategie anzupassen ist noch kein Garant für Innovation. Oftmals ist eine Neustrukturierung der Organisation notwendig. __VON URSULA DEPLAZES, WOLFGANG DEPLAZES UND ROMAN BOUTELLIER

In Kürze **Traditionelle Managementkonzepte stossen angesichts der neuen Herausforderungen des 21. Jahrhunderts an Grenzen. CEOs sind gefordert, ihre Unternehmensmodelle gesamthaft auf deren Strategietauglichkeit zu überprüfen. Der Artikel analysiert die wichtigsten neuen Herausforderungen an der Schnittstelle zwischen Strategieentwicklung und Unternehmensdesign, welche entscheidende Potenziale und Risiken bergen: Zunehmende Komplexität, Routinisierung der Innovation und diskontinuierliche Entwicklungen. Es wird ein methodischer Ansatz vorgestellt, wie Unternehmensmodelle systematisch entwickelt werden können, um diese Herausforderung zu überwinden und die Unternehmensstrategien konsequent zu implementieren.**

URSULA DEPLAZES, *M.Sc. LSE, M.Sc./lic.oec. HEC, ist externe Doktorandin am Institut für Technologie und Innovationsmanagement an der ETH Zürich. udeplazes@ethz.ch*

WOLFGANG DEPLAZES, *M.SC./lic. oec. HEC, ist externer Doktorand am Institut für Technologie und Innovationsmanagement an der ETH Zürich. wolfgang.deplazes@mac.com*

PROF. DR. SC. MATH. ROMAN BOUTELLIER *ist ordentlicher Professor für Technologie- und Innovationsmanagement am Departement für Management, Technologie und Ökonomie der ETH Zürich. rboutellier@ethz.ch*

Technologie-Entwicklung, kürzere Produktlebenszyklen, verstärkter Wettbewerb und differenzierte Kundenbedürfnisse bieten neue Potenziale, setzen aber auch viele Unternehmen zunehmend unter Druck. Um Wachstum zu erzielen, müssen Firmen schneller innovative Angebote entwickeln und mehr Märkte mit einer grösseren Produktvielfalt bedienen. Komplexität scheint also unweigerlich mit Wachstum einherzugehen. Sie beeinträchtigt aber auch die Leistungsfähigkeit der Unternehmen, die über komplexe Organisationen, aufwändiges Krisenmanagement und mangelnde Innovationskraft klagen.

Fokus auf Unternehmensdesign

Traditionelle Managementrezepte setzen meist punktuell an und stossen an Grenzen. CEOs sind gefordert, Unternehmensmodelle gesamthaft zu hinterfragen und ihre Organisationen so aufzustellen, dass die neuen strategischen Potenziale gehoben werden können.

Dabei zerfliessen die Grenzen zwischen Strategieentwicklung und Unternehmensdesign immer mehr. Einige Autoren sprechen gar davon, dass Unternehmensdesign «zum Herzstück der Strategie» wird. Drei zentrale Herausforderungen an der Schnittstelle zwischen der Unternehmensstrategie und dem -design bergen neue Chancen und Risiken: Zunehmende Komplexität, Routinisierung der Innovation und diskontinuierliche Entwicklungen.

Komplexität reduzieren

Neue Märkte, Produkte, Kunden und Produktionsstätten fördern Wachstum, erhöhen aber auch die Komplexität im Unternehmen und bremsen dessen Leistungsfähigkeit. Dies zeigt sich beispielsweise in einer zunehmenden Anzahl von Schnittstellen und Prozessen, einem hohen Koordinationsaufwand, verspäteten Markteinführungen aufgrund von langen Entwicklungszeiten und steigenden Kosten in Produktion und Vermarktung.

Häufig wenden Unternehmen eine Vereinfachungsstrategie an, um der wuchernden Komplexität beizukommen: Man redimensioniert Produkt-, Kunden- und Lieferantenportfolios, stellt geografische Expansionen in Frage und richtet die Organisation eindimensional produktbasiert oder geografiebasiert aus. Entwicklungsvorhaben werden vermehrt aus der Primärorganisation ausgelagert, um sie vor den Auswirkungen der Komplexität zu schützen. Eine solche Strategie kann Skaleneffekte gefährden, Gewinnpotenziale zerstören und zukünftiges Wachstum untergraben. Nach einer Untersuchung des Economist haben 50 Prozent aller Unternehmen nach solchen Eingriffen mehr Probleme als vorher: Die besten Leute verlassen das

Komplexität, Routine und Entwicklung bieten sowohl Chancen als auch Risiken.

Unternehmen und die Aktienkurse sinken.

Ein Beispiel: Ein internationaler Konsumgüterhersteller büsste nach einer aggressiven Expansionsphase deutlich an Durchschlagskraft ein. Die Manager beschwerten sich, einen Grossteil ihrer Zeit in aufwändigen Koordinationsmeetings verbringen zu müssen. Das operative Geschäft fing an zu leiden und strategische Initiativen wurden verspätet eingeführt. Dies führte zu signifikanten Umsatzeinbussen. Eine geografische Refokussierung der Firma brachte keine merkliche Verbesserung. Aufgrund der Unternehmensstrategie und einer systematischen Strukturierung der Komplexität wurde ein neues Unternehmensmodell entwickelt. Es erlaubt dem Unternehmen, trotz breiterer Produkt- und Kundenvielfalt, kürzere Entwicklungszeiten und nachhaltiges Wachstum zu erzielen.

An der Schnittstelle zwischen Unternehmensstrategie und -design muss man Komplexität differenziert angehen, denn es gibt wertvermehrende und wertvernichtende Komplexität. Einfacher ist nicht immer besser, wie schon Einstein bemerkte.

Innovation routinisieren

Miniaturisierung und Modularisierung treiben die Entwicklung von Produktarchitekturen in fast allen Industrien voran. Sie führen zu einer wachsenden Anzahl von Modulen, die sich fast beliebig kombinieren lassen. Die Innovationstätigkeit vieler Unternehmen beschäftigt sich mit der Realisierung von solchen Kombinationsmöglichkeiten, um Kundenbedürfnisse präziser zu treffen. Dies bedarf weniger einer unternehmerischen «Kreativitätsleistung» als einer möglichst effizienten «Fleissleistung». Ein grosser Teil der Innovationstätigkeit kann – analog zum Produktionsprozess – systematisch abgewickelt werden, das heisst, mit einer strukturierten und wiederholbaren Abfolge von definierten Aktivitäten mit definiertem Output. Damit wird der Innovationsprozess bezüglich marktentscheidender Leistungsgrössen steuerbar. Diese «Routinisierung» der Innovationstätigkeit ist die Voraussetzung für einen kontinuierlichen Ausfluss an neuen Produkten.

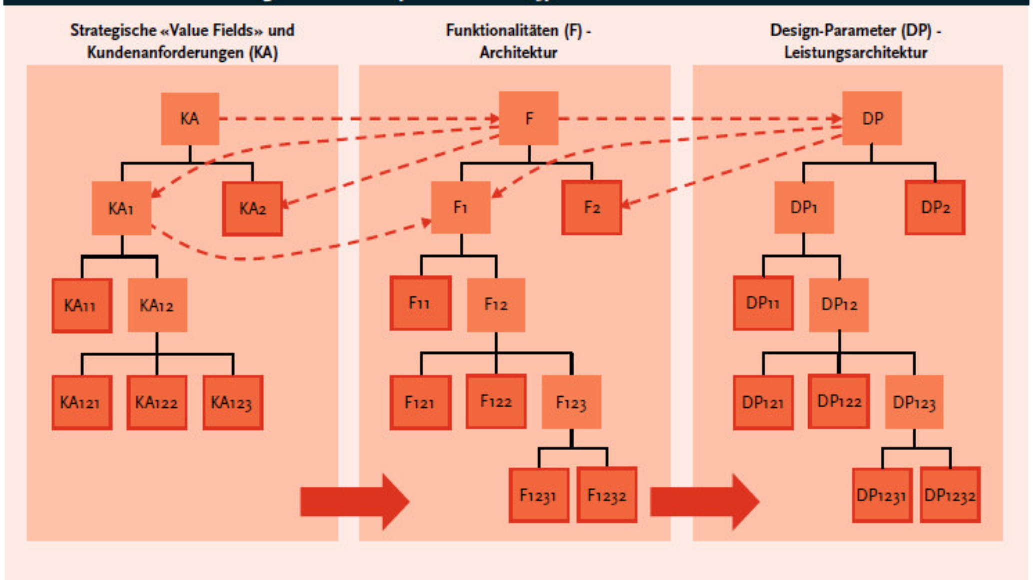
Traditionelle Ansätze des Projektmanagements entsprechen selten diesem Anspruch. Sie führen oft zu unsicheren Innovationstrefferquoten, langen Entwicklungszeiten, überfüllten Innovationspipelines mit zahlreichen konkurrierenden Vorhaben und aufwändigem Projektportfolio-Management. Unternehmen verabschieden sich deshalb vermehrt von projektorientierten Ad-hoc-Organisationen und implementieren prozessbasierte permanente «Innovationsfabriken». Sie gründen auf dem Zusammenspiel von modular definierten Prozessen mit durchgängigen, aufeinander abgestimmten und zeitlich entkoppelten Innovationsroutinen. Durch eine solche Innovationsfabrik konnte ein Süsswarenhersteller die Entwicklungszeiten von 24 auf 6 Monate reduzieren. Trotz geringerer Komplexität in der Organisation wurde die Produktvielfalt um ein Vielfaches erhöht. Ein führender Mobiltelefonhersteller und ein internationaler Konsumgüterhersteller haben diese routinisierte Innovationstätigkeit im operativen Geschäft angesiedelt und steuern sie wie die übrigen operativen Geschäftsprozesse. Dabei entstehen keine radikalen Neuheiten, aber doch Innovationen, die den Kunden passen und dem Unternehmen erlauben, aktuelle strategische Positionen kurz- und mittelfristig zu sichern.

Radikale Innovationen generieren

Vergleichbar mit CIM, TQM oder Lean Management in den Achtziger- und Neunzigerjahren, wird routinisiertes Innovationsmanagement in vielen Industrien zu einem Muss. Um langfristig Wachstum zu erreichen, reicht es aber nicht, das aktuelle Angebot systematisch und kontinuierlich zu innovieren. Technologieentwicklung, Globalisierung und Konvergenz von Märkten und Technologien bieten diskontinuierliche Potenziale, welche zur Ablösung der aktuellen Produkte, Technologien oder Geschäftsmodelle führen können. Erfolgreiche Unternehmen haben Wege gefunden, diese Potenziale systematisch aufzuspüren und in marktfähige Produktkonzepte umzusetzen. Dies erfolgt in sogenannten «Innovationsateliers».

So hat Ciba Vision in den Neunzigerjahren neben der kontinuierlichen Verbesserung der konventionellen Kontaktlinsen in getrennten organisatorischen Einheiten neue Produkte und Herstellungsprozesse entwickelt. Das Unternehmen stärkte damit seine Stellung im konventionellen Kontaktlinsengeschäft und generierte gleichzeitig genügend Mittel, um radikale Innovationen (Tages- und Langzeitlinsen) zu entwickeln. In zehn Jahren hat Ciba Vision den Umsatz ver-

Abb. 1: Iteratives Vorgehen im «Zig-Zag» zur Bestimmung der Architekturen der Kundenanforderungen, Funktionalitäten und Design-Parameter (nach Suh 2005)



Ausgangspunkt für den Design-Prozess sind kundenorientiert strukturierte Value-Fields. Mittels der Funktionalitäten-Architektur werden die Design-Parameter definiert. Aus der resultierenden Leistungsarchitektur lässt sich dann die Prozess-Architektur des Unternehmens ableiten.

dreifacht und in einigen Segmenten Marktführerschaft erlangt. Das Unternehmen hat ein weltweites Netz von kleinen und mittelgrossen «Innovationsateliers» geschaffen, um radikale Innovationspotenziale zu identifizieren und marktfähige Konzepte zu entwickeln.

