The Implementation of Performance-oriented Systems

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Abstract:

The study at hand examines the strategic perspective of the emerging phenomenon of performance-oriented systems, e.g. car-sharing or cloud computing, in the mobility, IT, energy and chemical industries. In all four industries, firms have likewise implemented a novel system-based offering recently, which is providing the performance of their products for shared use. The existing literature that has already acknowledged the phenomenon is fragmented across different areas of expertise. The emphasis of the contributions resides on the operational level and a consistent strategic innovation management perspective is absent. Thus, the study strives to synthesize the literature into a larger perspective and provide a strategic rationale to explain the phenomenon.

The study follows an iterative, interpretative approach based on the methodological foundations of Grounded Theory. The findings are based on semi-structured, qualitative interviews with executives from twenty-seven system examples from four industries, clarifying the motivation for and differences in system development. Items from the substantive concept of dynamic capabilities and the juvenile strategy of superior architectural knowledge are used in a novel approach for interpretation.

Based on the compiled data, the study derives ten founding propositions that delineate the strategic characteristics of the case examples, composes a coherent framework and identifies nine initial enabling factors that illustrate the context. The research reveals that novel user preferences towards a higher elasticity of resource deployment have facilitated the system development. The examined firms have integrated downward into the use phase and explicitly met the identified demand in offering the performance of several joint resources to the user instead of selling single complements. The created value is protected through the implementation of a central platform. The governance of the platform secures three types of hidden information; the capacity, the user demand and the efficiency information. The information base in the platform determines the firm's competitive advantage, as the incentive regime of a performance-oriented system is inherently oriented towards resource efficiency. Thus, the implementing firms need to continuously develop process innovations and systematically reduce slack of the system components.

The study provides managerial guidance for future system developments, contributes a novel perspective on the phenomenon and qualifies recent conceptual work on superior architectural knowledge.

Zusammenfassung:

Die vorliegende Dissertation untersucht die strategische Perspektive des aufstrebenden Phänomens von Performanz-orientierten Systemen, z.B. Car-Sharing oder Cloud Computing. In zahlreichen Branchen haben Firmen gleichermaßen eine neuartige System-Innovation implementiert, die die Performanz von Produkten zur geteilten Nutzung anbietet. Die existierende Literatur ist bruchstückhaft über verschiedene Fachrichtungen verteilt. Der Schwerpunkt der Beiträge liegt auf der operativen Ebene und eine konsistente strategische Innovations-Management-Perspektive ist bisher nicht vorhanden. Daher strebt die Arbeit eine Zusammenführung der Literatur und die Erarbeitung einer Strategie-basierten Erklärung für das Phänomen an.

Die Arbeit folgt einem iterativen, interpretativen Ansatz, der an den Forschungsansatz der 'Grounded Theory' angelehnt ist, um die Motivation und die Unterschiede dieser System-Innovation zu klären. Die Ergebnisse basieren auf semistrukturierten, qualitativen Interviews mit Führungskräften in siebenundzwanzig Fallbeispielen aus vier Branchen. Elemente des etablierten 'Dynamic Capabilities'-Konzept und der vergleichsweise jungen 'Strategy of Superior Archtiectural Knowledge' werden in einem neuartigen Ansatz zur Interpretation genutzt.

Die Studie leitet aus den erhoben Daten zehn Propositionen ab, die die strategischen Besonderheiten der Fallbeispiele beschreiben, bringt diese in ein Bezugssystem und identifiziert neun Erfolgsfaktoren. Die Forschung zeigt, dass neue Nutzer-Präferenzen zugunsten einer höheren Elastizität im Ressourceneinsatz die System-Entwicklung gefördert haben. Die untersuchten Firmen haben sich abwärts in die Nutzungsphase integriert und explizit diese Bedürfnisse berücksichtigt, indem sie die Performanz von mehreren Komponenten anbieten, anstatt diese einzeln zu verkaufen. Der geschaffene Wert wird durch die Implementierung einer zentralen Plattform geschützt. Die Kontrolle der Plattform sichert drei Arten von verdeckter Information: über die Kapazität, den Bedarf und die Effizienz. Diese Informations-Basis bestimmt den Wettbewerbsvorteil der Firma, da das Anreizregime inhärent an Ressourceneffizienz orientiert ist. Daher muss die Firma kontinuierlich Prozess-Innovationen entwickeln und systematisch den Schlupf in den Komponenten reduzieren.

Die Arbeit bietet einen Managementleitfaden für zukünftige System-Entwicklungen, steuert der Literatur eine neue Perspektive bei und stärkt bestehende, konzeptionelle Arbeiten im Bereich von 'Superior Architectural Knowledge'.

Contents

List of Figures and Tables

List of Abbreviations

General Abbreviations

CapEx	Capital Expenses
CC	Cloud Computing
cp.	compare
EES	Eco-efficient Services
e.g.	for example (exempli gratia)
et al.	and others (et alii)
GPS	Global Positioning System
HP	Hybrid Products
i.e.	that is (id est)
IPS^2	Industrial Product-Service-Systems
IT	Information Technology
OpEx	Operational Expenses
POS	Product of Service
PPS	Product-Service-System
PUS	Product Utility Services
ROIC	Return on Invested Capital
SaaS	Software-as-a-Service
SD-Logic	Service-Dominant Logic
vs.	versus

1. Introduction

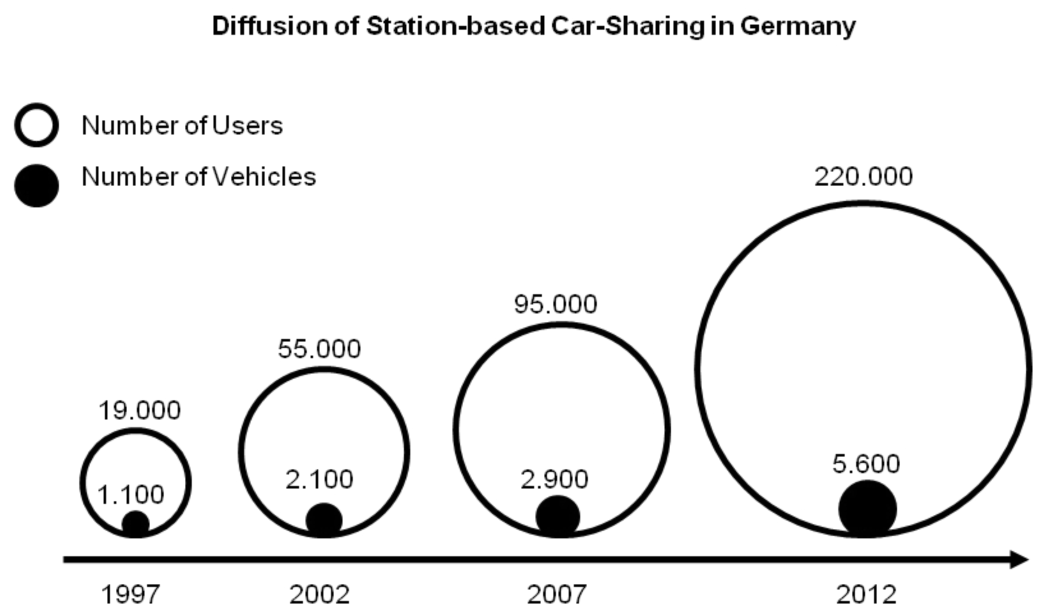
1.1. Description of the Phenomenon

In recent years, several major industries experienced a significant technological transformation to the detriment of the conventional product sale that dominated these industries for decades. For example, the emergence of car-sharing is altering the prior settled structure of the mobility industry. The IT industry is severely influenced by cloud computing and software-as-a-service. The appearance of chemical management systems and power purchase agreements in the chemical and energy industry are further cases for these transformations. Others, e.g. bike-sharing, flat-sharing, apparel-sharing or music streaming, perpetuate but do not complete the long list of case examples.

Although the examples derive from industries with very diverse characteristics, they delineate the same phenomenon: Firms that are selling their products or services on determined conditions are confronted with novel competition from firms that are implementing a system-platform offering the performance of these products for shared use on flexible conditions. The observed phenomenon of these performance-oriented systems is not only based on the activity of entrepreneurial companies but also considerably adopted among incumbent firms. In the mobility industry for example, nearly all major car manufacturers and car rental companies are engaged in car-sharing besides entrepreneurial firms, totaling in 130 providers in 309 cities and municipalities in Germany alone [BVCS, 2012].

Depiction 1 complements the described firm engagement in illustrating the number of vehicles and users of car-sharing in Germany. The number of vehicles has sextupled in fifteen years; the number of users has grown by factor ten. In comparison, the number of new passenger vehicle registrations is constantly declining in Germany, as well as in the European Union [ACEA, 2013]. Other industries exhibit a similar pattern. Exemplary, the recent emphasis in the IT industry on cloud computing and software-as-a-service influenced the major industry fair CeBIT in Germany to align their 2013 theme with the emerging phenomenon of 'shareconomy' [CeBIT, 2013]. As a consequence, the hitherto portrayed transformation within different industries has also directed the attention of various magazines and newspapers in and outside Germany to the phenomenon, all accentuating that the novel model of shared assets is increasingly replacing the conventional ownership of products in different industries, e.g.

[Hamburger Abendblatt, 2013; Stern, 2013; New York Times, 2013; The Economist, 2013]. The renowned TIME magazine has ranked economic sharing among their list of top ten ideas that will change the world [TIME, 2011].



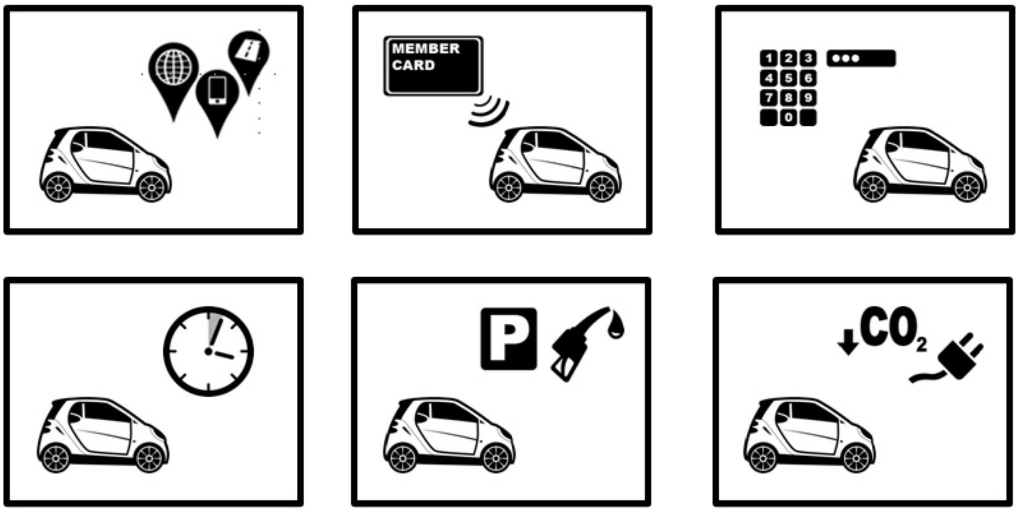
Depiction 1: Diffusion of Car-Sharing in Germany[1]

The following excerpts illustrate four examples from the mobility, IT, chemical and energy industries in greater detail to enhance the understanding of the phenomenon and its difference to conventional offerings. These system examples are based on the innovation activities of three incumbents and an entrepreneurial firm.

In the mobility industry, 'Car2Go' is a free-floating car-sharing system by the German automobile manufacturer Daimler AG. Instead of selling a vehicle, Car2Go offers the performance of the products, 'mobility', to their users (cp. Depiction 2). The vehicles of the system are not station-based but widely distributed in a specified inner-city area. Available vehicles in the vicinity can be located online, via phone application or visually on the street. The user unlocks and activates the car with the help of a membership card, a personal identification number and the key inside the vehicle. The cost for mobility is calculated on a minute, hourly or daily basis and includes the gas, insurance, mileage

[1] Own Depiction based on [Becker, 2013]

coverage, taxes, maintenance and parking fees on designated areas [Daimler AG, 2010]. The firm offers fuel-driven as well as environmental-friendly electric cars. Car2Go started in Ulm, Germany, in 2008 [Daimler AG, 2008]. In 2013 Car2Go has expanded into 16 cities in Europe and North America operating around 5.500 vehicles [Car2Go, 2013].



Depiction 2: Characteristics of Car-Sharing[2]

The phenomenon also altered the IT industry with an abundant number of transformation cases in recent years [cp. Larry Ellison, cited in Farber, 2008]. Exemplary, the firm Aqilla provides an online accounting software solution to its users through a 'Software-as-a-Service'-system instead of selling software products that rely on expansive client server infrastructures. The 'accounting performance' is delivered through a platform via the internet on-demand, anywhere and at anytime to the user. System implementation, upgrade, security, maintenance and advancements are included in Aqilla's offering. The UK-based entrepreneurial firm started business in 2006 [Aqilla, 2013].

[2] Own Depiction based on [Car2Go.com, 2013]

In the chemical industry, the firm Cabot Specialty Fluids is offering a high-value drilling fluid for offshore oil-well operations as a performance-oriented system. Cabot charges their users on a daily or monthly fee for the performance of the fluid as well as inadvertent losses. The offering is integrated in a system architecture, as production, distribution and withdrawal of fluids as well as their reclamation lies within the stewardship of the firm. Additionally, a range of technical services, e.g. operator training and engineering support, complement their offering. Cabot Specialty Fluids has serviced over 250 oil-well operations since starting operations in 1998 in Texas, USA [Cabot Specialty Fluids, 2013].

A fourth example from the energy industry is provided by Lakeland Electric offering a system named 'Solar Hot Water Program' since 1998 in Florida, USA [Lakeland Electric, 2013]. Users are charged for 'thermal heat' generated on a fixed monthly basis instead of purchasing solar-technologies for home use. The providing firm installs, operates and maintains the technological system, whereas the users solely host the necessary components at their properties and utilize their performance over a determined period.