Ein Fallbeispiel

Der vorgeschlagene Unternehmensdesign-Ansatz basiert darauf, dass Organisation die Implementierung der Unternehmensstrategie ermöglichen soll. Oder anders ausgedrückt: Unternehmensdesign stellt die Konsistenz zwischen Strategie und Organisation sicher. Das folgende Beispiel basiert auf einem realen Fall, der Name der Firma ist indes fiktiv. Der Unternehmensdesign-Ansatz wurde bei Main Ltd., einem Logistik-Dienstleister im Bereich der Instandsetzung, angewandt. In der Gründungsphase hatte die Firma auf ein zentralistisches Unternehmensmodell gesetzt. Die hohe planerische Komplexität lag in der Obhut einiger weniger Schlüsselpersonen in der Unternehmenszentrale. Die Geschäftsführung erkannte aber die Grenzen des zentralistischen Modells angesichts des geplanten Wachstums. Ein neues Unternehmensmodell sollte die strategischen Wachstumsziele unterstützen. Zur Entwicklung eines strategiegerechten Unternehmensmodells wurde ein Design-Vorgehen in drei Schritten gewählt:

Zunächst werden aufgrund der Unternehmensstrategie die «Value Fields», die Produkt-Marktbereiche ermittelt: Die bestehenden Wettbewerbsvorteile sollen durch höherwertige Angebote verstärkt werden. Die inkrementellen Veränderungen der bekannten Ausgangslage ergeben sich durch Extrapolation. Zusätzlich werden durch Methoden der Retropolation auch radikale Veränderungen angegangen. Diese können zur Ablösung von aktuellen Produkten, Technologien oder Geschäftsmodellen führen: Zukünftige Märkte ergeben Hinweise für neue Produkte.

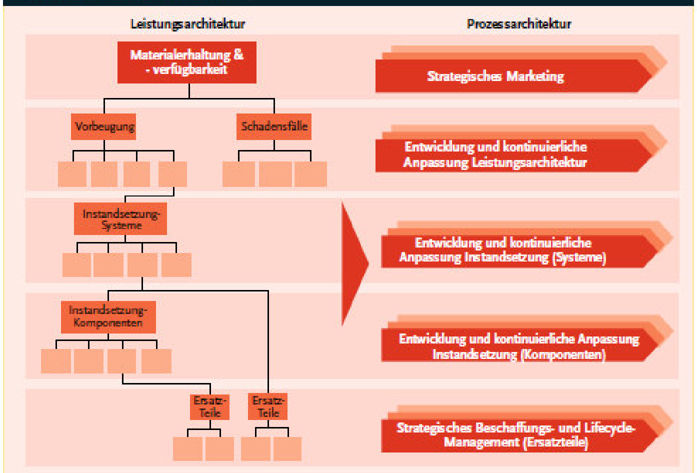
Im nächsten Schritt wird eine Prozessarchitektur entwickelt, welche die «Value Fields» optimal abdeckt. Da sich die extrapolierten und retropolierten «Value Fields» stark unterscheiden, werden unterschiedliche Architekturen von Kundenanforderungen gebildet. Dazu werden die jeweils passenden Funktionalitäten und modularen Designparameter ermittelt. Es entstehen «Leistungsarchitekturen», auf deren Grundlage die «Prozessarchitekturen» für die innovative Tätigkeit des Unternehmens definiert werden. Dabei kommt ein iteratives Zig-Zag-Verfahren (siehe Abbildung 1 auf Seite 35) zum Einsatz, welches der Komplexitäts- und Designtheorie (Suh 2005) entlehnt wurde. Es stellt sicher, dass die Prozessarchitektur die wertvermehrende Komplexität systematisch fördert, damit das Unternehmen die strategischen «Value Fields» optimal ausfüllen kann. Abbildung 2 auf dieser Seite zeigt die Ableitung der Prozessarchitekturen für die «Innovationsfabrik». Die Prozessarchitektur für das «Innovationsatelier» wird analog aufgrund der retropolierten «Value Fields» ermittelt.

Dann gilt es, die in der Prozessarchitektur definierten Prozessbereiche zu modellieren. Anschliessend wird die Organisation prozessbasiert aufgestellt (siehe Abbildung 3 auf der rechten Seite). Auch Verantwortlichkeiten, Zuständigkeiten und die Ressourcen-Anforderungen werden prozessbasiert definiert. Die notwendigen Fähigkeiten sollen gezielt dort entwickelt werden, wo sie aus gesamtunternehmerischer Sicht den grössten Nutzen erbringen.

Für Main Ltd. ist es noch zu früh, um Verbesserungen quantitativ zu belegen. Doch bereits in der Einführungsphase zeichnen sich Vorteile des neuen Unternehmensmodells ab:

1. Die modular eingegrenzten Verantwortungsbereiche mit den zugehörigen Planungs-, Steuerungs- und Ausführungsaufgaben ermöglichen eine eigenverantwortliche Steuerung und Optimierung der Prozesse. Dadurch werden Mehrspurigkeiten vermieden, Skalen- und Lerneffekte

Abb. 2: Systematische Ableitung der Prozessarchitektur für die Innovationsfabrik



Die Innovationsfabrik stellt einen kontinuierlichen Ausfluss an Innovationen sicher.

systematisch realisiert, Fähigkeiten gezielt entwickelt und Wissen dezentral aufgebaut.

2. Angesichts des sich abzeichnenden Konkurrenz- und Preisdrucks stellt eine massgeschneiderte «Innovationsfabrik» die laufende Überprüfung und Verbesserung der aktuellen Leistungen sicher.
3. Das «Innovationsatelier» versetzt das Unternehmen in die Lage, neue Fähigkeiten und Angebote zu entwickeln, welche über die traditionellen Logistikdienstleistungen hinausgehen. Als Output liefert es radikale Innovationen auf Ebene «proof-of-concept». Diese werden über die Innovationssteuerung an die Innovationsfabrik für die «Industrialisierung» und anschliessende kontinuierliche Verbesserung übergeben.
4. Die systematische Abstimmung von Strategie, Prozessen und Anforderungen an HR, Systemen und Infrastruktur beseitigt eine wichtige Quelle wertvernichtender Komplexität: Systeme und Ressourcen, die nicht den Prozessanforderungen entsprechen, wurden angepasst oder aufgegeben.

CEOs sind sich einig, dass profitables Wachstum langfristig nicht ausschliesslich aufgrund von Effizienz-Programmen, Akquisitionen und «gelegentlichen» Produktinnovationen erfolgen kann. Sie wollen ihre Unternehmensmodelle gesamthaft hinterfragen und auf Strategietauglichkeit hin ausrichten. Da traditionelle Managementkonzepte dabei häufig an ihre Grenzen stossen, erhalten neue und pragmatische Ansätze von Unternehmensdesign wachsende Aufmerksamkeit. Die hier angewandte Design-Methode dient der Entwicklung von Unternehmensmodellen, die einen kontinuierlichen Ausfluss von Innovationen generieren. Dadurch werden einerseits aktuelle strategische Positionen mittelfristig gesichert und andererseits langfristiges profitables Wachstum über Markt- und Technologiezyklen hinweg ermöglicht.

Literatur

Boutellier, R.; Deplazes, U.; Deplazes, W. (2007): *How to Innovate beyond Discontinuity. An Integrated Approach Based on the Concepts of «Innovation Factory» and «Innovation Atelier». CINet Conference, Gothenburg, Schweden.*

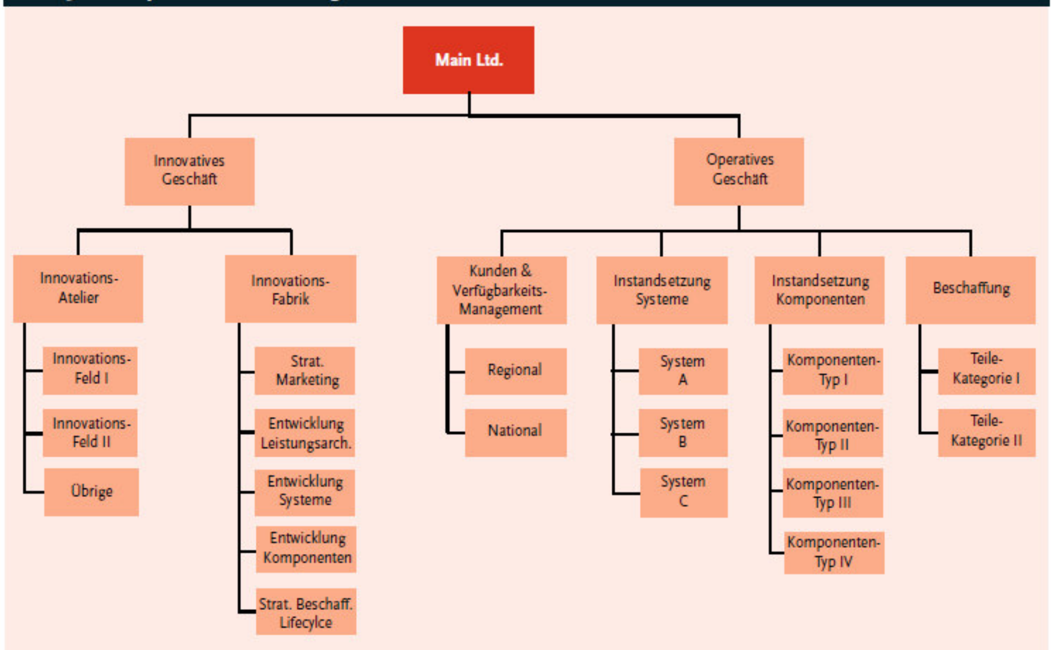
Boutellier, R.; Deplazes, U.; Löffler, K. (2007): *Model of Technology Foresight. An Innovative Approach. IEMC Conference (IEEE), Austin, Texas.*

Brian, L.; Joyce, C. (2007): *Mobilizing Minds: Creating Wealth from Talent in the 21st Century Organization. McGraw-Hill, New York.*

Suh, P. S. (2005): *Complexity Theory and Applications. Oxford University Press, New York.*

Suter, A. (2004): *Die Wertschöpfungsmaschine. Wie Strategien ihre Stosskraft entwickeln. Edition «io new management», Verlag Orell Füssli, Zürich, für Verlag Industrielle Organisation.*

Abb. 3: Neue prozessbasierte Organisation von Main Ltd.



Die Vorteile: Geringe Komplexität, zielgerichteter Aufbau von Wissen, höhere Planungssicherheit, optimierter Ressourceneinsatz und ein strategiegerechter kontinuierlicher Ausfluss an Innovationen.

12.9 Making Business Design the Heart of Strategy

Boutellier R, Deplazes U and Deplazes W (2007) Making Business Design the Heart of Strategy – The Strategic Importance of Innovation Factories & Ateliers. Proceedings of CINet Conference

MAKING BUSINESS DESIGN THE HEART OF STRATEGY

- THE STRATEGIC IMPORTANCE OF INNOVATION FACTORIES & ATELIERS

Prof. Roman Boutellier[1], Ursula Deplazes[1], and Wolfgang Deplazes[1]

[1]Swiss Federal Institute of Technology, Zurich, Switzerland

wolfgang.deplazes@mac.com

ABSTRACT

The paper presents a comprehensive approach of Business Design illustrated by a case study. Business Design is seen as a process guiding the systematic design of organizations, which allow the company to implement its strategy. The authors start with a brief analysis of the changes in the business environment and their implications for company strategy. Based on this, they describe the generic 'functional requirements' organizations have to fulfil: operate, explore and exploit. After a brief analysis of the intersection of company strategy and organization, the phenomenon of complexity is analysed. A thorough literature review leads to the introduction of the concept of 'relative complexity' as opposed to 'absolute complexity'. A definition of complexity in the context of Business Design is the basis for the development of a set of design principles fundamental to the approach of Business Design chosen by the authors. The approach is then explained and illustrated with a case study in the last section. The concepts of 'Innovation Factory' and 'Innovation Atelier' are introduced.

Keywords: Complex systems; Innovation management; Organization management; Business modelling; Organizational design.

1. ENVIRONMENTAL CHANGES

Globalization of markets and competition, fundamental changes in the economic and political landscapes, progressing deregulation, technological innovation and ecological awareness are driving profound changes in the business environment in terms of scale, pace, complexity and uncertainty. Across industries, the degree of competitiveness is increasing. This is evidenced by mounting price pressure on traditional offers, frequent market entrances of disruptors with novel business models generating greater value for core customers, and accelerating innovation cycles leading to shrinking innovation premiums both, in amount and duration. Companies are constrained to overcome the complex challenge of having to develop innovative offerings at an increasingly fast pace to serve an increasing number of markets with an increasing variety of products at decreasing price premiums. This opens a widening gap between the exponential increase of performance requirements and the linear development of corporate organizations:

On the one hand, the population engaged in consumption and production has grown by three bio. over the past 15 years. The number of products and services in the global economy has grown over ten billion – more than the number of species on the planet, as Beinhocker (2006) estimates. And many companies have already seen dramatic increases in the variety of products and services they offer, the number of countries they operate in and the sophistication of the demands made by their customers. On the other hand, this came at the price of increased complexity and significant organizational inertia: companies are stuck with organizational structures designed for the industrial age and focusing on operational effectiveness to maximize return on capital invested – the scarce resource in past times. Traditional approaches to tackle the increasing complexity are based on simplification and drastic cost cutting. While these seem to ease the pressure of costs resulting from complexity in the short-term, gains are seldom sustainable and often jeopardize profit opportunities and future growth.

In the face of exponentially increasing performance requirements, traditional organizations progress only in a linear fashion and seem to reach their systemic limits. While this would require a comprehensive look at the fundamentals of their organizations, many CEOs seem to turn to "high visibility" measures such as "ad hoc structural change, the big acquisition, or a focus on where and how to compete" (Bryan and Joyce 2007:21). However, the attention given to the widening gap between performance requirements and organizational capacity is increasing among practitioners and scientists. Overcoming organizational inertia and closing this gap fast might very well become the prime competitive field at the beginning of the 21st century. Some authors even see the need for CEOs to make Business Design "the heart of strategy"(Brian and Joyce 2007:21) in order to create durable competitive advantage.

2. Impact on Strategy

To secure a continuous flow of innovations companies tend to focus on incremental investments offering improvements relative to a known top- and baseline. Returns on such investments become quite predictable and risks can be managed more reliably. We observed two ways of dealing with this challenge:

2.1 Institutionalization of Innovation

Enterprises abandon the single-project mindedness fostered by traditional approaches of project management: development times tend to be excessively long, innovation pipelines crowded and innovative outcomes do not systematically meet customer requirements. These drawbacks can partially be made up by multi-project management practices. These adopt a cross-project view and aim at coordinating a large number of complex innovation projects with varying objectives, lead-times and maturities. It allows for the realization of synergies and economies of scale, while taking into account the uniqueness of the individual projects. More recent approaches, however, go beyond multi-project management and structure innovation activities in analogy to other operative processes, such as the manufacturing process. In *"Innovation Factories"* the innovation process is structured, based on varying competences and time-horizons, into an architecture of processes following a sequence of pre-defined steps. In this way, a predictable flow of innovations can be generated and managed based on clear key performance indicators. Investments in innovation become thus transparent and compete against other investments such as in manufacturing and marketing. This approach often involves the development of product platforms incorporating the latest incremental advances in technology. Such routinized innovation systems have "everything to do with organization and attitude and very little to do with nurturing solitary genius" (Hargadon and Sutton 2000:157). They can easily be replicated outside the company and thus offer only short-lived competitive advantage. By analogy to the fate of other prominent management practices such as 'TQM', 'project management' and 'lean management', we advocate that 'routinized' innovation will soon be widely adopted. It will lose its importance as a source of noteworthy competitive advantage and simply become a must for long-term survival. While some companies are still struggling to institutionalize their innovation activities, successful companies are managing incremental innovation as part of their operative businesses. The strategic importance of continuous improvements of current offerings relates less to building competitive advantage and securing future growth, then to securing differentiation and current competitive positions. A CEO of an international consumer goods company confirmed that in a fast changing business environment "this kind of innovation is a must for the survival of just any company" (Deplazes and Deplazes 2007).

2.2 *CRISIS-DRIVEN DISRUPTIVE INNOVATION*

In an increasingly competitive environment, however, companies' strategies aim at leveraging existing core competencies beyond the boundaries of current markets and create new competitive space. However, as Clayton Christianson describes in "The Innovator's Dilemma" (2003), the longer companies enjoy market dominance, the more difficult it becomes for them to recognize and productize new and disruptive technologies. Studies show that most companies struggle with this "organizational inertia". CEOs confirm that imminent "crises" are in many cases the primary driver for more radical innovation activity. An increasing number of large companies revert to acquisitions. They integrate smaller companies that already developed innovative technologies into their existing business. As a reaction to rising revenues from online advertising, Yahoo! acquired Overture and thus managed to secure its competitive position against Google. Following the increasing uncertainty of "one-size fits all, blockbuster offerings" and the mounting pressure of "personalized medicine", the Swiss pharmaceutical firm Roche recently made a series of acquisitions to enhance the value of its targeted cancer therapies. This includes the take-over of 454 Life Sciences which makes gene-sequencing technology, NimbleGen, which makes technologies used in identifying the genetic causes of disease, and the recently announced hostile take-over bid for Ventana Medical Systems, a diagnostics firm (The Economist 2007:61-62).

2.3 *STRATEGY UNDER UNCERTAINTY*

In a discontinuous environment companies need to find ways to pre-empt innovative opportunities rather than react to crisis after crisis. Courtney et al. (1997) warn that "underestimating uncertainty can lead to strategies that neither defend a company against the threats nor take advantage of the opportunities that higher levels of uncertainty may provide". This contrasts with traditional approaches to strategy development based on the assumption that the environment develops along a fairly predictable continuity. Companies therefore need to develop their strategies in a perspective of discontinuity and uncertainty.

Courtney et al. (1997) advocate that "even the most uncertain business environments contain a lot of strategically relevant information" (1997:67). They developed an approach guiding managers to more informed and confident strategic decisions in uncertain business environments. First, they differentiate between "knowable" and "residual" uncertainty. Knowable uncertainty can be accounted for by doing the right analysis. Thus, performance attributes for current technologies, elasticities of demand for stable categories of products, and competitors' capacity-expansion plans fall into this category of "knowable" uncertainty. With regard to "residual uncertainty", Courtney et al. define four broad levels: (i) *Clear-Enough Future*, which can be understood based on a single forecast; (ii) *Alternate Futures*, in situations where a few discrete outcomes define the future; (iii) *A Range of Futures*, when there are no natural scenarios, but a range of possible outcomes; (iv) *True Ambiguity*, where there is no basis to forecast the future. From the business design perspective adopted in this article, it is important that in uncertain business environments companies can take three strategic postures (or a combination of them): (i) *Shape* the future by playing a leadership role in establishing how the industry operates, e.g. by setting standards or creating demand. (ii) *Adapt* to the future by winning through speed, agility, and flexibility in recognizing and capturing opportunities in existing markets. (ii) *Reserve* the right to play by investing sufficiently to stay in the game, but avoid premature commitments. We conclude that changes in the business environment require companies to widen their strategic perspective beyond continuity to include opportunities offered by higher levels of uncertainty. This "dual" perspective widens the range of "functional requirements" towards organizations, which traditionally are built for operative efficiency grounded on the "continuity paradigm".

3. REQUIREMENTS TO ORGANIZATIONAL STRUCTURES

Organizations face a conflictual challenge between the requirement to secure efficiency of existing operations and the requirement to create the kind of environment that will permit new ideas to flourish – and eventually increase the rate of what Joseph Schumpeter called "creative destruction". Based on the above (ch. 2), we conclude that organizational structures are faced with three generic functional requirements. These have to be taken into account in the process of business design:

3.1 OPERATE AND EXPLOIT

Strategic objectives based on "continuity" assumptions define a clear framework for the requirements to organizational structures. These have to *operate* within and *exploit* this clearly defined framework. Organizational structures are thus based on the concepts of convergent action, risk minimization and operational effectiveness. They are designed to ensure the predictable achievement of clearly defined goals: volume and turnover, continuous flow of innovative products, costs, quality, lead-times. Business design will focus on clear responsibilities, standardization, interface engineering, unambiguous measurement systems. At the same time, organizational structures have to be flexible enough to react to variations between the assumed framework and the actual market development. In terms of operating, they will have to be able to accommodate for unpredicted short-term variations in market demand, cost developments, capacity utilization and availability of materials. In terms of exploiting, organizational structures need to allow for speed and agility in recognizing and capturing incremental opportunities. Incremental improvements to the actual offerings have to be developed fast to secure current competitive positions.

3.2 EXPLORE

Strategies based on "discontinuity" assumptions define ranges of potential developments and levels of preparedness. Organizational structures are therefore required to *explore* systematically these ranges and ensure the necessary rate of creative destruction. For perspective, Foster and Kaplan (2001:49) associate the rate of creative destruction within a corporation with its continued long-term competitiveness and performance. They advocate that "the fundamental concepts of operational excellence are inappropriate for a corporation seeking to evolve at the pace of the markets". Organizational structures are thus based on concepts such as fostering creativity and divergent thinking. From a business design perspective it is important to note that "one cannot just 'add on' creation and destruction, one has to design them in". Similar views are expressed by authors on "ambidexterity", the organization's ability to meet the requirements of a dual innovation strategy encompassing its exploitative and explorative dimensions (among others O'Reilly and Tushman 2004).

The challenge in the process of business design is to align the varying and often contradictory demands of the two types of innovation activities while securing operational effectiveness. "In the end, both divergent and convergent thinking must successfully coexist" (Foster and Kaplan 2001:50). This cannot be achieved by making simple adjustments or by "designing uniform systems that have to be implemented, throughout a corporation, independent of the business" (Foster and Kaplan 2001:51). Business design will have to adopt a comprehensive view of the organization based on the company's strategy. And the corporate level will be in charge of integrating the "operate", "exploit" and "explore" dimensions of the organization and align them with the company's strategy. These are in fact the strategic building blocks leading to sustained long-term performance of a company.

4. Requirements to Business Design and Methodology

Research has shown that about 90 percent of companies were not able to generate growth over a decade and generate above-average shareholder returns (Christensen and Raynor 2003:7). Only 26% of companies on the Fortune Top 100 Ranking of the year 1980 could still be found on the list of 2001. To a large part, this can be traced back to the inability of companies to overcome discontinuous changes of the environment (among others Capelli and Hamori 2005). Their organizational set-ups appear to be an important barrier to achieve the strategic objectives. In some cases organizational inertia is so massive that it jeopardizes future growth and threatens the survival of the company. Thus, the topic of business design has been receiving a great deal of attention among practitioners and scientists. For a detailed literature review and discussion on "business design", "business modeling", "business model design" and "organizational design", we refer to Deplazes and Deplazes (2007). We adopt a holistic view of the business organization. Thus, Business Design is seen as a formal, guided process for structuring organizations, integrating human resources, information and technology with the focal point being the company strategy. The process of Business Design has therefore to make sure that organizations are designed to achieve the functional requirements of "operate", "exploit" and "explore" as detailed in the strategic objectives.

The article aims at closing a dual gap: On the one hand, the concepts of uncertainty, ambidexterity and discontinuous innovation are well-documented in literature, but we are not aware of a systematic Business Design approach linking organizations to business strategies. On the other hand, practitioners understand the relevance of these concepts, but often fail when implementing them in their organizations. The article aims at addressing this gap and outlines a theoretical framework and a systematic approach to Business Design. The research approach chosen is based on action research (Lewin 1946) specified by Kubicek (1975) as 'research by development'. Practitioners and scientists jointly designed and implemented the concept proposed in this paper: the theoretical concept was designed based on explorative research (literature review combined with interview-based case studies). Subsequently, it was applied and further developed action research based case studies, one of which is illustrated in the article. We started off by analyzing the main challenges at the intersection between strategy and organizational design: Complexity, Routinization and Discontinuization. For a detailed discussion of this intersection, we refer to Deplazes and Deplazes (2007). For the purposes of this article, we would like to focus on the phenomenon of complexity.

5. COMPLEXITY

5.1 *RELEVANCE FOR BUSINESS ORGANIZATIONS*

New markets, products, customers and production facilities are associated with growth. But they also drive the complexity within companies and weaken their effectiveness. Traditionally, companies revert to simplification strategies to cope with this proliferating complexity: portfolios of products, customers and suppliers are restructured, geographic expansions scrutinized, organizations structured one-dimensionally based on product categories or geography. Such strategies of complexity reduction might yield short-lived cost savings, but will most probably also jeopardize economies of scale, destroy profit potential and undermine future growth opportunities. After an aggressive expansion phase into Central and Eastern European markets, a German consumer goods manufacturer reported a drastic decrease of the company performance. Managers were complaining about having to spend a significant amount of their time in coordination meetings. As a consequence, the operative business suffered and strategic initiatives reached the market with significant delays. Eventually, revenues and market shares came under pressure. At first, the company shied away from fundamental changes and introduced an international matrix organization combined with a geographical re-positioning. This did, however, not yield the benefits hoped for. And the company realized that its new strategy would lead to new levels of complexity, which even sophisticated "add-ons" to the current business model would not be able to handle. In fact, the strategic complexity had to be "designed into" the company's business model. Therefore, a systematic and comprehensive approach to designing the business model was chosen. Based on the company's strategy, sources of complexity were identified in a comprehensive manner: productive complexity associated with the growth strategy of the company were structured into the business model, while unproductive complexity had to be avoided. Despite broader product and customer portfolios, the new business model allowed the company to achieve shorter development times and realize its strategy of sustained growth in Eastern Europe.