1.2. Research Motivation, Contribution and Approach

The previous section highlighted that the phenomenon of performance-oriented system innovations can be observed in diverse industries with different characteristics. Remarkably, the transformation has constantly gained momentum in recent years as it is embraced by entrepreneurial as well as incumbent firms. This context raises several questions, e.g. why should an established company, (partially) transform its organization towards providing numerous users one product for shared use on flexible conditions instead of selling each single user one product? What is the strategic rationale behind this significant transformation in all these industries?

When reviewing the existent literature it becomes apparent that different areas of expertise have already acknowledged the phenomenon, ranging from the industrial economics [Baines et al., 2007] and environmental sciences [White et al., 1999] towards the engineering and design literature [Meier et al., 2010] as well as the computational sciences [Marston et al., 2011]. The literature is fragmented and not yet synthesized. The emphasis of these contributions resides on the operational level and a coherent strategic innovation management perspective in excess of single assumptions [Mont, 2002;

Tukker, 2004] is absent. Against the background of the existing literature base, the incorporation of a strategic perspective should be of interest for practitioners and scholars alike. This novel perspective has the potential to serve as a managerial guidance whether performance-oriented systems are a reasonable opportunity for implementation in the context of their business. In terms of scientific research, the study strives to put the fragmented literature of performance-oriented systems into a more integrated perspective. Further, the study seeks to fill the identified research gap and explain the recent emphasis on performance-oriented systems from a strategic innovation management perspective in greater detail. The main research question within this study explicitly targets the aforementioned aspects:

RQ: In what context are performance-oriented systems a viable strategy of a firm to gain competitive advantage?

This research question is further operationalized in the course of this study, clarifying the firm's motivation and the relevant differences in system development as well as its enabling factors. The study consults the strategic innovation management literature in a novel approach to answer the research question and complements the deficiency of the existing literature base on the phenomenon. The comparatively broad theory of dynamic capabilities [Teece and Pisano, 1994; Teece et al., 1997] plays a decisive role in this second strand of literature. A complementing and more applied approach to gain a strategic advantage without industry dominance is superior architectural knowledge of a technological system [Baldwin, 2010; Baldwin and Clark, 1997]. To the author's knowledge, the juvenile theory has its heritage in the computer industry and has not been applied to other including the observed phenomenon.

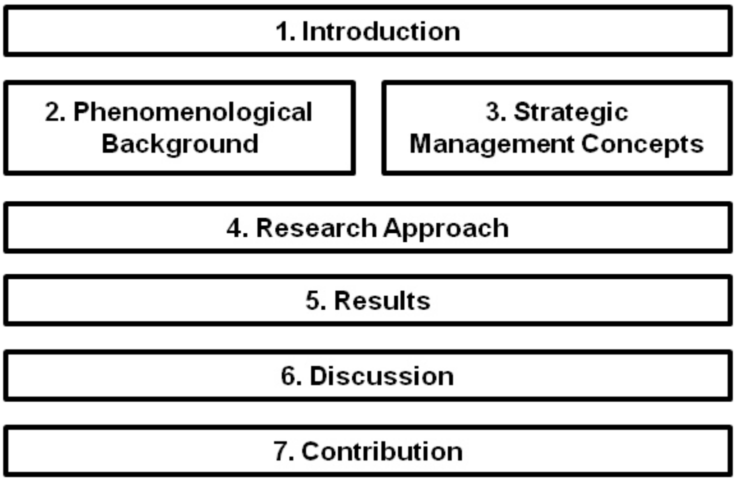
Thus, the present study seeks to close the identified research gap and explain the recent emphasis on performance-oriented systems from a strategic innovation management perspective in greater detail. The research attempts to synthesize the literature of performance-oriented systems and link this strand to the conversation of strategic innovation management research. The study follows an interpretative approach based on the methodological foundation of Grounded Theory [Glaser and Strauss, 1967; Strauss and Corbin, 1994]. The findings are based on semi-structured, qualitative interviews with executives from twenty-seven system examples from four industries. Items from the substantive concept of dynamic capabilities and the strategy of superior architectural knowledge are used for interpretation. Albeit the research was conducted iteratively, the presentation of the study is oriented at the positivist paradigm and framed sequentially for the sake of advance clarity [Suddaby, 2006]. A purist presentation of an iterative, interpretative research would comprise a lengthy and unsorted illustration of raw data in combination with constant consultations of relevant literature before the reader learns about the final structure of the outcomes in the end of the report. In contrast, the selected presentation within this study disentangles the union of primary data and relevant literature and portrays both sequentially according to the final framework of the results. Thus, the selection of relevant literature in the introduction and the theoretical sections is already oriented towards the concepts that actually emerged from the study. To clarify this aspect, the reader of this study basically learns in four closely related loops, i.e. introduction, literature, results and discussion, about the phenomenon in this work.

1.3. Thesis Outline

The remainder of this work is structured in the following. The second chapter portrays the selected scientific literature from different disciplines that have already detected the phenomenon. The relevant strategic innovation management concepts are presented in chapter three. The fourth part comprises the selected research approach. The findings of the study are presented in the fifth section and discussed in the sixth chapter. The work closes with the conclusions, contributions and implications for academia and praxis in chapter seven (cp. depiction 3).

The subsequent second chapter examines the theoretical background of performance-oriented systems from different areas of expertise in the first part. The chapter 2.1.1 discusses the term product-service-system and the interrelated notions. The section 2.1.2 highlights the concept cloud computing and software-as-a-service. The service-dominant logic and the notion shareconomy are explained in the third section. Additionally, the role of environmental aspects in performance-oriented systems is discussed in section 2.2. The chapter closes with the derivation of a working definition of performance-oriented systems in the third part.

In chapter three, two generic strands of strategic innovation management literature are presented. First, the leading and well-established frameworks that emerged from the management sciences are described in chapter 3.1, with a focus on the widely adopted dynamic capabilities theory. Chapter 3.2 introduces the strategy of superior architectural knowledge as a promising novel theory that has its origin in the engineering sciences. Recent research discusses the interrelation between these two strings of literature. Chapter 3.3 attempts to contribute to this current discussion.



Depiction 3: Structure of the Study

Chapter four comprises the derivation of the research questions as well as the description of the selected qualitative research strategy. Chapter 4.1 connects the two strands of literature from chapter two and accentuates the most relevant publications for the respective research questions. Chapter 4.2 portrays the selected methodological foundation of Grounded Theory and the used methods for data sampling, data collection, data analysis and data presentation.

The results in chapter five portray the sequence of activities for implementing performance-oriented systems that has been identified in the examined firms. The presentation of findings is structured according to the prevalent two-step approach of environment analysis in chapter 5.1 and the adaption of the firm resources. The firm adaption is divided into the two aspects of value creation in chapter 5.2 and value protection in chapter 5.3. Relevant contextual factors are briefly portrayed in chapter

5.4. The section closes with the derivation of comprehensive framework for system development in the fifth part.

In chapter six, the findings are discussed with regards to the existing theory. The part is structured into a discussion of the results with regards to the established strategic management theories in chapter 6.1 and with the existing scientific research on the phenomenon of performance-oriented systems in chapter 6.2. The chapter closes with the derivation of nine propositions that determine the success of performance-oriented systems in section 6.4.

The study closes with the contributions and limitations of the study as well as future research recommendations in chapter seven. Section 7.1 comprises the theoretical contributions and section 7.2 incorporates the managerial contributions. The limitations and future research recommendations are described in chapter 7.3. The study closes with a final conclusion in the fourth part of chapter seven.

1.4. Prior Research and Publications

The study at hand contributes to the green innovation research at the Institute for Technology and Innovation Management Department of the Technical University Hamburg-Harburg. The 'Green Innovation Project' was co-founded by the author in 2010 together with Dr. Frank Tietze who also accompanied this study in its early stages. The project incorporates basic research to understand innovation activities with an ecological impact as well as the examination of applied concepts that are suitable for implementation in industrial praxis. The emphasis of the research project resides on novel, environmentally benign concepts that incorporate the adaption of the organizational structures, e.g. the integration of the use phase and/ or the end-of-life phase, to align ecologic and economic objectives for an exceeding number of resource types.

The iterative and interpretative research approach selected within this work has substantially contributed to and consequently also uses insights from the prior publications of the author as well as the received feedback. All proceedings from the author are based on the same research-logfile that has been written throughout the analyzing process and captured the analytical and interpretative progress. Especially, the publications

Tietze, F., T. Schiederig, and C. Herstatt (2011), Firms' Transition Towards Green Product-Service-System Innovators, R&D Management Conference, 2011.

and

Schiederig, T., and C. Herstatt (2013), Performance-oriented Systems as a Strategy, ICE & IEEE-ITMC 2013 Conference, 2013

exemplary document the progress within the pilot and the main study at different stages together with their precedent versions as a working paper. Other, less successful interpretative attempts with the innovation networks theory, e.g. [Hagedoorn, 2002; Chiu, 2008; Chetty and Stangl, 2010], or the framework for disruptive innovations, e.g. [Christensen, 1997], lead to dead-ends in the process and the related exposés thus remained internal. Further contributions specifically laid ground for the examination of environmental aspects within the phenomenon, e.g.

Schiederig, T., F. Tietze, and C. Herstatt (2012), Green Innovation in Technology and Innovation Management – An Exploratory Literature Review, R&D Management 42(2), 180–192.

and the related antecessors as conference proceeding and working paper. The publications illustrate that the ecological aspect of the phenomenon, albeit quite influential in the beginning of the research, has been constantly declining over the course of the studies development due to the interpretative progress. The final results of the study clearly contrast the prior existing literature with regard to the environmental aspect. The study at hand solely presents the final interpretation of the results from the author with the theory of dynamic capabilities as well as the strategic use of architectural knowledge.

2. The Phenomenon of Performance-oriented Systems

2.1. Theoretical Background of Performance-oriented Systems

When reviewing the existent literature it becomes apparent that different areas of expertise have already acknowledged the phenomenon of performance-oriented systems. Several notions are existent with their interrelations organized in depiction 4. The generic concept of 'product-service-system' (PSS) has been coined in the industrial economics sciences and subsequently adapted by other scientific disciplines ranging from the environmental sciences to the design and engineering literature. Other notions that are used by researchers to explain the concept of PSS more precisely are 'eco-efficient services' (EES) and 'product utility services' (PUS) in the environmental sciences, 'product of service' (PoS) originating from design research and 'hybrid products' (HP) or 'industrial product-service-systems' (IPS) referring to the engineering and manufacturing literature. The terms 'cloud computing' (CC) and 'software-as-a-service' (SaaS) emerged from the computational sciences and are not directly related to the aforementioned notions. A broader perspective on the phenomenon is provided by the 'service-dominant logic' (SD-Logic) mainly used in marketing management science and the notion of 'shareconomy', which is based on the insights of general social research.

Chapter	Notion	Discipline	Scope
2.1.1.	Product-Service-System	Industrial Economics	Medium
	Eco-Efficient Services	Environmental Sciences	Narrow
	Product Utility Services		
	Product of Service	Design Sciences	
	Industrial Product-Service System	Engineering Sciences	
	Hybrid Product		
2.1.2.	Cloud Computing	Computational Sciences	Narrow
	Software-as-a-Service		
2.1.3.	S-D-Logic	Management Sciences	Broad
	Shareconomy		

Depiction 4: Structure of the Chapter Two

The following sub-chapters examine the existing literature from these different areas of expertise. The first section discusses the term PSS and the interrelated notions. The second section highlights the concept cloud computing and software-as-a-service. Service-dominant logic and the notion of shareconomy are explained in the third part. Additionally, the role of environmental positive effects in performance-oriented systems is discussed in the fourth section. Against the backdrop of the omissions and weaknesses in the existing conceptions, the present study will derive an inclusive working definition of performance-oriented systems in last section.

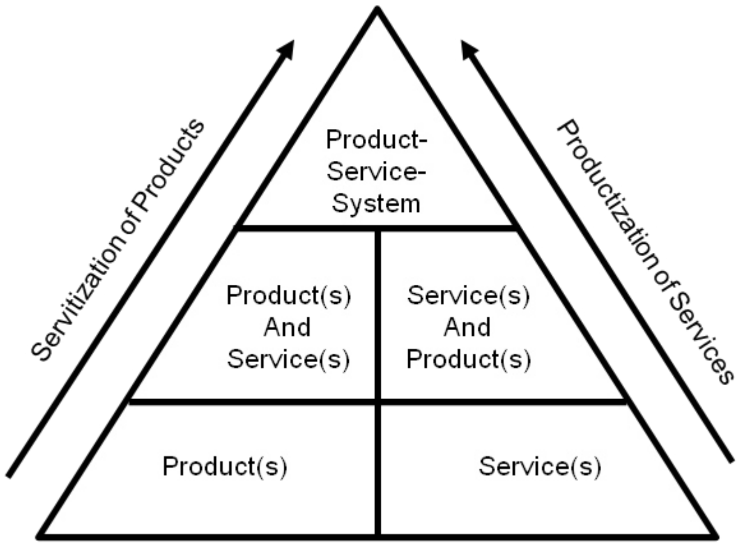
2.1.1. Product-Service-Systems and Related Notions

The concept of product-service-systems (PSS) strives to explain the detected phenomenon. [Goedkoop et al., 1999] are regarded to be the first to provide a formal definition, stating more than a decade ago that *"a product-service-system is a system of products, services, networks of 'players' and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models"*. Subsequent scholars have only slightly adjusted this initial definition, commonly emphasizing the combination of single components, the need for customer satisfaction and the change of the business model, e.g. [Mont, 2000; Brandstotter, Haberl et al., 2003; Manzini and Vezolli, 2003; Yang et al., 2007]. The majority of these authors link the concept of PSS with a reduced environmental impact compared to conventional alternatives with [Manzini et al., 2001] emphasizing this aspect as the principal objective. Building on the existing definitions, [Tietze et al., 2011] characterize product-service-systems as *"an integrated offering of tangible products, intangible services and the enabling infrastructure providing a product-unspecific functional value. While the user and the offering firm engage into an enduring contractual relationship, the ownership is not transferred to the user, with the user becoming only the temporary proprietor enabling a high use-flexibility"*. This definition firstly integrates the aspect of flexibility and the change in ownership as central characteristics of PSS. The notion of product-service-system emerged from the industrial economics sciences and has been applied widely in different areas of expertise due to its broad initial definitions. Several scholars developed other related notions to explain the concept more precisely with regard to their scientific background, which are presented in the following.

[White et al., 1999] defined 'product utility services' as a sub-class of eco-efficient services where the *"ownership of goods resides with the service provider. Customers have the use of the product, but maintenance as well as end-of-life disposition are the responsibility of the service provider"*. Besides the emphasis on the service-component, the authors propose the transfer of ownership and the responsibility of the providing firm for the whole life-cycle as key characteristics. Their work concentrates on the assessment of ecological gains possible through implementation of these services. [McDonough and Braungart, 2009: 111] provided a similar definition from their design perspective, labeling it as 'product of service'. Accordingly, the authors describe 'product of service' as follows: *"instead of assuming that all products are to be bought, owned, and disposed of by 'consumers', products containing valuable technical nutrients – cars, televisions, carpeting, computers, and refrigerators, for example – would be reconceived as services people want to enjoy. In this scenario, customers would effectively purchase the service of such a product for a defined user period..., rather than the ... [product] itself"*. Regarding the ecological benefits [McDonough and Braungart, 2009] pointed out that products of service have a potential to increase resource efficiency but also enable the combination with other environmental concepts such as the Cradle-to-Cradle approach, an advanced method of life-cycle-assessment.

A third notion for this construct mainly used in the engineering science is 'hybrid products'. [Berkovich et al., 2009] determine that *"a hybrid product is a complex solution consisting of several parts, usually hardware, software and service elements, which are not easily recognized as single parts, but different characteristics of these three parts define the hybrid product. [...] The company that builds hybrid products does also offer services in combination with the product, what means in practice that the later operation of the product is also important. The operator model changes from 'build & forget' to 'build, operate & advance'. Ultimately also the business model of the company changes to a 'pay per use' philosophy"*. In addition to the emphasis of the operational phase of the system, this definition includes the change of the business model as prerequisite. The terminology of hybrid products has a regional focus in German academia; more widespread is the notion of 'industrial product-service-systems' or IPS^2. [Meier et al., 2010] suggest a new system understanding as the IPS^2 is *"characterized by the integrated and mutually determined planning, development, provision and use of product and service shares including its immanent software components in Business-to-Business applications and represents a knowledge-intensive* *socio-technical system".* The authors differentiate their notion from product-service-systems twofold. They limit their concept to industrial applications and they do not demand a distinct separation between product and service.

Reviewing the diverse range of definitions in the field of product-sharing-systems raises the question about the novelty of this concept since all products and services are to a certain extent part of some kind of system. For example, a conventional car manufacturer is part of the national mobility system including numerous products, services and networks as roads, gas-stations, workshops, insurance etc. [Brezet et al., 2001] clarify that the contribution of this concept lies within the explicit determination of a system boundary to deliver a predefined functionality and the firm's responsibility for the system components within the boundary.



Depiction 5: Classification of Product-Service-Systems[3]

Based on the publications in the field of PSS until 2007, [Baines et al., 2007] characterize product-service-systems in their literature review as the convergence of the trends 'servitization', e.g. enhancing the value-proposition of a product through additional services, and 'productization', e.g. including a product in a service-based

[3] Own depiction based on [Baines et al., 2007]

offering. The underlying assumption is the clear distinction between a pure product-based firm and a pure service-based firm as a starting point in combination with the possibility of a flawless evolution towards a product-sharing-system through integration of the opposing item (cp. Depiction 5).

Few attempts have been made to further classify product-sharing-systems, e.g. [Brezet et al., 2001; Zaring et al., 2001], proposing three generic classes of PSS: product-oriented services, use-oriented services and result-oriented services with a decreasing importance of the product in the value proposition. Product-oriented services are characterized by a central product sale including complementing services, e.g. maintenance contract for a designated time span. In the case of use-oriented services the product remains in ownership of the provider and is made available through shared use to the clients. The literature often refers to car-sharing as exemplary case of this type. The third class of result-oriented services describes user-provider agreements on a pre-determined product-unspecific result. An example regularly presented is a guarantee of a dedicated limited harvest loss by a system-provider of pesticides. The provider is independent in its choice of technology to provide the result. The differentiation into eight different types by [Tukker, 2004] even broadens the PSS scope by including complementing concepts as renting, leasing, pooling and outsourcing which are not presented in detail due to its limited relevance for this work.

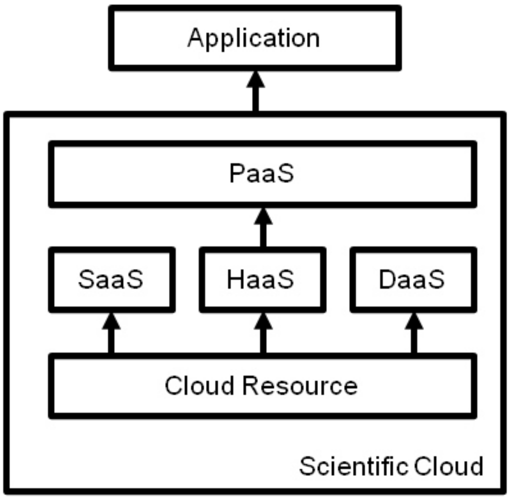
There are three key characteristics of product-service-systems beside the importance of the central product in value proposition. First characteristic of PSS is the possibility for dematerialization through the systemic approach, i.e. the possibility to decouple economic success from material consumption, e.g. [Cooper, 2000; Aurich et al., 2009]. The majority of classified systems deliver value through a service that incorporates the use or the result of shared physical assets. Hence, there is no direct connection between amount of delivered value and quantity of physical material compared to product-based sales. Second characteristic is the consideration of the whole life-cycle of the product including the operational and recycling phase. The implementation of an (eco-) effective post-production phase is regarded to be a crucial factor for successful product-service-systems, e.g. [White et al., 1999; Mont, 2002; Sandberg et al., 2005]. The third aspect concerns the importance of the relationship between user and firm for identifying and satisfying consumer needs. The user preferences may have an economical as well as ecological dimension.

As the majority of the existent publications analyze qualitative cases of product-based firms, the authors detect an increased value for the customer through the integration of additional service elements as main benefit of product-sharing-systems, e.g. [Baines et al., 2007]. Furthermore, PSS have the potential to provide firms strategic advantages through differentiation in price-sensitive markets, e.g. with a service element that is difficult to imitate [Goedkoop, 1999]. Other researchers see PSS as a strategic opportunity to explore new market trends and developments or as growth strategy on innovation in mature industries [Mont, 2000; Mont, 2002]. Further benefits for companies identified by single authors include higher quality, additional functionality [Cook et al., 2006] and removal of administrative or monitoring tasks for the user as well as a more sustainable approach to business [McAloone and Andreasen, 2004; Manzini et al., 2001]. The dominant barrier for adapting PSS is the cultural shift necessary towards a preference of ownerless consumption by the user as well as a lack of experience from firms in system implementation combined with their inherent risk avoidance [Baines et al., 2007]. As the concept is used in diverse scientific disciplines, various methodologies and tools are presented for designing PSS with a heritage in Concurrent Engineering, Lean Product Development and Life-Cycle-Assessment, e.g. [Hepperle et al., 2010; Briceno et al., 2005; Bey and McAloone, 2006]. A detailed discussion of the existing operational development methods can be found in [Meier et al., 2010] or [Van Halen et al., 2005]. [Baines et al., 2007] also recognized the aforementioned widespread application of the PSS concept in literature and conclude in their review that *"in-depth and rigorous research is needed to develop models, methods, and theories. More widespread adoption of the PSS concept needs better understanding of PSS practices, of methods to assess value, and of organizational transitions."*

Although the concept of product-service-systems acknowledges and includes the detected phenomenon, it is still an undeveloped and generic conception due to its wide but shallow application. It is a rather descriptive approach cumulating different phenomena in one concept because of its initial definitions and classifications. A clear distinction between a sharing-system and e.g. renting or leasing service is absent. Hence, a wide array of cases is included under the umbrella of PSS by the contributing authors which partly exhibit minor to none resemblance to the phenomenon analyzed in this work. The conceptual emphasis in the literature is on the operational level, i.e. the development and optimization of dedicated processes, methods and tools. The environmental impact of PSS compared to existing alternatives is often assessed on industry or national level. Additionally, an analysis of the strategic relevance of PSS in excess of single assumptions is absent. This context allows only for a limited transfer and application of the prior identified characteristics. Furthermore, most authors put their effort on a clear distinction between the single components product, service, network, infrastructure and their dedicated contribution to value proposition which might be difficult to assess and of minor relevance in economic praxis. Last, the concept evidence mainly relies on the evolution of product-based firms, whereas the author observed an equal transition of service and entrepreneurial firms as well. Nevertheless, there are few findings in this concept that resemble the detected phenomenon and may be used as theoretical starting point. First is the clear definition of and responsibility for a sub-system within the industry by the providing firm. The defined system consists of several physical and non-physical components whereas the non-physical service components are of ascending significance. The responsibility of the firm extends to the whole life-cycle of the components including the operational and recycling phase. And last, the transition towards a system offering requests a reconfiguration of the firm`s business model.

2.1.2. Cloud Computing and Software-as-a-Service

A second area of expertise that has acknowledged the phenomenon within this work is the computational science. The two associated notions 'cloud computing' and 'software-as-a-service' (SaaS) were coined by practitioners and are nowadays vastly used in the IT industry [Farber, 2008]. In academia it is still an evolving concept with no widely accepted definitions existent to date, although various attempts have been made, ranging from technology-oriented, e.g. [Buyya et al., 2009] towards more economic-oriented, e.g. [Marston et al., 2011]. Exemplary, [Wang et al., 2010] state that *"a computing Cloud is a set of network enabled services, providing scalable, QoS* [i.e. qualitiy of service] *guaranteed, normally personalized, inexpensive computer platforms on demand, which could be accessed in a simple and pervasive way".* Furthermore, the authors propose that these clouds deploy an application with combined services to access hardware (hardware-as-a-service, HaaS), software (software-as-a-service, SaaS) and data resources (data-as-a-service, DaaS) through an integrated computing platform (platform-as-a-service, PaaS) to the user (cp. Depiction 6). The key technological characteristics of computing clouds are user centric interfaces that are easy to access, on-demand service provisioning (e.g. pay-as-you-go subscription service), guaranteed service quality (e.g. quality of service, QoS), autonomous third-party system implementation and inherent flexibility and scalability of system.



Depiction 6: Classification of Cloud Computing[4]

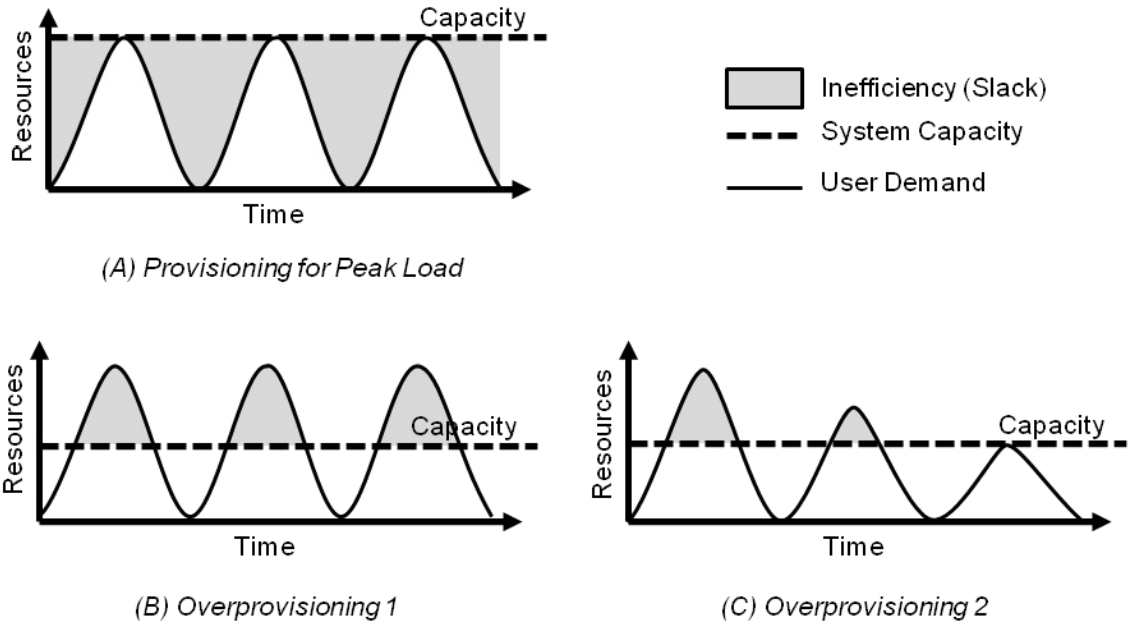
Other scholars try to eschew the vast notion of 'x-as-a-service' as precise differentiations are absent. [Armbrust et al., 2010] suggest that *"cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services. The services themselves have long been referred to as Software as a Service (SaaS). The datacenter hardware and software is what we will call a Cloud. When a Cloud is made available in a pay-as-you-go manner to the public, we call it a Public Cloud; the service being sold is Utility Computing. We use the term Private Cloud to refer to internal datacenters of a business or other organization that are not made available to the public. Thus, Cloud Computing is the sum of SaaS and Utility Computing, but does not normally include Private Clouds".* The authors are putting the emphasis on the relation between the notion cloud computing and SaaS, as well as defining SaaS as the principal service in the offering, while the term cloud computing incorporates all system components. The role of the

[4] Own depiction based on [Wang et al., 2010]

business model is only indirectly addressed through the comparison with other existing utilities (e.g. water, gas, electricity), a connotation that has also been used in the term 'product utility services' of the previous chapter (cp. Chapter 2.1.1).