5.2 *APPROACHES TO COMPLEXITY*

Numerous approaches to complexity have been developed in a variety of scientific disciplines. There is, however, no established and generally accepted theory. In our attempt to define a comprehensive approach to business design, we thus needed to better understand the phenomenon of complexity. After a thorough literature review had produced a variety of possible understandings of complexity, we looked at typologies to define an understanding of complexity for the purposes of Business Design. Based on this, we defined a set of basic design principles in view of coping with complexity.

5.3 *UNDERSTANDINGS OF COMPLEXITY*

Our literature review shows that there are a multitude of understandings of the phenomenon of complexity. On the one hand, the understandings of complexity vary based on the scientific discipline they relate to: For instance, Whitesides and Ismagilov (1999) describe some aspects of the phenomenon in chemistry, while Weng, Bhalla and Lyengar (1999) focus on biology, specifically, biological signalling systems, and Koch and Laurent (1999) in neurosciences. On the other hand, a closer look at a selection of authors in fields relevant to organizational studies (Fig. 1) shows that understandings of complexity are mostly driven by the authors' specific research interests. For instance, Simon (1988) is focussing on the structure of complex systems without determining in detail how complexity should be measured. Suh (2005; 2006) is viewing complexity in the context of designing systems to achieve a certain goal. His understanding of complexity focuses on the extent to which a system does or does not satisfy the goals it was set up to achieve. Complexity according to Suh (2005; 2006) is a measure of the inefficacy of a system.

5.4 TYPOLOGIES OF COMPLEXITY

The next step in our attempt to understand the phenomenon of complexity was to classify these multi-facetted understandings into typological categories. In his typology of complexity, Rescher (1998) focuses on the epistemic, ontological and functional dimensions of complexity. He covers approaches adopted up to the 1990s, which typically view complexity in "absolute" terms. Suh (2005) refers to this "search for an 'absolute measure' of complexity" as the one "common thread in these earlier approaches" (Suh 2005:13). Complexity is for instance measured by the amount of components of a system (see constitutional complexity in Fig. 2). The more components, the more complex the system is considered to be.

These absolute measures and understandings of complexity are quite "simple" to understand. However, applied to the context of business design, they might be "simplistic" suggesting that more complexity is worse than less complexity. In fact, managers tend to see complexity as something that makes life unnecessarily difficult and therefore needs to be reduced or eliminated. As seen above, complexity is also associated with company growth and can be a vital source of competitive advantage. Therefore, we could not adopt this absolute view of complexity within the context of business design and had to look for a more differentiated view. In fact, in the context of business environments, complexity appears to be contingent upon certain external factors, which cannot be influenced or reduced in the process of business design. We were looking for a "relative" notion of complexity.

In his theory of complexity, Suh advocates a "definition of complexity as a relative quantity". (Suh 2005:4). Complexity is viewed as being contingent upon certain factors exogenous to the complex system under consideration. Systems are designed to meet certain pre-determined objectives. Therefore, Suh's measure of complexity is contingent upon the goals the system is set up to achieve. The higher the extent to which a system does not achieve its goals, the more it is complex. According to Suh (2005 and 2006), a given system might be more complex than another in terms of constitutional complexity, but less complex in terms of its "relative" complexity. This type of "relative complexity" could be termed as "teleological complexity". More recently, Bryan and Joyce (2007) also seem to adopt a relative perspective on complexity. They differentiate "productive" from "unproductive" complexity based on its contribution to the value of the company. Complexity is seen as "productive" when it produces value. A company will thus adopt different strategies according to the type of complexity it encounters. It will "remove unproductive" (Bryan and Joyce 2007:24) and foster productive complexity. We refer to this type of "relative complexity" as "value-related complexity".

5.5 IMPLICATIONS FOR BUSINESS DESIGN

In our attempt to develop a comprehensive approach to Business Design, we adopt a relative view of complexity. The "teleological" dimension relates to the "value" complexity generates, more specifically towards achieving the company's strategic objectives. In the process of Business Design, complexity has therefore to be identified based on the company's strategy and structured such as to (i) eliminate "unproductive complexity", and (ii) systemically foster "productive complexity". The company's strategic objectives become the focal point in the process of Business Design.

For perspective, there are several theories explaining the mechanisms underlying the enhancement of complexity, among others, the Intelligent Design Theory, the Inherent Teleology Theory and the Chance-Plus-Self-Perpetuation Theory" (Rescher 1989:4-5). Based on the common understanding, that complexity in organizations develops exponentially, we adopt insights of the "Self-Potentiation Theory". It states that "complexity is in its own inherent nature self-propagating. (…) once present it clambers up upon itself to achieve yet higher levels of complexity" (Rescher 1989:6). From a perspective of business design it becomes therefore key to avoid unproductive complexity right from the outset. This is confirmed by our experience in a variety of business design exercises. We conclude that (i) during the process of business design, compromises to accommodate for political or personal concerns should only be made after clearly understanding the opportunity costs associated in terms "self-potentiating" complexity which generates "self-potentiating" costs and (ii) a comprehensive and fundamental exercise of Business Design often results in less interference for then frequent cost-cutting exercises yielding mostly temporary benefits.

5.6 Principles for Business Design

Based on the above, we were able to define some basic principles for a comprehensive approach to Business Design (see Deplazes and Deplazes (2007) for more details).

5.6.1 Business Organizations have a "Parts-in-Parts Structure"

We view business organizations as complex adaptive systems. These are artefacts moulded, by goals, to environments in which they live (Simon 1996). They are adaptive and reflect characteristics of the environment (e.g. complexity) according to the design's objectives. The appropriate design will therefore take into account relevant characteristics of the outer and of the inner environment. From a systemic point of view, social systems have a "parts-within-parts structure" (Simon 2003:17). This latter is hierarchical with different levels of subsystems. "Hierarchies have the properties of near decomposability" (Simon 2003:28). Thus, interactions within subsystems are strong and interactions among them are weak. Structuring complex systems is therefore about "separating the high-frequency dynamics of hierarchy (internal structure of the components) from the low-frequency dynamics (interaction among components)" (Simon 2003:28). The intensity of interaction between the sub-systems appears to be a key lever of Business Design. Pending on the strategic objectives, a system can be structured in a way such that some sub-systems are more loosely and others rather tightly coupled. (i) *Tightly coupled processes* are associated with a managerial preference for controlling their activities tightly. Activities are seen from an integrative perspective to achieve overall cost efficiencies. However, business designs based on tightly coupled processes are inflexible and adapt slowly to an unstable environment. (ii) *Loosely coupled processes* allow companies to unlock the full value of specialization and gain the flexibility to make operational changes quickly. The organization becomes thus more adaptive to a changing environment. Efficiencies are gained through specialization within the company and its network. The case of Main. Ltd. (ch. 7) shows the benefits of a fundamental switch from a tightly coupled centralized structure to a loosely coupled and decentralized organization: in an uncertain environment, Main Ltd. increased customer satisfaction, reduced delivery times and secured availability of spare parts while significantly decreasing working capital. Additionally, the learning effect associated with specialization will allow for continuous improvement of the current offering and eventually drive costs down.

In our approach to business design, we structure complex systems as "parts-within-parts" hierarchies. Simon (2003) points out that this enables human beings with only bounded rationality to assess complex systems. From a perspective of Business Design it makes complexity understandable and offers transparency for decision-making.

5.6.2 ORGANIZATIONS ARE DESIGNED TO MEET FUNCTIONAL REQUIREMENTS

"Complexity theory is applicable to the design of engineered systems and to understanding of the behaviour of natural systems such as biological systems" (Suh 2005:18). According to Suh "complexity must be defined in the 'functional domain', not in the 'physical domain'" (Suh 2005:4). Physical systems, their constituents and the physical interaction among them do not determine complexity. Business design is thus about truly understanding the goals to be achieved, i.e. the strategic objectives of the company. Then, it is about designing all elements of the business model so that these goals will be achieved. Thus analysing a company's innovation processes and interfaces between processes does not give an idea of the complexity of the system. The analysis has to start somewhere upstream in another "domain". Suh's theory is based on the principles of axiomatic design. It differentiates four design worlds: The design process starts with the *Customer Domain* and iteratively progresses via the *Functional Domain* and the *Physical Domain* to the *Process Domain*. From a business design perspective, the approach chosen will secure the consistency between the company's strategy and its process architecture, based on which the organizational set-up results. For a detailed discussion on process-based organizations, we refer to Deplazes & Deplazes (2007).

Fig. 3 illustrates the approach guiding designers through the four domains of the design world. It is based on the concepts of "*mapping*" and "*zigzagging*": (i) Mapping: the designer will come to a structure of the Process Domain by proceeding step by step from the customer attributes {CA} in the Customer Domain to the functional requirements {FR} in the Functional Domain. Then, he will proceed to the design parameters {DP} in the Physical Domain and eventually come to process variables {PV} in the Process Domain. Mapping is done from the left domain (i.e. what we want to know or achieve) to a domain on its right (i.e. how we hope to satisfy the "what"). The process is iterative in the sense that the designer can go back to the domain on the left based on the ideas generated in the right domain. (ii) *Zigzagging* refers to what happens between two adjacent pairs of domains: while decomposing customer attributes {CA} into a hierarchy of higher- and lower-level attributes, the business designer uses a technique called "zigzagging" to iteratively map between the adjacent design domains of customer attributes {CA} and functional requirements {FR}. Then he gradually proceeds decomposing and zigzagging between the next adjacent pairs of domains, i.e. {FR} and {DP}, and subsequently {DP} and {PV}. This design process will help the designer to identify independent, uncoupled (or at least decoupled) design parameters. Design specifications will thus be reduced to their simplest components. This is how one could qualify 'good' designs.

6. Business Design Approach and Case Study

The Business Design approach adopted is based on a pragmatic view, that organization has to allow for the implementation of the company's strategy. As part of our action-based research, the approach is currently applied, fine-tuned and further developed in a variety of cases. Main Ltd., a leading logistics company specialized in the field of maintenance of weapons systems is one of them. Its successful expansion phase was enabled by a centralistic business model, which concentrated the highly complex planning tasks in a few key functions at the company's headquarters. In the face of future growth, however, management clearly recognized the limitations of the centralistic model and looked for alternative models allowing for the aggressive expansion strategy.

6.1 Identification of "Strategic Value Fields"

Based on the above, we proceeded to define a set of basic principles guiding us in The process of Business Design started off by identifying "*strategic value fields*" based on the company's strategy: on the one hand, current competitive advantages should be secured with a continuous flow of improvements and higher-value offerings. These incremental changes were detected using methods of extrapolation. On the other hand, radical changes had to be pre-empted, even if they could lead to the substitution of current products, technologies or business models. These "radical value fields" were detected using methods of retropolation. For a more detailed discussion of "extrapolation" and "retropolation" we refer to Boutellier, Deplazes and Löffler (2007).

6.2 Designing by "Mapping" and "Zigzagging"

In a second step, the company's process architecture was designed to allow for an optimal coverage of the identified "value fields". Based on the significant differences and requirements the extrapolated and retropolated "value fields" were structured in different architectures. Following the design principles outlined above, we proceeded by structuring the customer requirements based on which – via zigzagging across the functional requirements and the design parameters – the process architecture was designed. Thus the consistency between the process architecture and the strategic objectives was systematically secured. The process architectures for the operative business and the Innovation Factory were designed based on the extrapolated "value fields", while the process architectures for the Innovation Atelier was designed based on the retropolated "value fields". In a matching procedure both routes of design were continuously scrutinized for redundancies and potential economies of scope and scale. Based on the process architectures, the organization was detailed along with responsibilities, competences, capabilities and other resource requirements. The necessary capabilities are be developed decentrally where they produce most value from an overall perspective. Eventually, a migration plan was developed before proceeding to the implementation phase.

6.3 Evaluation and Outlook

Based on the above, we proceeded to define a set of basic principles guiding us in At this point it is too early to verify the approach with quantitative results. However, during the early implementation phase several benefits of the new model became apparent: (i) The modularly defined areas of responsibility integrate the tasks of planning, steering and executing. Thus continuous feed-back is materialized and allows for systemic learning. Separately, redundancies decreased dramatically allowing for the realization of economies of scope and scale. (ii) The cyclical approach in planning, steering and execution cycles allows for increasing planning stability, availability of spare parts, optimization of resource and capacity utilization. There are also indications that costs, lead-times and quality can be improved significantly. (iii) In the face of threatening competition and price pressure, the custom-designed "Innovation Factory" will allow for continuous improvements of the current offerings. (iv) Profound changes in the business and market environment will be pre-empted and countered by the "Innovation Atelier". It will enable the company to develop new capabilities and offerings, which go beyond the traditional logistics services. (v) Finally, the consistency among company strategy, processes and system requirements allowed to eliminate an important source for cost-driving complexity: systems which do not meet requirements from the business processes.