A more economic-oriented definition is given by [Marston et al., 2011], who propose that cloud computing *"is an information technology service model where computing services (both hardware and software) are delivered on-demand to customers over a network in a self-service fashion, independent of device and location. The resources required to provide the requisite quality-of-service levels are shared, dynamically scalable, rapidly provisioned, virtualized and released with minimal service provider interaction. Users pay for the service as an operating expense without incurring any significant initial capital expenditure, with the cloud service employing a metering system that divides the computing resource in appropriate blocks"*. The key elements in this definition are the on-demand self-service business model, the shared use of resources and usage-based payment as operating expense that also apply to performance-oriented systems observed in other industries. This perception is largely shared by the American National Institute of Standards and Technology that characterizes cloud computing as *"a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider action"* [Takai, 2012].

The aforementioned authors identified three economic key advantages of Cloud Computing. First, the availability and immediate access to computing resources eliminates the need for users to forecast and plan their individual demand. The second advantage lies within the elimination of an upfront capital investment for the users and third is the ability to pay on short-term when resources are needed [Armbrust et al., 2010; Marston et al., 2011]. These three aspects may be summarized under the notion elasticity or transference of risk in terms of underutilization and saturation of resources. Cloud computing is converting capital expenses to operating expenses, so-called 'CapEx' to 'OpEx', or alternatively coined as pay-as-you-go or usage-based pricing. The unit costs of the pay-as-you-go pricing model is more expensive compared to the investment and depreciation of a privately owned datacenter, but it allows far more flexibility for the user to adapt resources to actual workload instantly, e.g. during peak times. In comparison, a private datacenter normally provides capacity for peak or average demand resulting in unused resources or shortfalls in certain times (cp. Depiction 7, grey-shaded area). This efficiency outweighs the initially higher unit price as capacity in cloud computing always equals demand. Cloud computing also allows for green computing [Marston et al., 2011] as it is seen to be the convergence of the two trends IT efficiency, i.e. efficient IT resource use, and business agility, i.e. competitive IT use.



Depiction 7: System Capacity Provisioning[5]

A strategic view on cloud computing and SaaS is given by Cusumano relating the two concepts to his well-developed theory of industrial platform leadership [Cusumano, 2010a]. The theory is based on founding work regarding platform development in the software and computer industry, e.g. [Evans et al., 2006] or [Bresnahan and Greenstein, 1999]. The theory of industrial platform leadership argues that companies from information technology business are most successful when they implement industry wide platforms [Cusumano and Gawer, 2002; Cusumano, 2010b]. These industry platforms deliver their function through a technological system consisting of components delivered from different companies. The value of the platform increases with the number of complementing products and services. The notion is closely related

[5] Own depiction based on [Armbrust et al., 2010]

to the term industry standard which is specifying the technical rules and protocols for interconnecting the components of an industry platform. Recent examples for industry platforms are VHS or DVD players, as well as Microsoft Windows and the personal computer. Industry platforms are opposed to product platforms which form the basis for an internal technological development strategy of a firm. In this strand of literature, *"a product platform is a set of common components, modules, or parts from which a stream of derivative products can be efficiently created and launched."* [Meyer and Lehnerd, 1997]. As an exemplary product platform the authors propose the use of one chassis for different car models in automobile firms. Regarding cloud computing and SaaS, Cusumano identified some identical characteristics with his industrial perspective stating that *“Saas and the cloud are clearly new platforms for computing”*. But he immediately constrains that *“product firms seem to offer SaaS and the cloud as another mode of delivery and pricing”* [Cusumano, 2010a] and that the acknowledgement of such offerings as an industrial platform needs wider technological integration among complementors and competitors.

It becomes apparent that the literature of cloud computing and SaaS is confronted with similar problems regarding a clear definition of system components and system boundary. The detected phenomenon is more than a simple product bundle, i.e. product plus additional services, or an in-house development strategy, but less than an industrial platform or standard. The relevant definitions attempt to characterize the physical and non-physical resources of the systems as precise as possible without consensus. Commonly, all authors have identified one dominant service providing a function that is delivered through a platform to the user, e.g. comparable to an utility service. Analog to the literature on PSS, the authors emphasize the change of the business model. They typify the business model as an on-demand, self-service model that is independent of device or location. The dominant service is remunerated as an operational expense that does not require any initial capital investments. Last, the systemic approach allows elasticity and a lower risk in resource provisioning.

2.1.3. Service-Dominant Logic and Shareconomy

The previous chapters indicate a superior role of the service component in performance-oriented systems. For example, the PSS literature identified an increased trend of 'servitization' within system offerings and the computational sciences explicitly declare these systems as being a service model. The three commonly described characteristics of services are intangibility, the uno-actu-principle and the integration of the external factor [Torney et al., 2009]. The first aspects refers to the non-physical character of services, whereas the second aspect describes the circumstance that a service is produced and consumed at the same time. The third prerequisite accentuates the active role of the consumer during production of the service. An abstract concept that is discussing the role of goods and services in the value proposition originates from the marketing sciences and has been directly linked to the aforementioned theories only to a very limited extend, e.g. [Kowalkowski, 2010; Kindström, 2010]. According to [Vargo and Lusch, 2008] service-dominant logic (S-D logic) as opposed to the goods-dominant logic (G-D logic) *“superordinates service (the process of providing benefit) to products (units of output that are sometimes used in the process)”* and furthermore *“that it is not products that are the aim of the customer`s acquisition but rather the benefit available […] customers purchase solutions”*. According to the authors, this concept supports a recent development of marketing from management of customers and markets towards collaboration with customers and partners to produce and sustain value [also cp. Vargo and Lush, 2004; Ballantyne and Varey, 2008; Maglio and Spohrer, 2007]. The concept of service-dominant logic is purely economic driven; ecological benefits of service-oriented offerings are embraced under the term 'functional economy'. According to [Stahel, 1997] the objective of a functional economy is *“to create the highest possible use value for the longest possible time while consuming as few material resources and energy as possible”*. As a strategy to reduce the volume and speed of the resource flow and therefore resource efficiency, Stahel proposes system solutions from a technical as well as an economic perspective, e.g. selling results instead of goods. The service-dominant logic is suitable to partially explain the phenomenon in the market diffusion or operational phase as it clarifies the importance of the service component in the system offering. Additionally it supports the evaluation of [Cusumano, 2010a] who characterizes the phenomenon as being solemnly a marketing strategy. Contrary to this perspective is the evidence from the PSS literature which identified the need to develop integrated operational tools and methods for planning, development, provision and use phase [Meier et al., 2010]. These findings indicate an explicit need to develop strategic concepts that start well before the diffusion phase.

The phenomenon of performance-oriented systems is regularly characterized as product-sharing in certain industries, e.g. car-sharing in the mobility industry. A comprehensive classification of commodity sharing is provided by [Belk, 2010] in his recent literature review of anthropological studies which will be briefly summarized in the following. In historic terms, sharing is regarded to be the oldest and most basic form of human economic behavior. The rise of the rational choice theory, e.g [Ostrom, 1998; Coleman and Fararo; 1993], that assumes selfish individuals competing for scarce resources accompanied the emergence of a consumer culture towards increased atomization, possessive individualism and less sharing in reality [Belk, 2007; Tuan, 1982]. The diffusion of the internet in the last decade revitalizes the patterns of sharing in western societies as new phenomena emerge, e.g. open source communities, that also attract new research. Sharing as a form of economic distribution among a group is the antidote to ownership and materialism, which are characterized by privacy and individualism. *"Sharing [...] improves the efficiency of resource use, increases security by sowing seeds of reciprocal obligations, or enhances the status or mating opportunities of those who share"* [Belk, 2010; based on Gurven, 2006; Hawkes, 1991; Kelly, 1995]. Because of these characteristics, economically disadvantaged groups have widely adopted this type of collective behavior. The advantage of sharing is more solidarity without compromising the level of consumerism. A negative effect of sharing is the feeling of dependency by those who do not contribute into the commons. [Belk, 2010] discusses sharing as an economic behavior in the broader context of gift giving and commodity exchange. The author asserts that *"the lines between gift giving, sharing, and commodity exchange are imprecise"* [Belk, 2010] and further, that there is a continuum between pure gift, i.e. no reward expectation, and a pure trade, i.e. the exchange of money for resource. In between he detects several blurred modes of commodity exchange, e.g. the reciprocal gift that is expecting a direct or indirect benefit. Generally, gifts reinforce connections between individuals and act as a form of social communication. The primary objective of a trade or barter is an increase of materialistic consumption which is rather impersonal. All modes of gift giving and commodity exchange along the continuum are characterized by a transfer of ownership between individuals, de jure or at least de facto. In contrast, the separation between distinct parties in commodity sharing as basis to assess a transfer is difficult. For example, an ideal mode of sharing can be observed in the pooling of resources within private households [cp. Hunt, 2005]. Only some individuals of the family are contributing the necessary resource(s) into the family boundary, whereas all are allowed to use or consume them. Exemplary, all members of the family use the furniture or the food commons within the refrigerator. Hence, several authors accentuate the role of the ordinary social context for sharing, e.g. the family boundary or, in a larger context, the village, e.g. [Belk, 1988]. Within this boundary, sharing is not an exchange of commodities but rather a contribution into a commons. The more users contribute into the commons, the more possibilities arise for all individuals. Besides the social context, researchers also stress that the relationship between people (independent vs. interdependent) and the relationship between people and objects (alienable vs. inalienable) are influencing the selection of the economic behavior towards giving, sharing or exchange [cp. Humphrey and Hugh-Jones, 1992]. Remarkably, all three types of behavior are coexisting within a defined group boundary, e.g. the family. The choice of behavior depends on the occasion. Sharing as an economic behavior can be further segregated into the two types of 'sharing in' and 'sharing out' [cp. Widlok, 2004]. 'Sharing in' is closer to the notion of gift giving as it creates bonds between individuals through expanding the domain of common property, e.g. moving into the apartment of the girlfriend. Thus, this type broadens the individual, private boundary in including other (often closely related) persons. In contrast, 'sharing out' characterizes the division of a resource or commodity between individuals with the same discrete economic interest, e.g. the acquisition of an expensive sportscar. This type preserves the self/ other boundary and is not intended to create bonds. The latter type has also been detected within the notions 'collaborative consumption', e.g. [Botsman and Rogers, 2010] and 'shareconomy' [CeBIT, 2013], both reflecting on its relation towards a classic economic-driven commodity exchange. To summarize, the general social sciences provide a broader perspective on sharing as an economic behavior that comprises mixed characteristics of gift giving and classic commodity exchange. The behavior of sharing has been revitalized in western societies with the emergence of the internet. Especially the second type of 'sharing out' with a clear economic intention reflects on the phenomenon within this work. The creation of 'shareconomy', that inherently merges sharing and economy, seems most capable to serve as an umbrella term for this research, due to its strong connection to industrial praxis, i.e. integrating the firm perspective, as well as its established linkage to the notions of software-as-a-service and cloud computing of the previous chapter.

2.2. Environmental Benefits of Performance-oriented Systems

2.2.1. Green Innovation in Technology and Innovation Management[6]

Most of the aforementioned concepts include ecological aspects as a benefit of system offerings. Although the transfer of findings is limited due to the identified reasons, the existence of ecological benefits might also be a relevant factor in strategic management. Therefore, the subsequent chapter firstly provides a clarification of the general concept of 'green innovation' before focusing on the assessment of the environmental aspects potentially implied in performance-oriented systems. Comparable notions commonly used in literature are explicitly included in this overview, i.e. ecological innovation, environmental innovation, and sustainable innovation. In the following, a number of widely cited definitions will be briefly reviewed.

According to [Church et al., 2008: 3] citing [Dresner, 2008: 30], the term 'sustainable development' was first used in 1980 by the International Union for Conservation of Nature and Natural Resources in their World Conservation Strategy report. The report defines sustainable development as *“the integration of conservation and development to ensure that modifications to the planet do indeed secure the survival and well-being of all people”*. As stated in several publications, e.g. [Mebratu, 1998; Dixon and Fallon, 1989], the notion of 'sustainable development' was essentially coined by the Brundtland report, commissioned by the UN, where it is defined as meeting *“the needs of the present without compromising the ability of future generations to meet their own needs. The concept of sustainable development does imply limits - not absolute limits but limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities”* [World Commission on Environment, 1987: 24].

A number of definitions exist for the notion 'eco-innovation'. One of the first [Fussler and James, 1996], define eco-innovations as *“new products and processes which provide customer and business value but significantly decrease environmental impacts”*

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[6] The chapter is closely related in form and content to, and thus uses concepts from the author's contribution in: Schiederig, T., F. Tietze, and C. Herstatt (2012), Green Innovation in Technology and Innovation Management – An Exploratory Literature Review, R&D Management 42(2), 180–192.

[Bartlett and Trifilova, 2010: 2]. In a similar manner [Kemp and Pearson, 2007: 3] define eco-innovation as *"the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives"*. The Europe INNOVA panel concludes that *"eco-innovation means the creation of novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimal use of natural resources (material including energy carriers and surface area) per unit output, and a minimal release of toxic substances"* [Reid and Miedzinski, 2008: 7]. Based on the industrial dynamics perspective [Andersen, 2008: 5] defines eco-innovation *"as innovations which are able to attract green rents on the market. [...] The concept is closely related to competitiveness and makes no claim on the 'greenness' of varies innovations. The focus of eco-innovation research should be on the degree to which environmental issues are becoming integrated into the economic process"*. In line with this argumentation is the definition from the [OECD, 2009: 19]. Accordingly eco-innovation is defined as *"the creation or implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organisational structures and institutional arrangements which - with or without intent - lead to environmental improvements compared to relevant alternatives"*. Building on these two definitions [Arundel and Kemp, 2009: 34] conclude that eco-innovation is *"a new concept of great importance to business and policy makers. It is about innovations with lower environmental impact than relevant alternatives. The innovations may be technological or non-technological (organizational, institutional or marketing-based). Eco-innovations can be motivated by economic or environmental considerations. The former includes objectives to reduce resource, pollution control, or waste management costs, or to sell into the world market for eco-products"*.

In comparison to the eco-innovation definitions, [Oltra and Saint Jean, 2009: 567] define environmental innovation *"as innovations that consist of new or modified processes, practices, systems and products which benefit the environment and so contribute to environmental sustainability"*. To define the notion 'green innovation' [Driessen and Hillebrand, 2002: 344] apply *"a rather pragmatic definition"* stating that it *"does not have to be developed with the goal of reducing the environmental burden. [...] It does* *however, yield significant environmental benefits"*. [Chen et al., 2006: 332] define green innovation *"as hardware or software innovation that is related to green products or processes, including the innovation in technologies that are involved in energy-saving, pollution-prevention, waste recycling, green product designs, or corporate environmental management"*.

To summarize, the above mentioned definitions of the four notions sustainable, eco, environmental and green innovation show minor differences in their descriptive precision. With regards to content they seem to examine the same topic and can be used largely interchangeably. Nevertheless, the founding research of this study identified six important aspects in the different definitions:

1. Innovation object: Product, process, service, method
2. Market orientation: Satisfy needs/ be competitive on the market
3. Environmental aspect: Reduce negative impact (optimum = zero impact)
4. Phase: Full life cycle must be considered (for material flow reduction)
5. Impulse: Intention for reduction may be economical or ecological
6. Level: Setting a new innovation/ green standard to the firm

The first two aspects have a general character and apply to nearly all innovation definitions, stating that the innovation object may be a product, process, service or method, e.g. business model, and that an innovation should satisfy a user's need or solve a problem and therefore be competitive on the market. Concerning the environmental aspect all cited definitions agree that the innovation should have a reduced negative impact, i.e. lower negative externalities. The optimum would be an innovation without any negative impact on the environment at all. This aspect requires the comparison to existing intra- or inter-organizational alternatives and may therefore only be specified relatively and temporary. The fourth aspect appears only in two of the definitions by [Kemp and Pearson, 2007] and [Reid and Miedzinski, 2008]. The authors call explicitly for a full life cycle analysis and a thorough analysis of all input- and output factors. The aim is a reduction of resource consumption. In this point there may well be a differentiation between the notions, as mainly scholars of the notion eco-innovation call for precise impact analysis whereas scholars using the term green innovation remain at a shallow level. Fifth, the definitions emphasize that the intention for the reduction may be economical or ecological, stating that for example the reduction of material usage in a new product development could have different causes. The last aspect covers problems related to the definition of innovation and environment-friendly as the two notions are both relative and have no absolute value, e.g. any innovation could be new to the world, industry or the firm. Both notions may well be interpreted as setting a new innovation/green standard to the firm.

The last two aspects are the main reasons for a scientific discussion as they impede researchers to clearly separate green and non-green innovations and determine their degree of 'greenness'. Due to the numerous types of innovation, these fuzzy aspects allow nearly all firms to be included into the definition of a green innovator [also cp. Andersen, 2008]. Comparing the UN Brundtland definition for sustainability with the other three notions, the most important difference in this definition is the consideration of the ecological and social dimension. The development of sustainable innovations therefore implements economical, ecological and social aspects. This characteristic is the main difference between 'sustainable' and the other three notions which only include the former two aspects.

2.2.2. Resource Efficiency of Performance-oriented Systems

The review in chapter 2.2.1 reveals several challenges in the environmental assessment of innovations and the distinction between green and non-green innovations. When analyzing the available definitions the interrelation with the literature on product-service-systems becomes apparent as some of the identified six important aspects are regularly reflected in the PSS research as well (cp. chapter 2.1.1.). Exemplary, several scholars put an identical emphasis in their definitions on the competitive market orientation, the need for a life-cycle analysis and a reduced environmental impact in comparison to existing alternatives. Contrary to the authors above, the PSS research examines a combination or collection of physical and non-physical components. The ascending complexity in performance-oriented systems, i.e. several bundled products and services, even deepens the challenges of a thorough impact assessment.

Subsequently, the findings regarding ecological benefits of system offerings also comprise the weaknesses of the general green innovation research and therefore remain on a conceptual level. Several authors only identify generic measures, instruments or effects. For example, [Mont, 2004: 239] concludes that PSS can reduce the environmental impact of consumption by four measures: *"Closing material cycles and re-use of components in next generations; Reducing consumption through alternative scenarios of product use; Increasing overall resource productivity and dematerialization of PSSs; Providing system solutions seeking the perfection in integrating system elements along with improving resource and functional efficiency of each element"*. The central theme of dematerialization, i.e. the possibility to decouple economic success from material consumption, is strongly linked to the increasing importance of the service component in the systems offering.

[Tietze et al., 2011] attempt to arrange the ecological benefits of system innovations in groups, an approach which is contrary to the identification of single instruments or measures by e.g. [Mont, 2004]. The former authors identified three different groups of environmental gains in product-service-systems: two system inherent effects, that are realized automatically or potentially respectively, and an additional system independent effect. The first aspect that is system inherent and realized automatically results from a higher resource utilization rate of PSS compared to conventional product use. For example, an average owner of a purchased car normally uses the vehicle on a work-day solely to drive to work in the morning and back home in the evening leaving it unused amid. The vehicles of a car-sharing in comparison are driven by different users with diverse schedules throughout the day and night. This first effect is also supported by other studies, e.g. [Loose, 2008]. The second environmental benefit is only potentially implied in system offerings and is caused by the inclusion of the operational phase. To remain in the example of car-sharing, the operators provide their vehicles on fixed per minute or kilometer basis including all operational cost. A potential reduction of these variable costs is accompanied by a reduction of resource usage as well, but needs additional activity of the firm. The third ecological benefit is system independent and results out of a potential combination with other environmental beneficial concepts such as the Cradle-to-Cradle approach, as developed by [McDonough and Braungart, 2009].

There are only few authors that strive to provide a detailed resource analysis of all input and output factors of a complex system. An exemplary study is provided by [Firnkorn and Müller, 2010] who examine the environmental effects of a free floating car-sharing system (Car2Go by Daimler AG) over a five year period. In their model, the authors consider energy and material consumption during system construction, emission and land consumption during operation and possible recycling effects during system decomposition phase. Their results indicate a reduced CO_2 impact per average system user and a reduction in static land use. The authors immediately limit their findings as they partially rely on empirical data and partially on forecast of the derived results.

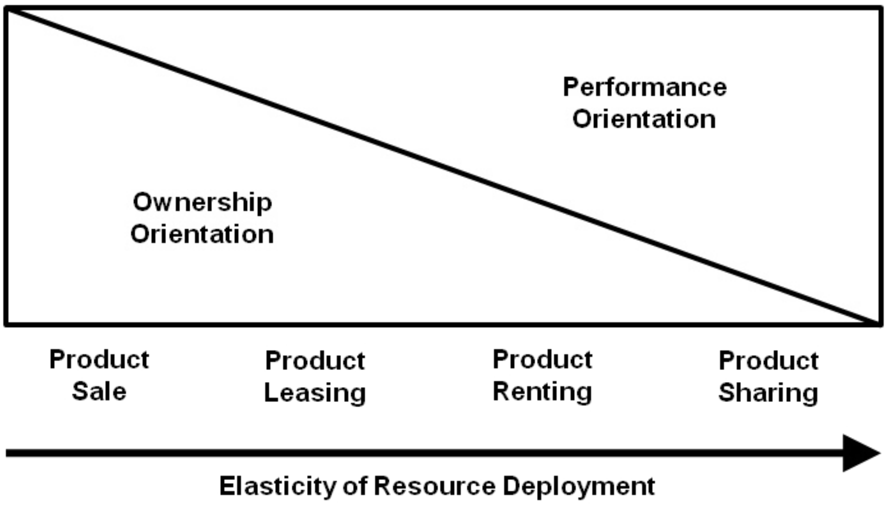
Although there are several indications that a system approach has inherent and/ or potential environmental benefits, profound scientific evidence is scattered and further investigation needed in this area. An exact life-cycle-analysis of the resource use in all the detected systems from the four industries in comparison to suitable alternatives would go beyond the scope of this work. Although it would add clarity to challenges of 'phase' and 'level' in environmental research (cp. aspect four and six in chapter 2.2.1.), it is of minor relevance for strategic management research from a firm's perspective. Nevertheless, a relevant aspect in the area of strategic management is whether the intention for system development and implementation is based in economic praxis on ecological considerations (cp. aspect five in chapter 2.2.1.) or whether this is solely an assumption by the scientific community. Thus, the scope of this work includes the verification of a firms` decision to innovate performance-oriented systems; whether it is purely economic driven, economic and ecologic driven, as proposed by [Porter and Van der Linde, 1995], or a decision based on users demand or proposition.

2.3. Development of a Working Definition

When reviewing the existent literature, it becomes apparent that several scholars have already acknowledged the phenomenon of performance-oriented systems and identified different characteristics with regards to their field of expertise. The concept of product-service-systems and its related notions clearly focus on the operational level. Additionally the concepts fall short of a clear and common understanding what phenomena the terms should embrace and which to exclude. Subsequently, the concept remains rather shallow in analyzing the different components and their role in the value proposition. The research in this field puts an emphasis on the ecological benefits of the systemic approach. Nevertheless, it provides initial evidence that the detected phenomenon is a well-defined sub-system within the respective industry with full life-cycle responsibility of the operating firm for the included components. These components may be physical and/ or non-physical, with a central service component. The last aspect specifies the need for a reconfiguration of the firm`s business model. The computational sciences precisely recognized the detected phenomenon in terms of cloud computing and software-as-a-service while not providing universal evidence for all cases included in this research. They classify the offering as a sub-system as well that is located between a product-bundle at the lower end and an industry wide system or standard at the upper end. Additionally they emphasize the role of a platform for interconnecting the single components and providing a central service. The business model is altered towards a flexible on-demand and product-unspecific offering. Regarding research on the strategic relevance of performance-oriented systems, the service-dominant logic is of limited use for strategic innovation management due to its restriction to the market diffusion phase. The notion of 'shareconomy', reflecting on the mixed characteristics of sharing and economy, primarily provides an initial, generic classification of the phenomenon. Last, the assessment of ecological benefits implied in a systemic approach remains on a conceptual level. Although all examined notions are linked to a dedicated strand of literature and area of expertise, none of the existing concepts describes the detected phenomenon thoroughly from a strategic perspective. Against the backdrop of the omissions and weaknesses in the existing conceptions, the present study derives the notion of performance-oriented systems and combines it with central aspects of existent prior research in an innovative approach.

To summarize the different research strings above, the working definition of performance-oriented systems within this study concludes that:

"A performance-oriented system is a well-defined sub-system in the respective industry combining different resources, e.g. physical and non-physical components, for shared use. The single resources are organized through an integrating module, often referred to as platform. This module provides the performance of the integrated components on flexible, usage-based conditions and does not request partial ownership of any resources by the user. Hence, a performance-oriented system features maximum elasticity of resource deployment for the user. The integration of the use phase within the system boundary results in an increased resource efficiency in comparison to existing alternatives."



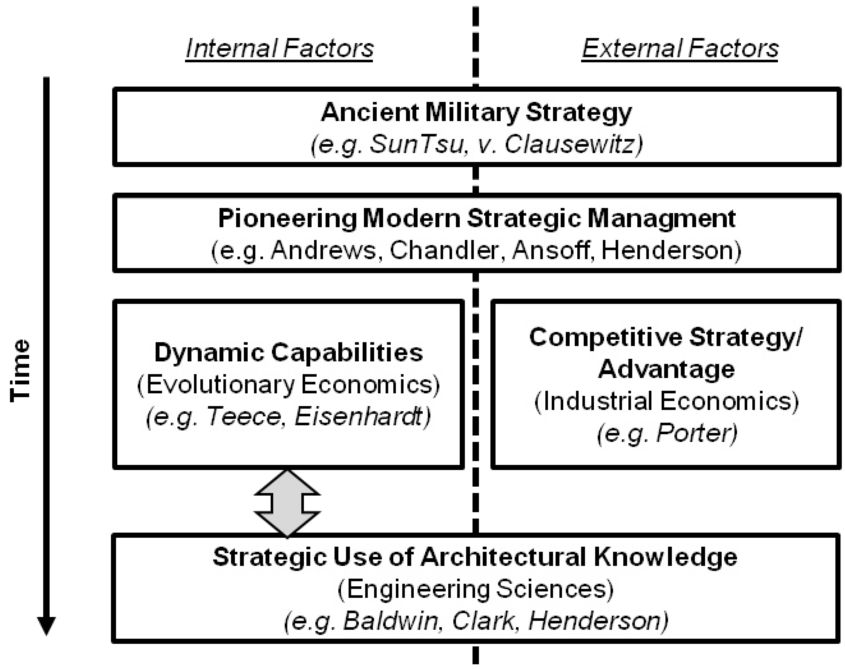
Depiction 8: Elasticity of Resource Deployment in System Offerings

Resembling bundles of components, e.g. renting, leasing or pooling services are not included under the notion performance-oriented system due to different characteristics that result in a reduced elasticity, i.e. inflexible contractual conditions, or the partial ownership of system-components by the user. Thus, elasticity describes in this study the user's flexibility in his resource use. Depiction 8 exemplary compares the four generic models product sale, leasing, renting and sharing according to their elasticity. In a product sale, the user is forced to plan his demand for the entire physical product lifespan and deploy necessary resources, e.g. financial, time and know-how resources, before usage. The ownership of the product and the related status is a relevant aspect for the user in this case. In comparison, product leasing already decreases the planning horizon significantly, e.g. half the product lifespan, and allows for a monthly resource deployment after an initial fixed payment. Product renting continuous this trend and allows a pure variable resource deployment on an even shorter basis. The highest elasticity is provided by product sharing, where the user may decide in some of the observed cases every minute whether he wants to deploy further resources. In this case the usage and the related performance play the central role in the user's considerations. To summarize this aspect, as no consistent definitions across industry sectors for the differing notions/ models are existent and intersections are blurred, performance-oriented systems always 'bang the right corner' in terms of elasticity of resource deployment relative to existent offerings. They are optimized towards performance, i.e. in this study 'work done over time', and its related costs. Likewise, it is neither an industrial standard nor platform that provides the core for complementing firm`s offerings because of the system governance by a single firm and its limited adoption within the industry.