REFERENCE

Beinhocker, E. D. (2006) *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics*, Boston: Harvard Business School Press.

Blecker, T. and Abdelkafi, N. (2006) *Complexity and Variety in Mass Customization Systesm: Analysis and Recommendations*, Management Decision, Vol. 44, No. 7, pp. 908-926.

Boutellier, R., Deplazes, U. and Löffler, K. (2007) *Model of Technology foresight: An innovative Approach*, Austin, Texas: IEMC Conference (IEEE), to be published in Aug. 2007.

Bryan, L. and Joyce, C. (2007) *Better Strategy through Organizational Design*, The McKinsey Quarterly, 2007, No. 2, pp. 21-29

Christensen, C. M. and Raynor, M. E. (2003) *The Innovator's Dilemma*, Boston: HBS Press.

Courtney, H., Kirkland, J. and Viguerie (1997) *Strategy Under Uncertainty*, Harvard Business Review, Nov-Dec 1997, pp. 67-79.

Courtney, H. (2001) *Making the most of uncertainty*, The McKinsey Quarterly, 2001, No. 4, pp. 39-47

Deplazes U. and Deplazes W. (2007) *How CEOs change their View on Innovation*, ETH Zurich: to be published 11/2007.

Deplazes U. and Deplazes W. (2007) *At the Intersection of Strategy and Business Design – The Phenomena of Complexity, Routinization and Discontinuization* ETH Zurich: to be published 11/ 2007.

Devan, J., Klusas, M. and Ruefli, T. (2007) *The Elusive Goal of Corporate Outperformance*, The McKinsey Quarterly: www.mckinseyquarterly.com, Web exclusive, April 2007

Foster, R. and Kaplan, S. (2001) *Creative Destruction*, The McKinsey Quarterly, 2001, No. 3, pp. 41-51

Hamel and Prahalad (1994) *Competing for the Future*, HBS Press.

Hargadon, A. and Sutton, R. (2000) Building Innovation Factory, HB Review, May-June, pp.157-166

Kaplan, S. and Henderson, R. (2005) *Strategic entrepreneurship: Creating competitive advantage through streams of innovation*, Organization Science, Vol. 16 No. 5, pp. 509-521

O'Reilly, C.A. and Tushman, M. L. (2004) *The ambidextrous organization*, HB Review, April, pp. 74-81

Rescher, N. (1998) *Complexity. A philosophical Overview*, New Brunswick: Transaction Publishers.

Stüttgen, M. (2003) *Strategien der Komplexitätsbewältigung in Unternehmen. Ein interdisziplinärer Bezugsrahmen*. Bern: Haupt Verlag.

Simon, H. A. (1996) *The Sciences of the Artificial*, Cambridge: The MIT Press.

Suh, P. S. (2005) *Complexity Theory and Applications*, New York: Oxford University Press.

Suh. P. S. (1990) *The Principles of Design*, New York: Oxford University Press.

The Economist (2007) *Beyond the Blockbuster*, Vol. 383, No. 8535, pp. 61-61

ATTACHMENTS

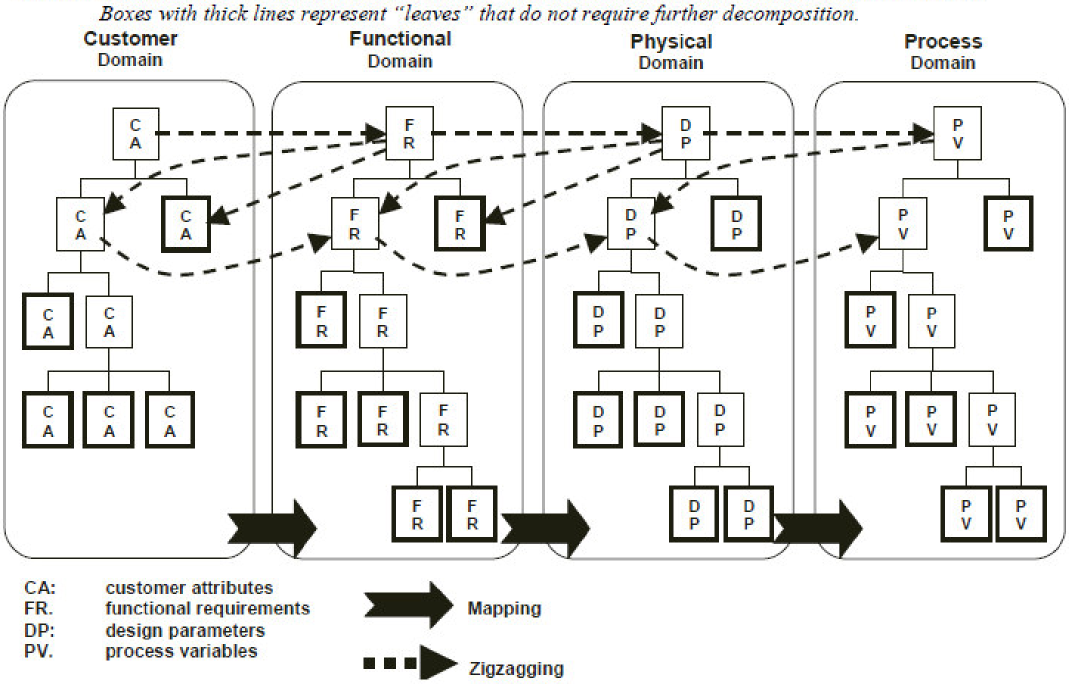
Fig. 1 'Understandings' of complexity (based on Blecker 2006:909; Stüttgen 2003:18-21)

Author	Approach to complexity
Shannon (1948)	System entropy
Ashby (1958)	System variety (i.e. the number of different states the system can assume)
Von Hayek (1972; 1975)	Number of parts and their interactions Diversity of relationships between the parts
Patzak (1982)	Number and diversity of the parts as well as of the relationships between the parts
Chaitin (1987)	Algorithmic complexity
Bennett (1988)	Logical depth
Simon (1988;…)	Structure based on nested sub-systems
Gomez, Malik and Oeller (1975); Gomez (1978; 1981); Gomez and Probst (1997)	Descriptiveness of the system Number of parts and their interactions
Suh (2005; 2006)	Degree of uncertainty in achieving a set of design goals
Bryan and Joyce (2007)	Extent of contribution to increasing the value of the company

Fig. 2 Types of complexity (according to Rescher 1998:9)

Types of Complexity (C)			Description
Epistemic Characteristics	Formulaic C	1. Descriptive C	Length of the account that must be given to provide an adequate description of the system at issue.
		2. Generative C	Length of the set of instructions that must be given to provide a recipe for producing the system at issue.
		3. Computational C	Amount of time and effort involved in resolving a problem.
Ontological Characteristics	Compositional C	1. Constitutional C	Number of constituent elements or components.
		2. Taxonomical C (Heterogeneity)	Variety of constituent elements: number of different kinds of components in their physical configurations.
	Structural C	3. Organizational C	Variety of different possible ways of arranging components in different modes of interrelationship.
		4. Hierarchical C	Elaborateness of subordination relationships in the modes of inclusion and subsumption. Organizational disaggregation into sub-systems.
Functional C		5. Operational C	Variety of modes of operation or types of functioning.
		6. Nomic C	Elaborateness and intricacy of the laws governing the phenomena at issue.

Fig. 3 Mapping & Zigzagging across the 4 domains of design *(adapted from Suh 2005:27)*
Boxes with thick lines represent "leaves" that do not require further decomposition.



12.10 Umsetzung einer dualen Innovationsstrategie

Deplazes U, Deplazes W and Boutellier R (2007) Von der Umsetzung einer dualen Innovationsstrategie. Swiss Innovation Guide. 10-13

Bild: iStockphoto.com/Alwyn Cooper

Von der Umsetzung einer dualen Innovationsstrategie

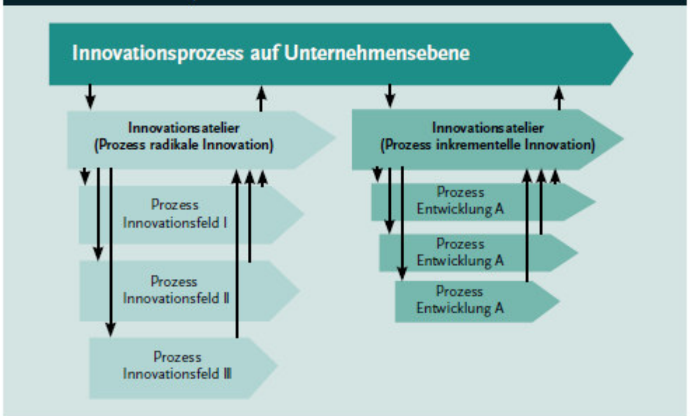
Innovationsstrategien Innovationsfähigkeit und Innovationseffizienz gehören zu den Top-Prioritäten von CEOs weltweit. Die Autoren führen aus, was es zur erfolgreichen Umsetzung braucht. _VON URSULA DEPLAZES, WOLFGANG DEPLAZES UND ROMAN BOUTELLIER

Es sind nicht die inkrementellen Innovationen, die nachhaltige Wettbewerbsvorteile bieten. Sie sind in vielen Industrien ein «Muss» für das Überleben eines Unternehmens. Zahlreiche Ansätze von Innovationsmanagement basieren auf dualen Innovationsstrategien: Einerseits wird ein regelmässiger, planbarer Ausfluss von inkrementellen Innovationen generiert. Andererseits müssen radikale Innovationspotenziale ausgelotet werden, um zukünftige strategische Positionen aufzubauen.

Seit Jahren gehören «Innovationsfähigkeit» und «Innovationseffizienz» zu den Top-Prioritäten von CEOs weltweit. Die Anforderungen an die Innovationsfähigkeit der Unternehmen ändern sich aber angesichts der Veränderungen des Marktumfeldes. Traditionelles Innovationsmanagement fokussiert darauf, Wettbewerbsvorteile durch inkrementelle Produkt- und Prozessinnovationen (d.h. durch Verbesserung der aktuellen Produkte und Prozesse) zu konsolidieren. Im Zeitalter von Globalisierung, diskontinuierlichen Entwicklungen, grosser Technologiegeschwindigkeit und Routinisierung der Innovation sind «gelegentliche» inkrementelle Innovationen nicht ausreichend. Für das Überleben eines Unternehmens wird eine systematische Innovationsfähigkeit unverzichtbar. Vermehrt richten Unternehmen ihr Innovationsmanagement so aus, dass ein kontinuierlicher und planbarer Ausfluss von inkrementellen Produktinnovationen entsteht.

Um jedoch über einen längeren Zeitraum erfolgreich zu bleiben, reicht auch ein kontinuierlicher Ausfluss solcher Innovationen nicht aus. Zusätzlich müs-

Prozessarchitektur, Innovationsfabrik und Innovationsatelier



sen Unternehmen Wege finden, um diskontinuierliche Markt- und Technologie-Entwicklungen vorwegzunehmen: Radikale Innovationen sollen zukünftige strategische Positionen aufbauen – über Markt- und Technologiezyklen hinaus. Zahlreiche Unternehmen verfolgen heute zumindest ansatzweise solche «dualen Innovationsstrategien», allerdings nur mit geringem Erfolg. So belegen Studien, dass die grosse Mehrheit der Unternehmen nicht in der Lage ist, über ein Jahrzehnt hinaus Wachstum und überdurchschnittliche Renditen zu erzielen.

Eine jüngst veröffentlichte Studie von McKinsey (Devan et al.) bestätigt, dass nicht einmal 1 Prozent der Unternehmen über den Zeitraum von 1994 bis 2004 ein höheres Umsatzwachstum und eine höhere Profitabilität als die Mitbewerber erreichen konnten. Dies wird meist auf die Unfähigkeit der Unternehmen zurückgeführt, neben kontinuierlichen Verbesserungen auch diskontinuierliche Markt- oder Technologie-Veränderungen zu bewältigen. Dabei spielt die organisatorische Aufstellung im Bereich Innovation eine entscheidende Rolle. Denn häufig verhindert die bewährte Organisation die Implementierung einer neuen dualen Innovationsstrategie. «Betriebsblindheit» baut auf bisher erfolgreiche Rezepte und verfolgt allenfalls inkrementelle Verbesserungen. Sie gefährdet aber gleichzeitig zukünftiges Wachstum, das auf radikalen Innovationssprüngen beruht.