Ecological characteristics are only indirectly included in the definition of performance-oriented systems under the notion of resource efficiency. The resource efficiency, that forms the basis for being an ecological benign offering, may well be motivated solely by economies of scale and scope during system composition and operation phase [cp. Henderson and Gälweiler, 1984; Hirschmann, 1964]. The rationale behind this conservative decision in the working definition is to potentially reduce inaccuracy. First, the previous chapters well illustrated the underlying challenges in precise assessment. An explicit inclusion of the environmental aspect in the working definition would require a thorough resource comparison of the observed cases as well as prospective alternatives, which is beyond the scope of this work. Second, the existing body of literature has not reached a consensus whether a managerial motivation for environmental benefits is existent. The findings within this study (cp. Chapter 5) will certainly add clarity to the latter aspect.

3. Strategic Innovation Management of Complex Systems

The previous chapter identified a research gap as no strategic research on performance-oriented systems is existent to date. To lay the foundations for such an analysis, two strands of strategic management literature will be presented in the following. First, the leading and well established frameworks that emerged from the management sciences are presented in chapter 3.1. In the past fifty years, these concepts constantly refined the two-step approach of an analysis of the firm`s environment (external factors) and the adaption of the firm (internal factors) (cp. Depiction 9).



Depiction 9: Overview of Strategic Management Concepts

Early concepts, e.g. [Ansoff, 1965; Henderson and Gälweiler, 1984] put an equal emphasis on the internal and external factors in their research but remain on a static level. Subsequent frameworks concentrated on examining the relevance of the external factors, e.g. [Porter, 1980] or the internal factors, e.g. [Barney, 1991] and increasingly considered dynamic market environments into their concepts, e.g. [Porter, 1996] or [Teece and Pisano, 1994] respectively. The underlying research approach from these authors is the conversion from a theoretical or conceptual towards an applied level. In contrast, Chapter 3.2 introduces the strategic use of architectural knowledge as a promising new field of research that has its origin in the engineering sciences. This strand of literature extends the concrete insights from simple technological product architectures towards a concept of strategic analysis at the firm or industry level, e.g. [Baldwin, 2010]. State-of-the-art research discusses the interrelation between these two strings of literature. Chapter 3.3 attempts to contribute to this current discussion and prepare for the development of the research questions and methodology in chapter four. Thus, the subsequent chapter three strives to portray relevant concepts from the broad spectrum of strategic management literature and accentuated their interconnections. The selection of the conceptions is based on their acceptance within the scientific community as well as their compliance with the phenomenon within this study. The focus resides on evolutionary-based rather than fully rational-oriented approaches, as the former seem more appropriate to explain the phenomenon against the backlight of the described characteristics within economic sharing.

3.1. Strategic Management and the Dynamic Capabilities Theory[7]

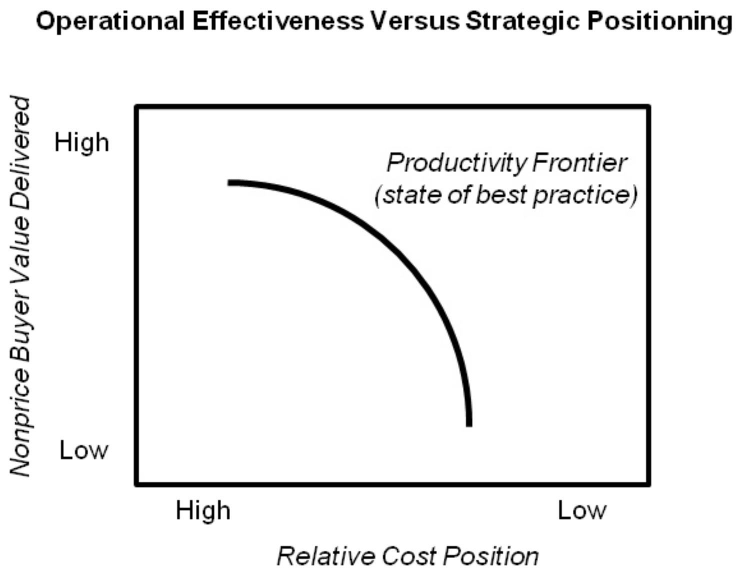
The notion strategy has a nearly 3.000 year old tradition in military research where rivalry, advance and defense are inherent for obvious reasons. Even today, the management literature regularly references back to some of its prominent authors, e.g. Sun Tsu ('The Art of War') or von Clausewitz ('Vom Kriege'). Besides [Kenneth Andrews, 1987] and [Alfred Chandler, 1977], Igor Ansoff and Bruce Henderson are regarded to be the pioneering researchers in modern strategic management literature [Eschenbach et al., 2008]. The central contribution of [Ansoff, 1965; Ansoff and McDonnell,1990] lies within the detection of discontinuities in the environment of the firm ('weak signal management') and the flexible adaption of the firm ('strategic issue and response management'). The result of his standardized strategic planning process is the Ansoff-Matrix which integrates the competitive and diversification strategy ('product-/ market-matrix'). Ansoff laid ground with his work for subsequent resource based concepts. Bruce Henderson also added significantly to strategic research with his work on the experience curve and his contribution to strategic portfolio management [Henderson and Gäweiler, 1984]. The concept of the experience curve is cumulating

[7] The chapter is loosely related in form and content to, and uses sporadic concepts from the author's contribution in: Tietze, T., T. Schiederig, and C. Herstatt (2011), Firms' Transition Towards Green Product-Service-System Innovators, R&D Management Conference, 2011.

earlier research on economies of scale and learning curves [Hirschmann, 1964; Lieberman, 1987] and estimates a twenty percent reduction of the single unit costs with every duplication of quantity. His second major contribution is the development of the well-known and widely-applied 'Growth-Share-Matrix', or 'BCG-Matrix' respectively, where all products of a firm are organized in relation to their respective market growth and market share. Albeit the long history and the widely known examples presented above, strategic research is characterized by comparatively little scientific progress [Eschenbach et al., 2008] which is also supported by the publication dates of the portrayed researchers. The two major advances in recent times are presented in the following in more detail.

The probably best known author in the strategic management discipline is Michael E. Porter [cp. Campbell-Hunt, 2000]. His two major contributions from an industrial economics perspective are 'competitive advantage' and 'competitive strategy' [Porter, 1980; 1985]. His work focuses primarily on analyzing the influence of external factors on the firm's position. [Porter, 1980] proposes an assessment of the industries five competitive forces (originating from competitors, suppliers, buyers, substitutes and new entrants) and to position the firm according to three generic strategic positions, i.e. cost leadership, differentiation and focus. In an update [Porter, 1991; 1996] partially acknowledges the criticism on his framework as being too static for dynamic markets but emphasizes that operational management tools are not capable of replacing strategy due to its long term horizon. In his revised view, the management has to clearly distinguish between operational effectiveness and strategy as they are both important to a firm’s performance but work in different ways. The author defines operational effectiveness as *“performing similar activities better than rivals perform them”* whereas *“strategic positioning means performing different activities from rivals` or performing similar activities in different ways”* [Porter, 1996]. Activities in this context are single elements of the total value chain in the firm or the industry. To further illustrate the difference, Porter uses an imaginary productivity frontier that marks the current state of best practices (cp. depiction 10).

The two dimension of the frontier where firms can improve are their relative cost position and quality or value delivered. In approaching the productivity frontier through constant improvements in those two dimensions, the firm achieves superior profitability. The emergence of new technologies or management tools moves the absolute frontier further outward. If the industry is characterized by competition far from the productivity frontier, rivals may internalize profits both on quality and costs simultaneously through operational effectiveness, i.e. performing single activities better than their rivals. The rapid diffusion of best practices in operational effectiveness, e.g. through imitation of rivals, leads to a competitive convergence down the same path towards the frontier and the competition constantly intensifies. The profits resulting from operations are persistently diminishing. Although an intense competition on operational effectiveness leads towards an absolute improvement of the productivity frontier, the relative improvements of a firm in comparison to its rivals declines. As a result the absolute gains are captured by customers or suppliers, often with superior positions, and the industry is ultimately consolidating through mergers and acquisitions.



Depiction 10: The Productivity Frontier[8]

In contrast to the competition of operational effectiveness, competitive strategy incorporates the execution of a set of activities that are different from a rival's activities, i.e. choosing a different path towards the frontier resulting in a different, unique position. The generic strategies are cost-leadership, i.e. following a path along the x-axis, differentiation, i.e. following a path along the y-axis, and focus, i.e. limiting the firm`s scope to a certain market, product or component, which can each be specified into the

[8] Own Depiction based on [Porter, 1996]

three bases varieties, needs and access. The underlying logic of the variety-based positioning is the concentration on a dedicated set of product(s) or service(s). A strategic positioning based on needs is oriented towards a segment of customers with differing demand. The access-based positioning has a geographic or customer scale orientation. All three bases rely on differences in activities on the supply side, whereas only the needs-based positioning includes different activities on the customer side. Although there is not only one ideal position in a market, a unique striking position will certainly attract imitation and lead towards competition on operational effectiveness. Consequently, a sustainable position includes essential trade-offs or choices as a protection against imitation. There are three types of trade-offs existent concerning the image or reputation of a firm, conflicting activities and complex internal coordination. Firms that attempt to reposition or integrate two positions create uncertainty among customers and employees if clear trade-offs exist. To summarize, strategy is about creating and deepening a determined set of activities with a high fit and clear scope, rather than the plain pursuit of growth through broadening or blurring of the initial position. The success of strategy is primarily related with increasing profit, rather than revenue. The framework principally does not differentiate between incumbent and entrepreneurial firms, as both types are confronted with the same challenges in finding an attractive strategic position. But entrepreneurial firms have an advantage in being more flexible in their reaction on changes in the industry as incumbents are normally restrained by their past activities. Porter explains the preference of operational effectiveness in economic praxis instead of strategy with organizational realities. Managers are forced to deliver constant improvements. They avoid expansive decisions and concentrate on measurable incremental improvements instead of risking a bad choice. They show "*a type of herd behavior*" rather than rational foresight [Porter, 1996].

The second major step in strategic research, besides the detailed analysis of external factors and the consistent positioning of the firm as proposed by Porter, is the consideration of internal corporate resources and competences to create competitive advantage. Initial contributions to the capability-based view (CBV) are rewarded to [Itami et al., 1991]. They were further refined by Gary Hamel and Coimbatore Prahalad in their work on core competencies [Prahalad and Hamel, 1990]. According to [Wang and Ahmed, 2007], other influential research originates from the areas of core capability and rigidity [Leonard-Barton, 1992], combinative capability [Kogut and Zander, 1992], organizational routine [Nelson und Winter, 1982], architectural knowledge [Henderson und Clark, 1990] and architectural competence [Henderson and Cockburn, 1994]. The capability-based view enhances the resource-based view (RBV) with an ongoing discussion about the exact extent. The underlying RBV states that superior structures and systems of a firm are the reasons for lower costs, higher product quality or performance [Wernerfeld, 1984; Barney, 1991]. This superiority originates out of the firm-specific resources that are rare, valuable, inimitable and non-substitutable. However, the resource-based approach concentrates on value appropriation and is rather static. It does not incorporate market dynamism or the transformation of a resource advantage towards a competitive advantage [Priem and Butler, 2001].

The theory of dynamic capabilities implements these missing aspects into the resource-based view [Teece and Pisano, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000; Barreto, 2010]. It suggests that it is more important for the economic firm success to identify new opportunities and to organize effectively and efficiently than to concentrate solemnly on external competitive forces. [Teece et al., 1997] initially defined the term dynamic capabilities "*as the firm´s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments*." Subsequent scholars further developed this initial definition. For example, [Eisenhardt and Martin, 2000] assert that dynamic capabilities "*are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die*". Others see dynamic capabilities as "*a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines*" [Zollo and Winter, 2002]. Encapsulating prior research, [Teece, 2007] operationalizes dynamic capabilities "*into the capacity (a) to sense and shape opportunities and threats, (b) to seize opportunities, and (c) to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise`s intangible and tangible assets*". A similar structure of four phases is proposed by [Barreto, 2010] in his recent literature review, suggesting that "*a dynamic capability is the firm`s potential to systematically solve problems, formed by its propensity to sense opportunities and threats, to make timely and market-oriented decisions, and to change its resource base*". Thus, the dynamic capabilities of a firm have to be understood as a steady analysis of the changing environment and the coordinated response to attain and sustain value. It is foremost a behavioral orientation embedded in processes that is in constant pursuit of reconfiguration [cp. Wang and

Ahmed, 2007]. The constant adaption incorporates the firm`s resources, i.e. the physical assets, and its intangible competences, i.e. the ability to deploy resources to attain a goal.