Roman Boutellier ist Professor für Technologie- und Innovationsmanagement an der ETH Zürich. www.ethz.ch

Einige Unternehmen haben Ansätze entwickelt, um diesem Dilemma zu entkommen. Dabei haben sich sechs wesentliche Ansätze durchgesetzt:

1. Innovationsmanagement als Grundkompetenz

Unternehmen erwirtschaften einen immer grösseren Anteil ihres Umsatzes mit neuen Produkten und Dienstleistungen. In einigen Industrien bieten Innovationen kaum mehr Wettbewerbsvorteile, da sie rasch imitiert werden. Ausserordentliche Innovationsrenditen sind rar und die Gewinnspannen von innovativen Produkten und Dienstleistungen sinken auf ein Preisniveau, das den Kapitalkosten entspricht. Kontinuierliche Innovationen sind also eher eine Grundvoraussetzung für das Überleben eines Unternehmens als ein eigentlicher Wettbewerbsvorteil. So betrachten erfolgreiche Unternehmen den Innovationsprozess im inkrementellen Bereich nach ähnlichen Gesichtspunkten wie die operativen Produktions- und Logistikprozesse. Prozesse sollen plan- und steuerbar, möglichst effizient und «lean» sein.

Investitionen in Innovation werden dadurch transparent und konkurrieren mit Investitionen in Produktion oder Vermarktung. Dabei ist immer weniger entscheidend, ob die Entwicklung der Innovation intern erbracht oder extern beschafft wird. Novartis hat sich beispielsweise zum Ziel gesetzt, bis 2010 etwa 50 Prozent des Umsatzes mit «fremden Produkten» zu realisieren, über In-Licensing und externe F&E-Leistung.w

2. Duale Innovationsstrategie für langfristige Performance

Um Wachstum und Profitabilität auch langfristig sicherzustellen, verfolgen erfolgreiche Unternehmen Strategien, die inkrementelle Innovationen fördern, um aktuelle Wettbewerbspositionen zu sichern und radikale Innovationen vorwegnehmen, um zukünftige Wettbewerbspositionen zu sichern. Bei der Entwicklung von dualen Innovationsstrategien kommen Foresight-Methoden zum Einsatz: Einerseits werden «aktuelle Positionen» in die nahe Zukunft extrapoliert (inkrementeller Ansatz) und andererseits werden diskontinuierliche Markt- und Technologieentwicklungen retropoliert (radikaler Ansatz). Dabei entstehen Zielkonflikte, die in der gesamtunternehmerischen Innovationsstrategie gesteuert und allenfalls gelöst werden müssen. Denn radikale Innovationen aufgrund von diskontinuierlichen Markt- und Technologieentwicklungen können zu einer beschleunigten Ablösung von aktuellen Positionen und deren kontinuierlichen Verbesserungsanstrengungen führen.

3. Das Geschäftsmodell zählt zum Innovationsspektrum

Vermehrt erweitern Unternehmen das Innovationsspektrum von Produkt-, Prozess- und Service-Innovation auf die Innovation des Geschäftsmodells. Verschiedene Studien belegen, dass Innovationen des Geschäftsmodells häufig einen signifikant höheren Marktwert bieten als Produkt- und Prozessinnovationen.

Auf diese Weise konnte Dell aufgrund des damals neuen Geschäftsmodells innerhalb weniger Jahre zum weltweit führenden Anbieter von Computern aufsteigen. Aktive, vorausschauende Unternehmen erkennen und schöpfen systematisch das Potenzial von Geschäftsmodellinnovationen.

4. Business Design als «Herzstück» der Strategie

Zahlreiche Unternehmen haben über die vergangenen Jahre eine dramatische Zunahme der Produkt-, Markt- und Kundenvielfalt erfahren. Das dadurch erzeugte Wachstum kam mit einer Zunahme der Komplexität und der «Trägheit» innerhalb der Unternehmen einher. Unternehmen sind in Organisationsstrukturen gefangen, die den neuen strategischen Herausforderungen nicht gerecht werden. Immer noch scheuen viele Unternehmen davor zurück, ihre Organisationen grundsätzlich zu überdenken und unternehmen stattdessen ad-hoc Anpassungen ihrer Strukturen.

Strategisch orientierte Unternehmen hingegen fokussieren darauf, ihre Organisationsstrukturen und die neuen Herausforderungen in Einklang zu bringen. Sie wenden sich ab von punktuellen Optimierungsübungen und überdenken ihre Geschäftsmodelle grundsätzlich. Dabei kommen neue «Business Design»-Ansätze zum Einsatz. Ein iterativer Design-Ansatz stellt die Konsistenz zwischen Strategie und Organisation sicher.

Er geht zunächst von der Unternehmensstrategie aus, definiert Funktionalitäten und modulare Designparameter aufgrund derer die Prozessarchitektur und schliesslich die Organisationsstruktur definiert wird. Das Vorgehen ist iterativ und vereint somit beide Sichten, «Top-Down» und «Bottom-Up». Es entstehen strukturierte «Innovationsfabriken» und «Innovationsateliers», welche mit der Unternehmensstrategie konsistent sind. «Innovationsfabriken» generieren inkrementelle Innovationen und «Innovationsateliers» nehmen radikale Innovationspotenziale vorweg.

Ein übergeordneter Prozess steuert die gesamte Innovationstätigkeit, insbesondere die Schnittstelle zwischen Atelier und Fabrik (siehe Grafik S. 11). CEOs bestätigen die zunehmende strategische Bedeutung von Business Design. Einige sprechen gar davon, dass Business Design das «Herzstück» ihrer Unternehmensstrategie ist.

5. «Innovationsfabriken» sichern Marktposition

Die «Innovationsfabrik» generiert einen planbaren und kontinuierlichen Ausfluss von inkrementellen Innovationen. Es geht darum, dem Unternehmen bekannte Produkte kontinuierlich zu verbessern. Analog zum Produktionsprozess wird der Innovationsprozess in modulare, durchgängige Aufgabenbereiche geteilt. Diese ste-

hen zueinander wie «steckbare», modulare Plattformen. Sie verlaufen aber nicht parallel zueinander (wie etwa im «multi-tasking» oder «simultaneous engineering»), sondern sind aufgrund der unterschiedlichen Zeithorizonte voneinander entkoppelt. Die Integration der innovativen Outputs erfolgt entsprechend der zugrundeliegenden Produktarchitektur.

Die «Innovationsfabrik» besteht also aus einem Zusammenspiel von modularen Prozessen mit dedizierten, durchgängigen, aufeinander abgestimmten Innovationsroutinen.

Analog zum Produktionsprozess können diese Innovationsroutinen bezüglich marktentscheidender Leistungsgrössen gesteuert werden. Solche Leistungsgrössen sind etwa Geschwindigkeit (Time-to-market, Time-to-life), Wirtschaftlichkeit (Payback, Break-even) und Marktservice (Life-Cycle maintenance, Road mapping, Pipeline-Füllstand).

6. «Innovationsateliers» für die künftige Strategie

«Innovationsateliers» bearbeiten systematisch die in der Innovationsstrategie festgelegten Innovationsfelder. Deren Ziel ist es, diskontinuierliche Markt- und Technologieentwicklungen vorwegzunehmen und zukünftige strategische Positionen zu begründen. Als Output liefern «Innovationsateliers» zumeist radikale Innovationen auf Ebene «proof-of-concept». Diese werden über die Innovationssteuerung an die Innovationsfabrik für die Industrialisierung, Anpassung und kontinuierliche Verbesserung übergeben. Obwohl die Analogie zum «Künstleratelier» bewusst gewählt ist, sind Innovationsateliers nicht eine freie Ansammlung von unstrukturierten und sich selbst managenden Ressourcen. Der zugrundeliegende Innovationsprozess lässt sich strukturieren. Dabei weisen die modularen Prozessbereiche signifikant höhere Freiheitsgrade auf als etwa in der Innovationsfabrik. So befolgt auch die Erstellung eines künstlerischen Gemäldes oder die Entwicklung einer Haute Couture-Kollektion gewisse Abläufe und Standards. Diese bilden gleichsam einen Rahmen für die Entfaltung der künstlerischen Kreativität.

Literaturhinweis:

Deplazes, Deplazes und Boutellier (2007): «Unternehmensdesign als Hebel der Unternehmens- und Innovationsstrategie», «Wie Innovation zur Routine wird», «Systematic approach to superior innovation structures» und «Making business design the heart of strategy».

12.11 Keine innovativen Unternehmen ohne innovative Versicherungen

Boutellier R, Deplazes U and Deplazes W (2007) Keine innovativen Unternehmen ohne innovative Versicherungen. In: 150 Jahre Helvetia Versicherungen. 103-108, Heer, Sulgen.

KEINE INNOVATIVEN UNTERNEHMEN OHNE INNOVATIVE VERSICHERUNGEN

Roman Boutellier

1. Innovationen sind notwendig

Das Marktumfeld Anfang des 21. Jahrhunderts ist tief greifenden Veränderungen unterworfen. Wirtschaftliche und politische Neuordnung, Globalisierung der Märkte und des Wettbewerbs, zunehmende Deregulierung und ökologische Risiken bewirken einen grundlegenden Wandel in den meisten Industrien. Heute wie in der Gründungszeit der Helvetia müssen neue Wege gefunden werden, um mit Unsicherheiten umzugehen. Bereits die Gründer des Unternehmens lernten die Risiken neuer Technologien kennen: Damals lösten Eisenbahnen, Stahlfabriken und Textilmaschinen grosse Emotionen aus. Heute sind es Nukleartechnologie, Gentechnik und Biotechnologie.

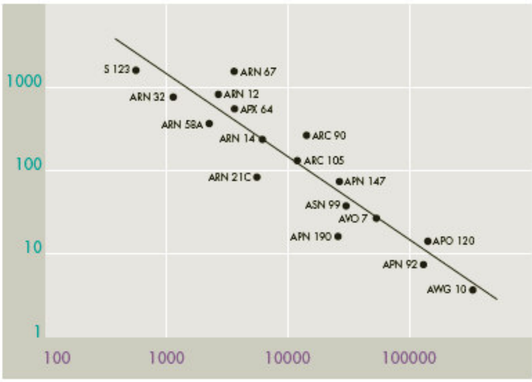
Trotz den technischen Unsicherheiten verlangen Kapitalgeber eine immer genauere Planbarkeit. Unternehmen sollten also Strategien entwickeln, um Unsicherheiten systematisch in den Griff zu bekommen, den Unternehmenswert langfristig zu steigern und den Kapitalgebern stabile Erträge zu verschaffen. Dies beruht darauf, dass Kapitalmärkte dem einfachen Prinzip der «Creative Destruction» folgen, das Unternehmen mit unterdurchschnittlichen Leistungen «verschwinden» lässt. So sind von den «Fortune Top 100-Firmen» aus dem Jahre 1981 nur 26 % auf der Liste von 2001 wieder zu finden. Eine jüngst veröffentlichte Studie von McKinsey kommt gar zum Schluss, dass nicht einmal 1 % der Unternehmen in den zehn Jahren von 1994 bis 2004 ein höheres Umsatzwachstum und eine höhere Profitabilität als der Wettbewerb erreichen konnten. Die wenigen nachhaltig erfolgreichen Unternehmen weisen zwei gemeinsame Merkmale auf: Sie haben stärker auf organisches Wachstum gesetzt und weisen hohe Market-to-book-Ratios aus. Offenbar verfügen sie über hochwertige «intangible assets» – hochwertiges intellektuelles Kapital.

Daraus kann man schliessen, dass nachhaltig erfolgreiche Unternehmen ihre wissensintensiven immateriellen Güter, wie Urheberrechte, Patente, Marken und Innovationsfähigkeit gezielt entwickeln. Unternehmen können nicht mehr «gelegentlich» Innovationen hervorbringen, sondern müssen – trotz den grossen Unsicherheiten – einen möglichst planbaren Ausfluss an Innovationen sicherstellen. Hauptmotor ist dabei die Institutionalisierung der Innovationstätigkeit: Einerseits wird das aktuelle Angebot systematisch verbessert; anderseits wird grundsätzlich Neues frühzeitig angegangen. Dies führt langfristig zur Ablösung der aktuellen Produkte, Technologien oder sogar Geschäftsmodelle. Der Anteil der Unternehmen, welche ihre Innovationstätigkeit institutionalisieren, ist in den vergangenen Jahren dramatisch gestiegen: Gegen eine Million Unternehmen sind heute ISO- zertifiziert, Hunderttausende haben also einen dokumentierten Innovationsprozess. Auch die Innovationsvielfalt nimmt in vielen Märkten explosionsartig zu. Beispielsweise gab es im Jahre 2006 allein beim VW Golf theoretisch mehr als eine Million Varianten. Zudem haben sich die Imitationszeiten über die vergangenen Jahrzehnte wesentlich stärker verkürzt als die Innovationszeiten. Dies treibt die Routinisierung der Innovation voran: Nettomargen von innovativen Produkten und Dienstleistungen sinken kurz nach Markteinführung auf ein Preisniveau, das etwa den Kapitalkosten entspricht. Innovationen verlieren also an Bedeutung für die Steigerung des Unternehmenswertes. Sie bleiben aber ein Muss.