There are three classes of factors that determine the firms' dynamic capabilities: position, paths and processes. The term position illustrates the specific internal and external assets of the firm. These assets describe the physical resources as well as the intangible assets like tacit knowledge, experience and intellectual property within a firm. A conceptual structure of assets is given by [Ambrosini and Bowman, 2009] differentiating between internal, e.g. technological, financial, structural, reputational or complementary assets, and external resources, e.g. market or institutional assets as well as organizational boundaries. The notion paths include all strategic alternatives that lie ahead. As paths describe the technologies and markets a firm can occupy with the help of its processes, the available options are limited by the firm's current position and the paths it has taken in the past, i.e. previous (non-)monetary investments and decisions restrain the firm´s future scope of action. Due to this path dependency a firm is forced to follow a certain trajectory and explore technological or market opportunities along its way. The notion of processes incorporates all managerial and organizational processes within the firm. Thus, they describe all internal routines or sequences of activities in a detailed way. They include operating routines and the modification of operating routines, the dynamic capabilities [Zollo und Winter, 2002]. The latter are structured into the generic phases 'sensing' opportunities, solving problems ('seizing') and 'reconfiguration' of the resource base. Generally, all processes shall fulfill one of the functions coordination, integration, learning and reconfiguration. In this context coordination and integration can be internal, e.g. between single actors or divisions, and external, e.g. partnership between different firms or integration of an acquisition. Learning refers to the capability to connect new information to existing knowledge by repetition and experimentation. Reconfiguration has already been previously described. A common mode of reconfiguration is co-specialization. *“Co-specialized assets are a particular class of complementary assets where the value of an asset is a function of its use in conjunction with other particular assets. […] With co-specialization, joint use is value enhancing.”* [Teece, 2007].

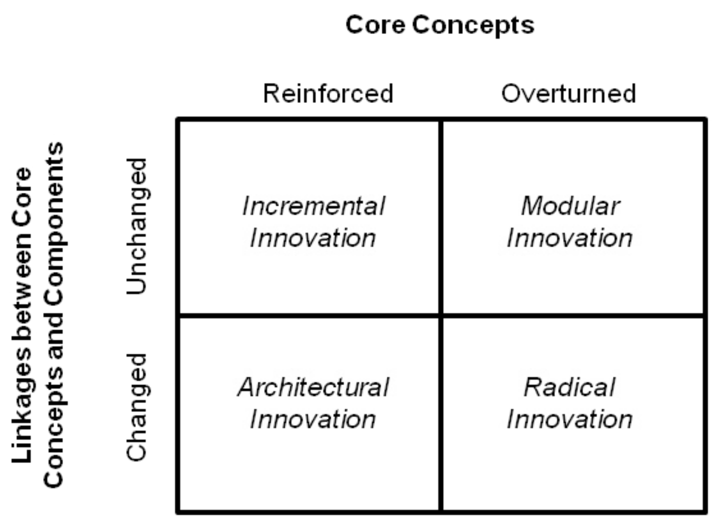
Thus, dynamic capabilities are an aggregated multidimensional construct with dimensions that might be weakly correlated. The operationalization of the single dimensions as well as the relations among the whole construct remains one of weaknesses of the theory and needs thorough future research [Barreto, 2010]. Some studies in the past circumnavigated this disadvantage by using qualitative case studies, e.g. [Galunic and Eisenhardt, 2001; Lampel and Shamsie, 2003; Pablo et al., 2007; Rosenbloom, 2000]. The second accompanying weakness is a common understanding on the relation between dynamic capabilities and the firms' performance. The scientific results on this aspect vary widely, e.g. [Teece et al., 1997; Zott, 2003]. Last, the theoretical assumptions about the managerial rationality are not congruent among past researchers, ranging from a more bounded towards a full rationality-oriented approach, i.e. drawing on classic evolutionary economics or encapsulating the resource-based theory more closely.

3.2. Strategic Use of Architectural Knowledge in Complex Systems

The prior chapter briefly examined the established strategic concepts. Due to their broad scope, their specific link to complex system innovations, and thus the phenomenon within this work, is limited. The emerging research on the strategic use of architectural knowledge within the firm complements this deficiency, as it enhances the understanding of complex technological systems and their strategic management. It is a comparatively novel conception originating from the engineering sciences. The structure of the current chapter follows the evolutionary development of the conception. First, the basic constructs of the concept are clarified, such as the relevant innovation types, their appearance over time and the differences between entrepreneurial and incumbent firms. Second, the chapter exploits the logic of modularity as a basis for technological analysis for modular and integral industries. Third, the role of the bottleneck in a technological system is illustrated. The chapter closes with a description of the strategic options for firm adaption that arise from a modular system analysis.

Research regarding the strategic use of architectural knowledge is based on quite basic assumptions. The first comprises an expanded view of existing innovation types which are portrayed in the following. Generally, [Roberts, 1987] defines innovation as invention and exploitation. More precisely, the OECD characterize innovation as the *"implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations"* [OECD 2005: 146]. At the micro-economic level, innovations often form the ground for competitive advantage of firms [Chandler, 1990]. Refocusing on product innovations, the differentiation *"between a* *product as a whole – the system – and the product in its parts – the components*“[Henderson and Clark, 1990] is even more granular. A component is *“a physically distinct portion of the product [...] and performs a well-defined function”* [Clark, 1985]. The design or the architecture of a product defines the way in which the components work together. Accordingly, the development of a product or system respectively, requires the two types of technological component knowledge and architectural knowledge. [Baldwin, 2010] proposes that architectural knowledge is defined as *“knowledge about the components of a complex system and how they are related”*. Innovations are thus classified with regards to these two dimensions (cp. Depiction 11) into four types, which complement the common distinction between radical and incremental innovations [Henderson and Clark, 1990; also cp. to 'transilience map' of Abernathy and Clark, 1985]. The horizontal axis describes the innovation’s impact on a single component, whereas the vertical axis describes the change in the linkage between separate components. An incremental innovation is characterized by minor changes in a single component of the existing technology while leaving the product architecture unchanged. A modular innovation introduces a new (superior) technology for the respective function which incorporates at least one new component to deliver that function but no change in the composition of the system. This is coherent with the definition of a module as an independent group of components, or more precise as *“a unit whose structural elements are powerfully connected among themselves and relatively weakly connected to elements in other units”* [Baldwin and Clark, 2000: 63]. In contrast, an architectural innovation changes the way the components of a product are linked together while leaving the technology of the components unchanged. A radical innovation has an impact on the technology of the components as well as their interrelation. The boundaries have a rather gradual than absolute character and simply illustrate four generic types. Noteworthy, architectural innovations are often initiated by a prior modular innovation.

The second underlying assumption of the conception is about timing, i.e. how firms build and preserve knowledge and capabilities over time with emerging product technologies [cp. Henderson and Clark, 1990; de Boer et al., 1999]. A new technology first creates a period of uncertainty and experimentation in the industry until a dominant design emerges [Abernathy and Utterback, 1978]. The dominant design marks a general acceptance in the industry of a superior basic product architecture [Clark, 1985]. This basic design is left unchanged in subsequent versions of the product and development activities are concentrated on improving the single components. The organizational knowledge and the competences of a firm are severely influenced by the aforementioned two generic phases, as both capabilities are the result of the tasks within and the environment around the firm [Lawrence and Lorsch, 1967]. Thus, before a dominant design emerges, a firm has to build architectural knowledge and component knowledge. After the emergence of a dominant architecture, a firm primarily focuses on building component knowledge, as future experimentation with the product architecture seems unnecessary and competition turns towards refinements of single modules or components. The organizational structure is adapted to the basic product architecture to further increase component learning efficiency. The result of the evolution is an industry with stable product architecture and predominantly incremental as well as modular innovations.



Depiction 11: Innovation Types[9]

The former two distinctions between innovation types and timing indicate that some innovations enhance and some destroy existing competences. The destruction of existing competences explains why established firms have difficulties in adapting to certain types of innovations. For example, incremental or modular innovations strengthen the

[9] Own Depiction based on [Henderson and Clark, 1990]

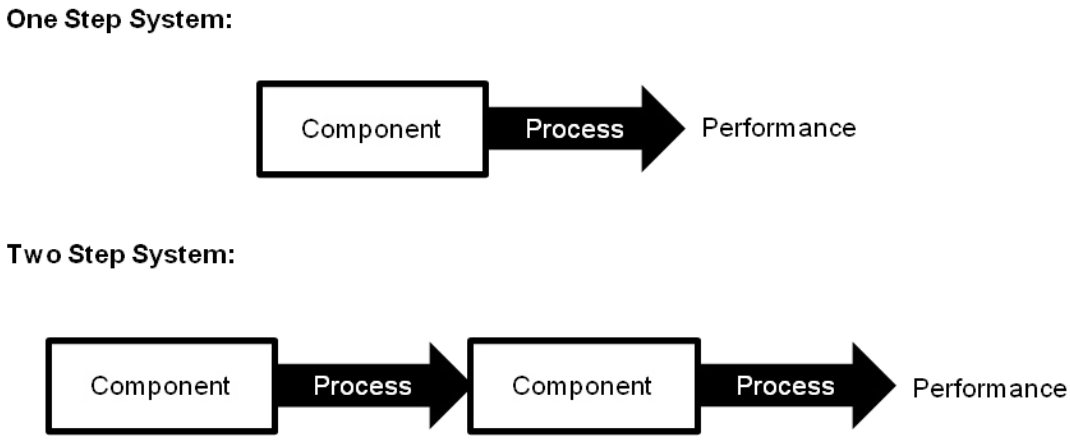
competitive position of established firms due to their existing knowledge base in the respective component development. In comparison, industry entrants have to build this knowledge and accompanying capabilities from close to scratch. In contrast, radical innovations destroy existing architectural and component knowledge bases and the usefulness of prior capabilities within the established firms of an industry. The uselessness of existing knowledge bases, and hence the loss of an inherent advantage, explains why established firms often struggle to adapt to this innovation type [Henderson and Clark, 1990; Schumpeter, 1934]. The fourth type of architectural innovation incorporates a divergent pattern, as the component knowledge base of an established firm is still useful, whereas it has to build novel architectural knowledge. Thus, architectural innovations incorporate two inherent challenges for established firms. First, the organizational structure of an established firm, e.g. the channels, filters and strategies, hinders the identification of an architectural innovation, as the structure of the firm is oriented and optimized towards the prior architecture. Novel technologies are often misjudged by the management as they are analyzed through the old structure. The second challenge is the need to build new architectural knowledge and adapt the resources of the firm as well as its organizational structure accordingly. The firm has to switch (back) from a stable industry environment towards a dynamic phase of experimentation and adaption. In comparison, an entrepreneurial firm is more flexible in building a novel architectural knowledge base because it is not restrained by prior structures.

The logic of modularity is based on the aforementioned characteristics. This mode of system development has been built on quite simple products, e.g. a room fan, but has subsequently been applied to more difficult inter-firm product or service developments, e.g. in the computer or mobility industry [Ulrich, 1995; Baldwin and Clark, 1997]. These comparatively complex system innovations [Katz and Shapiro, 1994] are developed by several firms in a joint effort and are composed of smaller subsystems, which integrate several modules that combine different components on the most granular level. Modularity allows firms to manage complex technologies efficiently and gain flexibility in inter-firm cooperation as the subsystems as well as the modules "*are designed independently but still function as an integrated whole*" [Baldwin and Clark, 1997]. The crucial aspect to achieve modularity is to divide the design information of the technological system into visible design rules and hidden design parameters. The visible information includes the system architecture, the interfaces and the standards. The system architecture defines the independent modules within the system and their specific function. The system interfaces specify the interconnection of the single modules and the system standard specifies an a priori benchmark for the subsequent module design and performance assessment. The hidden information includes all intra-module design parameters that do not affect the overall design. This information only needs to be distributed among the module design team. A prominent example for a modular technology can be found in the mobility industry, which is characterized by few car manufactures and many suppliers, e.g. [MacCormack, 2010]. An automobile manufacturing firm initially defines the car design parameters, i.e. the architecture of the technology, the interfaces and the standards. In a simple example, the car consist of the subsystems 'auto body', 'passenger cabin', 'dashboard', and 'engine'. The development and production of the single subsystems according to the preset rules is delegated towards a few large first tier suppliers who further divide their subsystem in smaller modules which are forwarded to specialized suppliers as well. For example, the subsystem 'dashboard' is separated into the 'radio module', the 'navigational unit', the 'air conditioning', etc. The development of the complex system 'automobile' is distributed along the supply chain down to the component level and produced in a joint effort of several firms according to the rules of modularity.

There is a keen strategic aspect in the concept of modularity as some of the design information is visible to all industry participants and some is hidden within single firms. Hence, there are two generic strategies to create a competitive position within a modular technology cluster: A firm can compete as an architect of a novel system or as a module designer for an existent system [Baldwin and Clark, 1997]. The position as an architect clearly has the advantage of the dominant role within the respective cluster and holds the potential to be very profitable. To realize this potential, a system architect has to convince a sufficient number of module designers first that contribute and comply with the given design rules. Additionally, as the design is modular, the architect has to make his architectural knowledge publicly available, i.e. the knowledge becomes visible information to all industry participants. A competitor could absorb the visible information, combine it with his own knowledge base and provide a superior architectural innovation that erodes the dominant position of the initial architect. The risk of replacement is imminent in industries that are characterized by an absence of mechanism to protect the visible knowledge. For example in the IT industry, several companies already failed to secure a sustained competitive advantage out of their role as an architect by diffusing all their knowledge into the industry. In contrast, the position of a module designer contributing to an existent system has the advantage that the technical knowledge of the module or component can be kept within the company, i.e. the knowledge is hidden information. Additionally, a module innovator has a clear and given development scope. On the downside, a firm taking this position is highly dependent on the design rules and decisions of the dominating architect. Last, the modular innovator faces the risk of interchangeability by competitors with superior modules. The latter risk can be diminished by supplying several systems with similar characteristics and/ or a high innovation rate. To summarize, there is no prevailing strategic approach that suits all industries as both positions comprise advantages and risks. The choice of a profitable position gets even more difficult with an increasing number of separation steps, e.g. system, subsystem, module, component, as a firm in the middle of the cluster incorporates characteristics of an architect as well as a module designer. [Baldwin and Clark, 1997; 2000] recommend a structured analysis of the modular technology, i.e. all modules within each cluster as well as the overall architecture(s) before opting for a dedicated position in the industry.