2. Neue Technologien führen zu neuen Risiken

Unternehmen müssen sich kontinuierlich durch neue Angebote differenzieren und die Entwicklungszeiten drastisch reduzieren, um kurzfristige Potenziale und die damit verbundenen Innovationsprämien vor den Mitbewerbern ausschöpfen zu können. Gleichzeitig müssen sie auch grundsätzliche Veränderungen vorwegnehmen und dadurch aktuelle «strategische Positionen» ablösen – bevor es die Konkurrenz tut. Dadurch entstehen besonders in der Produkt- und Technologieentwicklung grundsätzlich neue Risiken. Das «Gesetz von Augustine», dem ehemaligen CEO von Martin Marietta, besagt, dass in vielen Fällen die Erhöhung der Kosten pro Einheit um den Faktor 10 die Zuverlässigkeit um den gleichen Faktor sinken lässt. Ein typisches Beispiel sind militärische Fluggeräte.

Investitionen in Innovation können die Produktzuverlässigkeit reduzieren – Beispiel militärische Fluggeräte



Mittlere Ausfallzeit (Std)
Kosten pro Einheit (USD)

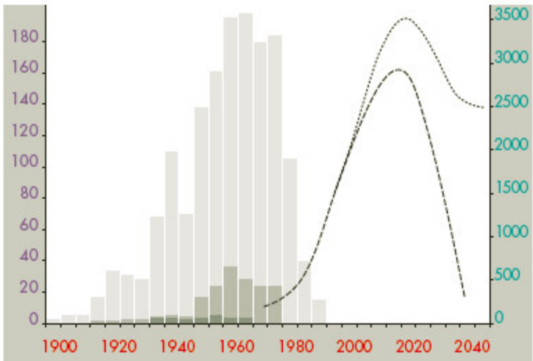
Quelle: Augustine, N.R. (1983:55): Augustine's Laws.
New York: American Institute of Aeronautics and Astronautics

Auch in der Automobilbranche zeigt sich ein ähnliches Phänomen. Mit den vielen Innovationen hat sich die Anzahl der Einsätze des Pannendienstes des Touring Clubs Schweiz pro 1000 Fahrzeuge seit 1980 für gewisse Marken um über 40 % erhöht. Es scheint, dass die zunehmende Innovationsvielfalt zulasten der Produktzuverlässigkeit erfolgt. Dadurch entstehen neue Unternehmensrisiken, besonders im Bereich der Produkthaftung, und damit neue Versicherungsansprüche für Autofahrer und Automobilproduzenten.

Die Zunahme der Vielfalt in der Grundlagenforschung generiert neue Technologien, deren Einsatz kaum abschätzbare Risiken in sich birgt. Besonders die Spätfolgen neuer Technologien stellen Unternehmen vor bisher unbekannte Herausforderungen. Die besten Ingenieure können langfristige Risiken kaum einschätzen. Kritische Konsumentenschutzverbände können aber negative Auswirkungen von Technologien immer genauer messen. So steigt die Anzahl der Produkte, die nachweislich krebserregende Stoffe enthalten. Lebensmittelingenieure versichern glaubhaft, dass unser tägliches Brot, wäre es nicht schon erfunden, heute nicht mehr eingeführt werden könnte. Unsere Vorschriften sind sehr strikt geworden.

Häufig kann man, wie im Falle von Asbest, eine grosse zeitliche Verzögerung zwischen dem Einsatz neuer Technologien und deren schadhaften Auswirkungen beobachten. Die «Wunderfaser» Asbest wurde aufgrund ihrer hohen Festigkeit, Hitze- und Säurebeständigkeit, der hervorragenden Isolations- und Verarbeitungseigenschaften zwischen ca. 1904 und 1990 in der Schifffahrt-, Isolations-, Autoreifen- und Bauindustrie verwendet. Vor allem in Gebäuden aus den 1950er bis 70er Jahren kamen asbesthaltige Bauprodukte zum Einsatz. Heutzutage ist bekannt, dass bereits geringe Konzentrationen von Asbeststaub, die beispielsweise bei Renovationen freigesetzt werden können, die Gesundheit gefährden. Diese Auswirkungen stellen sich aber erst Jahrzehnte nach dem ursächlichen Kontakt mit Asbest ein.

Asbest: Verzögerung von 50 Jahren zwischen Ursache und Auswirkungen



Asbest-Importe UK (Tausend t)
Jahr
Anzahl Mesotheliom-Todesfälle (pro Jahr)
Faserserpentin
blauer Asbest
brauner Asbest

Männer geboren vor 1953
Männer insgesamt (Annahme: Risiko für Männer geboren nach 1953 ist 50% von denen geboren 1943 bis 48

Quelle: Gee, D., et al. (2001:52): Late lessons from early warnings: the precautionary principle 1896-2000, in Harremoës, P. (Ed.) Copenhagen, European Environment Agency

Standard & Poor's schätzen die gesamte Schadensbelastung durch Asbest in den USA auf etwa 200 Mrd. USD. Es ist unbestritten, dass Unternehmen die Risiken, welche von Asbest ausgehen, unterschätzt haben. Es stellt sich auch die Frage, ob man – vielleicht geblendet von den enormen Markt- und Innovationspotenzialen – «schwache Signale» ignoriert hat. Denn Asbest ist seit dem Altertum bekannt. Es wurde bereits 4000 v. Chr. im heutigen Finnland und 2000 v. Chr. bei den Mykenern im alten Griechenland eingesetzt, um Gefässe bruchsicher und feuerfest zu machen. Warnende Signale über potenzielle Gesundheitsgefährdungen durch Asbest gibt es fast ebenso lange. Schon Plinius der Jüngere (etwa 100 n. Chr.) soll bei Sklaven, die mit Asbest arbeiteten, Krankheiten festgestellt haben. Der erste Todesfall mit amtlich beglaubigter Todesursache Asbestose wurde bereits um 1900 in Grossbritannien registriert. In der Schweiz wird Asbestose seit 1939 offiziell als Berufskrankheit anerkannt. Die Verwendung von Asbest wurde aber erst 1989 in der Schweiz und 1999 in der EU verboten.

Wissenschaftliche Ergebnisse bleiben oft lange widersprüchlich und führen zu gegensätzlichen politischen, regulatorischen und unternehmerischen Empfehlungen. Auch sind sie, gerade in Situationen grosser Unsicherheit, nicht über jeden Zweifel erhaben. Beispielsweise wurde die östrogenähnliche Wirkung von Bisphenol A seit der ersten Erwähnung 1936 immer wieder untersucht. Der Toxikologe Frederick vom Saal an der University of Missouri hat 130 wissenschaftliche Arbeiten analysiert, die sich von 1996 bis 2005 mit den möglichen Wirkungen niedriger Bisphenol A-Konzentrationen befasst hatten. Mehr als 90 Prozent der industrieunabhängigen Untersuchungen weisen auf Gesundheitsrisiken hin, und alle industriegeförderten Forscher kamen zum gegenteiligen Ergebnis. Die wissenschaftliche Lage bleibt widersprüchlich. Inzwischen ist Bisphenol A eine der meistproduzierten Chemikalien weltweit und wird in der Herstellung von Polykarbonat-Kunststoffen, Epoxydharzlacken und Flammschutzmitteln eingesetzt. Es tritt auch in Babyflaschen und Babyspielzeug auf.

3. Wer trägt die Risiken?

Die Akzeptanz von Innovationen in der Gesellschaft hängt oft von schwer einschätzbaren sozialen Parametern ab. Tendenziell wehrt sich die Gesellschaft zunehmend, Unternehmensrisiken zu übernehmen. In Medien und Verbraucherschutzkreisen wird gefordert, dass die Unternehmen gesamthaft für ihre Produkte haften und die Risiken nur in geringem Mass auf den Staat abwälzen können. Europaweit gewinnen Forderungen nach einer Reform der europäischen Produktehaftungsrichtlinie an Unterstützung. So soll die aktuell rechtlich verankerte Bestimmung gestrichen werden, wonach die Herstellerhaftung aufgehoben wird, wenn der vorhandene Fehler nach dem Stand der Wissenschaft nicht erkannt werden konnte. Die Beweislast soll zukünftig nicht der Geschädigte, sondern der Verursacher tragen. Medien und Öffentlichkeit verfolgen diese Thematik intensiv, und breit publizierte Schadensfälle heizen die Diskussion an. In den USA traten im September 2006 E.coli-Infektionen nach dem Verzehr von frisch verpacktem Spinat auf. Dies führte zu einer Verzichtempfehlung der Food and Drug Administration (FDA) und zu landesweiten, teilweise freiwilligen Rückrufaktionen. Obwohl die Verunreinigung bei der Verpackung und nicht bei den Spinatproduzenten selbst stattfand, erlitten diese enorme Einbussen: Zum Umsatzausfall kam hinzu, dass ein aufwändiges Krisenmanagement und die Produktrücknahme die Mitarbeiter noch während Wochen beschäftigten. Die Kosten der Betriebsunterbrechung wurden von den Versicherern oft nicht gedeckt, weil versicherbare Betriebsunterbrechungen im traditionellen Sinn durch Sachschaden, wie etwa Feuer, verursacht werden. Dazu kommen Einbussen infolge der stark ramponierten Reputation, langwieriger Rechtsverfahren und hoher Schadenersatzleistungen. Insbesondere bei Nahrungsmitteln und Bedarfsartikeln nehmen die Produktrückrufe auch in Europa zu. Dabei müssen die Unternehmen nicht nur mit objektiven, sondern auch mit emotionalen oder gar konstruierten Ursachen rechnen. Der Rückruf des Reinigungssprays «Magic Nano» vom deutschen Markt löste eine breite Debatte über die Gefahren der Nanotechnologie aus. Im Nachhinein hat sich herausgestellt, dass das Produkt wohl zu Intoxikationen geführt hatte, aber gar keine Nanomaterialien enthielt. Allgemein kann man feststellen, dass Unternehmensrisiken im Bereich der Produkthaftung, Produktrückrufe, Betriebsunterbrechungen, Reputationsschädigung, Rechtsverfahren und Schadenersatzleistungen signifikant steigen. Die traditionellen Angebote der Versicherer decken diese Risiken gar nicht oder nur mangelhaft.

Die Behörden können den Unternehmen noch keine umfassenden regulatorischen Richtlinien hinsichtlich des Umgangs mit Nanopartikeln geben. Die Technologie ist noch zu neu, zu unerforscht. Das deutsche Bundesinstitut für Risikobewertung hat verschiedene Projekte initiiert, um zu untersuchen, ob und in welchem Umfang der Verbraucher mit Nanomaterialien in Kontakt kommt und wie diese Materialien auf den Organismus wirken. Die amerikanische FDA untersucht die Risiken der Nanotechnologie für Arzneimittel, Nahrungsmittel, Kosmetik und medizinische Instrumente.

Die Versicherer verweisen auf Forschung und Industrie und fordern diese auf, Risiken gründlich abzuklären. Die Swiss Re vergleicht in ihrem Report «Nanotechnologie. Kleine Teile – grosse Zukunft» (2004) mögliche Auswirkungen von Nanotubes auf die menschliche Gesundheit mit denen von Asbest. Es wird den Versicherern empfohlen, die Risiken von Nanotechnologie auf keinen Fall unbegrenzt zu versichern und grundsätzlich maximal abzudeckende Schadenshöhen (Caps) mit den Unternehmen zu vereinbaren. Ein kompletter Ausstieg der Versicherungen würde Nano-Innovationen um Jahrzehnte verzögern. Bei Nuklearfällen in der Schweiz übernehmen Versicherungen maximal 400 Mio. CHF. Die weitergehenden Schäden soll der Bund übernehmen. Nur so konnte das Überleben der Nukleartechnologie gesichert werden.

Auch bei der Haftung für Umweltschäden sträuben sich die Versicherer, wenig bekannte Risiken zu übernehmen. Die EU hat bereits im April 2004 die Environmental Liability Directive angenommen mit dem Ziel, Umweltschäden durch das sogenannte «polluter pays»-Prinzip einzudämmen. Die Umwelt wird als juristische Person betrachtet, und die nationalen Regierungen sind gehalten, im Namen der Umwelt Schadenansprüche an den Verursacher zu erheben. Aufgrund des mangelhaften Versicherungsangebotes haben das Comité Européen des Assurances CEA und die Federation of European Risk Management Associations FERMA die Versicherungsgesellschaften aufgefordert, weniger risikoavers zu sein. Sie sollen neue Versicherungsprodukte entwickeln, welche die Unternehmen gegen Haftungsrisiken für Umweltschäden schützen. Aber durch die Zeitverzögerung zwischen dem Inkrafttreten der Direktive und der Innovation von Versicherungsprodukten wird den Unternehmen der Versicherungsschutz fehlen, weshalb sie nur bedingt in gewisse innovative Bereiche expandieren werden.

Die neuen Risiken bleiben also grösstenteils an den «innovativen Unternehmen» hängen, welche die enormen Marktpotenziale neuer Technologien, wie etwa der Nanotechnologie, ausschöpfen wollen. Negative Erfahrungen haben Unternehmen in ihrer Risikoeinschätzung vorsichtiger gemacht. Gerade in Fällen mit möglichen Auswirkungen über langfristige Zeiträume trifft die traditionelle Ansicht, dass der «First Mover» den grössten Vorteil einer Innovation für sich beanspruchen kann, kaum mehr zu. Unternehmen warten vermehrt die Diffusion von neuen Technologien ab und beobachten systematisch «warnende Signale», die in die Einschätzung des Risikos eines potenziellen Markteintritts einfliessen. So erinnern sich heute die wenigsten an damals radikal innovative Produkte, wie die erste Einwegwindel Chux, den ersten Videorekorder Ampex oder den ersten Taschenrechner Berkey. Die heutigen Marktführer haben die Diffusion dieser unsicheren neuen «Technologien» abgewartet, durch systematische Beobachtung «warnende Signale» erfasst und in ihre Entscheidung über den Markteintritt einfliessen lassen. Dieser erfolgte im Durchschnitt etwa 13 Jahre, nachdem die heute weitgehend unbekannten Pioniere ihre Produkte eingeführt hatten. Die Furcht vor unbekannten Nebenwirkungen erhöht die Vorteile des Abwartens.

4. Risikomanagement der Unternehmen und der Versicherungsgesellschaften

Aufgrund der veränderten Risikolandschaft gewinnt das Risiko-Management in innovativen Unternehmen an Bedeutung. Im Zentrum stehen nicht mehr traditionelle Sachrisiken, sondern zunehmend Haftungs- und Reputationsrisiken. Professionelle Risikomanager argumentieren aus Sicht des Gesamtunternehmens. Sie entwickeln Strategien, um die Risiken, welche die Stabilität von Bilanz, Erfolgsrechnung und Cash Flow gefährden, gesamthaft zu bewältigen. «Value at Risk» gewinnt an Bedeutung. Risikomanager versuchen aber auch, ihre Versicherungen möglichst kostengünstig zu decken. Das ist zum Teil möglich, weil die Deregulierung zu einer erhöhten Konkurrenz auch bei den Versicherungen geführt hat. Immer stärker drängen ausländische Versicherungskonzerne auf den Schweizer Markt. Deregulierung und neue Technologien, wie etwa das Internet, bieten aber auch das Potenzial für Innovationen in der Versicherungsbranche und in der Kooperation zwischen Versicherungen und Versicherten. Dabei lassen sich vier grundlegende Situationen unterscheiden.

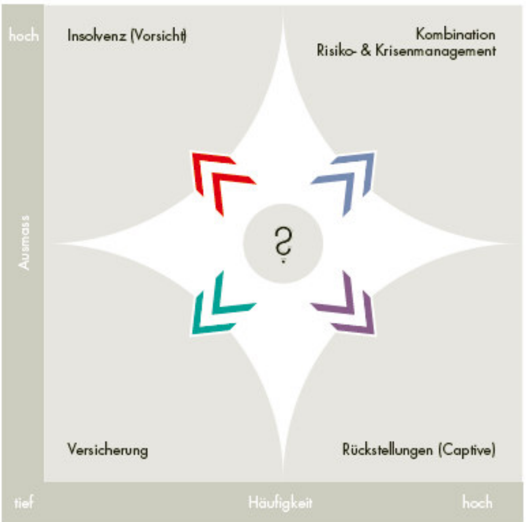
a. Verschiedene Unternehmen haben festgestellt, dass bei *vorhersehbaren* Risiken die Versicherungskosten die erfolgten Auszahlungen auch über einen längeren Zeitraum bei weitem übertreffen. So sind Unternehmen bestrebt, vorhersehbare und quantifizierbare Risiken vermehrt selbst zu übernehmen und aus dem Cash Flow oder über eine hausinterne Versicherung, eine Captive, selber zu decken. Hier zeigt sich einmal mehr: Hat man eine genügend grosse Stichprobe, so entscheidet letzthin die bessere Information über die Effizienz der Versicherung. Traditionell hohe Prämienzahlungen sind bei häufig auftretenden, kleineren und vorhersehbaren Schadenfällen kaum zu rechtfertigen. So kennen beispielsweise Autovermieter das Schadenaufkommen bei ihren Autos sehr genau und tendieren dazu, dieses vorhersehbare Risiko selbst zu versichern bzw. direkt aus dem Cash Flow zu bezahlen.

b. Hat das Unternehmen *selten vorkommende,* in ihrer Natur bekannte Risiken, verfügt aber nicht über eigene statistische Daten, kann der Risikomanager nur hoffen, dass andere Firmen die gleichen Risiken haben und deshalb die Statistik bei einem Versicherer, spätestens aber bei einem Rückversicherer, genügend robust wird. Ein typischer Fall ist die Versicherung von Flugzeugabstürzen oder von Betriebsausfällen wegen Feuer. Wenige Unternehmen haben schon einmal grössere Feuerschäden erlitten, und zum Glück hat keine Fluggesellschaft genügend eigene Erfahrung mit Abstürzen. Beide Unglücksfälle treten aber immer wieder auf. Sind die Schäden bei solchen Risiken sehr gross, drängt sich eine Kombination von präventivem Risikomanagement, Versicherung und Krisenmanagement auf: Im modernen Tunnelbau weiss man, dass trotz allen Sicherheitsvorkehrungen leider mit einem Toten pro 15 Kilometer Ausbruch gerechnet werden muss. Eine rechtzeitige intensive Zusammenarbeit zwischen Versicherung und Unternehmen kann jedoch helfen, neue Techniken der Unfallverhinderung rasch zu verbreiten und im Ernstfall angemessen zu reagieren.

c. *Neue, unbekannte* Risiken, die bei Innovationen entstehen, bringen unbekannte Risiken auch für die Versicherungsgesellschaften. Die Produkthaftung kann Unternehmen in den Bankrott treiben, wie das Beispiel der Silikon-Implantate zeigt. Dow Corning hat 2004 zugestimmt, für notabene wissenschaftlich nicht erwiesene Schäden 4 Mrd. USD zu bezahlen. Erst nach Jahren der Unsicherheit konnte das Unternehmen aus dem Bankrott wieder in den Normalzustand zurückkehren. Bei solchen Risiken können die Versicherer weder die potenziellen Verluste einschätzen noch das Risiko in einem homogenen Kundenpool bündeln. So schliessen sie diese Fälle häufig aus oder decken sie nur begrenzt mit Caps. Die Unsicherheit treibt auch die Versicherungsprämien in Höhen, welche bereits über wenige Jahre kumuliert die zu erwartenden Schäden übertreffen. Bei fehlender oder ungenügender Risikodeckung durch die Versicherer bevorzugen es die Unternehmen, sich gegen solche Risiken gar nicht zu versichern. Sie halten dagegen mit grundsätzlicher Risikoprävention und der Stärkung ihrer Krisenmanagement- und Rechtsabteilungen. Pharmaunternehmen betrachten das Risiko der Produkthaftung als eines ihrer Hauptrisiken. Dennoch decken Versicherungsgesellschaften diese Risiken nur mangelhaft zu exzessiv hohen Prämien. Zahlreiche grosse pharmazeutische Unternehmen mit mehr als 10 Mrd. USD Umsatz sind heute weitgehend selbstversichert.

d. In *Fällen grosser Unsicherheit* greifen Unternehmen auch zu legalen Konstrukten, um das Risiko einzugrenzen. Die rechtliche Aufbauorganisation soll es erlauben, Teile des Unternehmens bankrott gehen lassen zu können, ohne gleich das Gesamtunternehmen zu gefährden. Es ist erstaunlich, wie viele KMU in der Schweiz bereits solche Massnahmen eingeleitet haben. Dieses brachliegende Potenzial von unversicherten finanziellen, unternehmerischen oder Sachrisiken wird vermehrt auch vom Kapitalmarkt angegangen. Investoren sind überzeugt, dass sie einige Risiken besser einschätzen können als andere, und versuchen, eine Risikoprämie zu erwirtschaften. Sie machen den Versicherungsgesellschaften ihre Grundfunktion streitig, den Unternehmen in Krisenzeiten rasch bedeutende finanzielle Mittel zur Verfügung zu stellen. Investoren bewältigen das Risiko nicht durch Risikobündelung, sondern durch Diversifizierung der Risikopositionen und Reduzierung des Gesamtrisikos ihres Portfolios.

Risikomanagement aus Sicht der Unternehmen – 4 generische Situationen



Quelle: Eigene Darstellung.

Diese veränderte Einstellung zu Risiken stellt die Versicherer vor neue Herausforderungen. Im Bereich der Unternehmensrisiken existiert das Kundenbedürfnis nach spezifischem Schutz von Einzelrisiken kaum mehr. Traditionell bemessen die Versicherer das Risiko aufgrund des Gesetzes der grossen Zahlen und der Bildung von Kundenpools mit ähnlichem Risiko. Fälle ohne statistische Daten bewegen sich aber ausserhalb dieses Rahmens und werden gar nicht oder nur beschränkt und zu horrenden Prämien gedeckt. Aufgrund von schrumpfenden Märkten sowie hohem Preis- und Margendruck bei den traditionellen Versicherungsleistungen muss die allgemeine Anwendung dieses traditionellen Ansatzes der Versicherer im Falle von Unternehmensrisiken hinterfragt werden.

Unternehmen betrachten ihre Bedürfnisse nach Risikoschutz gesamthaft und gruppieren diese nach Zeithorizont, Schwere und Häufigkeit des Auftretens in unterschiedliche Segmente. Daraus ergibt sich eine neue Sicht des Marktes auf der Seite der Nachfrage. Dies verändert auch die Spielregeln für die Anbieter. Kritische Erfolgsfaktoren sind weniger Kapitalstärke und Grösse der Versicherer, sondern deren Wissen um Risikoprofile, Risikobündelung und -entflechtung sowie Finanzierungs- und Servicebedürfnisse der individuellen Unternehmen. Dadurch sehen neue Wettbewerber wie etwa Banken Potenziale für sich und drängen auf den Markt. Für das Problem der grundsätzlichen Innovationen bieten aber auch diese neuen Wettbewerber keine neuen Lösungen. Es bleibt nur der Weg über sorgfältige Abklärungen, intensive Beobachtung neuer Produkte am Markt und die rasche Reaktion auf schwache Signale.

Zusammenfassend kann gesagt werden, dass Versicherungen für Innovationen eine ausschlaggebende Rolle spielen. Dies gilt vor allem in den Anfangsstadien neuer Produkte, solange die Innovationen noch keine grossen Auswirkungen zeigen können bzw. solange die Produkte noch im Labor sind.

Autoren

Prof. Dr. Roman Boutellier, Professor für Technologie und Innovationsmanagement, ETH Zürich.

Ursula Deplazes, M.Sc. LSE, M.Sc./lic. oec. HEC, HLH.

Wolfgang Deplazes, M.Sc./lic. oec. HEC.

Information about the author

Name:	Ursula Deplazes
Address:	Tschachenweg 2
	CH – 6318 Walchwil
Telephone:	+41 76 470 50 85
E-mail:	udeplazes@ethz.ch
Date of birth:	April 30, 1969
Nationality:	Swiss

Education

The author acquired her academic baggage in a variety of countries and institutions including The London School of Economics (M. Sc. Finance and Accounting), the University of Lausanne HEC (M. Sc.), the University of Zurich (HLH) and Shibusawa International College in Japan. She specialized in the fields of Finance & Accounting, International Marketing and pursued advanced studies in Psychology, Philosophy and History. Her academic interest lies in the field of Innovation Management, Philosophy of Management and Techno-Ethics.

Working experience

The author gathered her professional experience in Europe and Asia, including Switzerland, the UK, Southern Europe and Japan. She worked in the fields of banking, international marketing and entrepreneurship with companies such as Citibank, Johnson & Johnson, Unaxis and also several start-ups and NGO's.