The proposed modular analysis of a technology and the subsequent positioning of the firm can not only be conducted in industries where inter-firm development is widely accepted and modularity is the dominant method of joint development. Remarkably, it can also be used as an assessment method to reduce analytical complexity in scattered or integral industries, where architectural dependencies between the firms are normally not specified a priori [cp. Fixson and Park, 2008]. [Henderson and Clark, 1990] and also [Christensen, 1997] revealed that there is a strong connection between the architecture of the industry and the architecture of the respective technology which is independent of the development method. The industry organizes itself according to the structure of the prevalent technology. On an aggregate level *"industry architectures characterize the nature and degree of specialization of industry players (or 'organizational boundaries') and the structure of the relationships between those players"* [Pisano and Teece, 2007]. In line with this definition, [Jacobides et al., 2006] interpret architecture as a *"description of the economic agents within an economic system [...] and the relationships among those agents in terms of a minimal set of rules governing their arrangement, interconnections, and interdependence"*. However, the emergence of the industry architecture is not only based on the dominant technology. Some authors also acknowledge the role of legal and regulatory authorities as influencing factors for industry architectures, e.g. [Jacobides et al., 2006]. Several mapping techniques are existing for executing a modular analysis in both industry types, e.g. design structure matrices, design hierarchy diagrams, network graphs and stack mapping [Baldwin and Woodard, 2009; Crawley et al., 2004]. In both cases, a thorough analysis of the existing technological structures, as well as the subsequent identification of a valuable strategic position, is a crucial concern. However, there is distinct difference between the two industry types. The integral industries are characterized by fierce competition between the contributing firms instead of common interest and preset rules. Additionally, the systems in integral industries are characterized by an imperfect interchangeability of modules and the interdependencies in these industries emerge and change dynamically. Both characteristics are fostering the formation of a bottleneck in the respective technological system [Baldwin, 2010]. In contrast, modular industries inherently strive to prevent the formation of bottleneck through conjoint technology planning, with a varying degree of success. Thus, the modular analysis of the technological system in integral industries includes not only the assessment of the technological structure but especially puts an emphasis on the identification of the current bottleneck location in the system. In modular industries the importance of the bottleneck for system analysis is highly dependent on its constriction, i.e. the more balanced the system technology, the less important is the bottleneck location for strategic decisions and vice versa. The following section clarifies the characteristics of a technological bottleneck and what strategic options arise from this expanded system analysis in greater detail.

The definition of a bottleneck originates from simple technical products as well. [Ethiraj, 2007], building on [Garud and Kumaraswamy, 1993], asserts that *“product or system performance is in part a function of how components interact together as a system. […] While some may be operating at their highest rated capacity, others may still have some slack”*. Hence, the overall system performance is constrained by the weakest component performance, a so-called 'bottleneck'. Bottlenecks are thus interpreted as *“places where performance is constrained by one or more components”* [Baldwin, 2010]. The definition locates the bottleneck at one or more component(s) and concentrates on the output factor performance for identification of the bottleneck. Another definition which is in line with this argumentation is given by [Ethiraj, 2007]. The author defines the 'constraint component', or bottleneck, as *“the component(s) that poses the greatest bottleneck to improving system performance”*. In contrast, other scholars with a scientific foundation in operation research explain bottleneck as *“the part of the firms'* *or the industry's system that is in most scarce supply"* [Jacobides et. al., 2006]. This view is also shared by [Pisano and Teece, 2007] defining bottlenecks as the *"'modules' that are in most scarce supply"*. Contrary to the former definitions, the latter authors clearly focus on the input factor(s) 'supply' as the identifier for a bottleneck. This emerging gap between two strands of literature in the compact research field can be explained with a broader perspective, including the two basic methodological principles in operational research and production planning.



Depiction 12: System Elements

Complex systems, e.g. a personal computer, as previously defined [also cp. Katz and Shapiro, 1994] are consisting at the most granular level of tangible components, i.e. physical parts or portions. A typical example for a component in a personal computer is the computing processor. Albeit the system reasoning can be applied for services as well, the notion of intangible components is not common in literature and normally referred to as being the performance of some prior tangible components. Performance in this context is understood in its pristine sense as 'work done over time', e.g. the calculation steps of the component processor within a certain period of time, and is used largely interchangeably by scholars with the less precise notion function and partially also with the term result. Performance, as defined, is therefore provisioned through processes. Processes describe sequences of activities in a detailed way. To summarize, the tangible components are used in processes to deliver a specified performance. A visualization of these basic definitions shall clarify their interrelations (cp. Depiction 12). Based on operational research reasoning, complex systems and their components can be visualized by stylized 'boxes' and connecting 'arrows', e.g. [Tayur and Ganeshan, 1999; Stadler, 2005]. The tangible components are represented by the boxes due to their static character as a basis or starting point. The processes that use the components are characterized by the arrows due to their dynamic time and path dependence. The performance as a result of the activities of the components stands at the end of the arrow. The most basic system depiction comprises one box and the respective out-going arrow pointing at a result, describing one physical component, its process and its performance. In a two-step, linear system with two boxes and their particular out-going arrows, the out-going arrow of 'box one' equates the in-going arrow for 'box two'. The performance of the first box is used by the tangible component stylized through the second box. In a complex system, numerous boxes are interconnected through an abundant number of input/output arrows, visualizing the processes between the related components as well as the overall system performance at the end. The overall system performance is constrained by the system bottleneck as described earlier. Regarding the theoretical discussion about the two related meanings of 'bottleneck', both notions are looking at the same box from different arrows. Both strands of research identify input/ output factors, and therefore arrows/ processes, as the indicator for bottlenecks. The bottleneck itself is allocated in the same box, i.e. in a component. The difference largely depends on the methodological approach of identifying the bottleneck, whether starting from end, i.e. the final system performance, to the beginning (bottom-up approach) or vice versa (top-down approach). In both cases the analysis detects the 'bottleneck-box' when examining the subsequent arrow. The definition by [Baldwin, 2010] and [Ethiraj, 2007] is in line with the push-principle of operational research, i.e. planning top-down. [Jacobides et. al., 2006] in contrast link their work to the pull-principle in operational research, a bottom-up methodological approach. A detailed comparison of the push-principle, e.g. MRT material requirements planning, and the pull-principle, e.g. Kanban, is given by [Olhager and Östlund, 1990]. To summarize, bottleneck in this study is defined as the element in the system that limits the overall performance.

The technological system structure can be visualized and analyzed in this manner at different levels, e.g. a description of all modules incorporated within the different firm boundaries. The visualization of the technology for identifying the bottleneck at the most aggregated level, i.e. the inter-firm technology structure, includes boxes or modules that characterize the steps of the value chain and the arrows their interrelation. At this aggregated level, the bottleneck location comprises for example the step of the value chain with the least throughput. This performance constriction, e.g. limited throughput, is often caused by a lack of competition within the respective step of the inter-firm value chain. In relation to the bottleneck, the complementary modules before and after the bottleneck are characterized by a comparatively higher competition, i.e. the modules of the supplying firms are interchangeable. Thus, a firm situated at the bottleneck of the value chain has a superior bargaining power as it can choose from a variety of complements. In contrast, a firm that is supplying a bottleneck complement has quite limited options of collaboration and is highly dependent on its partner. As a result the firm that is developing a bottleneck module is capable to secure a good portion of the system rents.

This rather static description of the bottleneck also affects the decision process of the strategic management in dynamic firm environments. The previous chapter has already highlighted that strategic concepts always incorporate the two-step approach of the analysis of the firm's environment and the adaption of the firm. This structure is also applicable for complex modular systems [Henkel and Baldwin, 2009]. The precedent sections within this chapter described so far the modular analysis of the technological architecture within an industry in greater detail, which includes the identification of the system's bottleneck. The second step of adaption incorporates the two instruments of new value creation and existing value appropriation, i.e. value protection, in complex systems. The decision of a firm to opt for one dedicated instrument is based on the location of the system bottleneck in relation to the firm's position. The objective of the adaption is always to the control the bottleneck, as the economic success of a firm rests on the integration and protection of the industries bottleneck within the realm of the firm to secure the rents of the system [Pisano and Teece, 2007; Jacobides et al., 2006]. Hence, in pursuing the strategy of concentrating on and supplying superior bottleneck-modules as well as outsourcing non-crucial modules, a firm may gain a competitive advantage in comparison with established companies [Baldwin, 2010; Baldwin and Clark, 2006].

The most 'comfortable' position of a firm in an industry describes the situation when the bottleneck is already located within the boundary of the firm. In this case the firm has to solely concentrate on value protection. There are two established modes of value protection existing: legal protection, e.g. patents, copyrights, etc., and natural barriers, e.g. reverse engineering is difficult to execute by competitors [Henkel and Baldwin, 2009]. The most suitable conditions for a firm controlling the bottleneck are strong protecting mechanisms in the industry, as *"the unavoidable implication is that unless the inventor/innovator enjoys strong natural protection against imitation and/or strong intellectual property protection (which collectively describe its "appropriability" regime) or unless the complements and other inputs are available in competitive supply, then the providers of complements and other inputs will force the innovator to yield a large portion (possibly the greater portion) of the fruits of innovation to them"* [Pisano and Teece, 2007]. The firm's possibilities of value protection through natural barriers are dependent on the two innovation types in complex systems that have been previously described: modular and architectural innovations. The development of modular innovations is accompanied by an aggregation of hidden information which can be protected comparatively easy by the firm. In contrast, architectural innovations mostly incorporate information that must be diffused to other industry participants, e.g. the information on the system interfaces. Hence, this visible knowledge is fairly hard to protect by a single firm. Subsequently, the preferred mode of innovation for value protection in rather modular industries with low protecting mechanisms, i.e. an industry which is characterized by standardized interfaces resulting in highly exchangeable components, modules or architectures, are modular innovations. In contrast, architectural innovations are more advantageous for value appropriation in rather integral or knowledge protecting industries, as the innovating firm remains in control of its knowledge as well as dominating the interface design.

The intersection of industry bottleneck and firm position is an optimum position a firm should strategically strive for. In economic praxis a firm seldom inherits this comfortable position (for a long time) especially in constantly changing, dynamic environments. If a firm is not in this position (any more), it can influence the appropriability regime to its favor to (re)establish in the optimum with three measures. First, a firm can alter the existing protection mechanisms by weakening the complementary asset position; second, by creating or integrating co-specialized assets, and thirdly, by architectural re-engineering, i.e. introducing a novel architectural innovation that integrates the bottleneck within firm. All three measures foster technological diversity of a firm along the vertical value chain [Patel and Pavitt, 1997], i.e. integrating additional technology modules of the primary value chain into the firm boundary. The first measure is based on the insight that "*the more competitive and mobile the complementary asset, the higher* *the returns, for any given level of intellectual right protection, of the innovation"* [Jacobides et al., 2006]. Subsequently, a firm shall encourage competition and mobility in the complementary asset outside the firm boundary to strengthen its own position. A capable instrument for this measure are so-called 'property-preempting investments' (PPI) [Merges, 2004]. The underlying logic of PPIs is that information, once published, cannot be privatized any more by a firm. The author asserts that *"if it is in a firm`s interest to preempt an asset from being privatized, the firm will invest in the creation of that asset and then inject it into the public domain"* [Merges, 2004]. PPIs are a valuable instrument, if the bottleneck is positioned upstream in the value chain beyond the reach of the firm. The firm weakens the position of the competitor(s) that dominate the bottleneck by making emerging knowledge about the respective module publicly available and thus encourage competition in this module. A second instrument to alter the existing structure concerns the development or integration of co-specialized modules that appreciate in value. This is a feasible instrument if the modules within the current firm boundary face a high competition and are complementary to the bottleneck module with little competition. The integration of an additional (critical) module into the realm of the firm enhances the probability to capture value. The instrument of co-specialization is often used in praxis along the vertical value chain. For example, an immature industry within an eager growth phase is characterized by a high demand. The bottleneck is normally situated upstream on the supply side. In this industry phase, a firm strives to integrate the upward assets to secure its supply, saturate the demand and thus create value. In contrast, mature industries comprise a declining demand and overall growth rate. Limited downstream force forms the bottleneck in these industries, i.e. the throughput or performance is limited at the lower end of the value chain. Firms co-specialize downward subsequently to preserve their supply capacity. The third instrument to alter the existing protection mechanism concerns a significant redesign of the industry architecture without changing the customer solution. The rearrangement of the existing modules in a novel architecture intends to integrate the bottleneck within the firm boundary as well. As illustrated earlier, the architect is highly dependent on other industry participants to contribute and comply with its system design. Hence, the successful renewal or significant alteration of the existing architecture is more probable in the founding years of an industry or during phases of fundamental change with no dominant design existent. Alternatively, a firm can *"'envelop' its sector by connecting to a broader 'bundle' of services and products that would leverage its own strengths while muting those of its competitors"* [Jacobides et al., 2006]. The aforementioned three instruments for value creation provide an initial direction for the development and adaption of a firm's strategy, albeit the location and nature of the bottleneck is constantly changing in and across different technology systems. Besides the dependence of the bottleneck location on the industry phase, as described earlier, there is also a fundamental relation to the system complexity. Remarkably, the more complex a system, the more important are system integration capabilities. A firm that is able to integrate the existing modules and components of a complex system as well as to secure a strong downstream position is dominating the value chain [Pisano and Teece, 2007]. Thus, in complex systems, the bottleneck asset regularly lies within system integration capabilities, independent from industry characteristics.

To summarize, the commercial success of a firm rests on the creation and protection of value. In complex systems, e.g. inter-firm value chains in modular or integral industries, the identification and integration of the bottleneck within the boundary of the firm is crucial to secure the rents of the system. The bottleneck is identified through a modular analysis of the technological architecture in the respective industry. A redesign of the system architecture, the modular co-specialization for vertical diversification as well as the promotion of competition within complement modules are feasible instruments to alter the industry structure and relocate the bottleneck into the firm. Subsequent modular innovations within the bottleneck module are a natural barrier to protect the value that supplements external legal mechanisms.

3.3. Architectural Knowledge as Dynamic Capability of the Firm

The precedent chapters portrayed different strategic management concepts with an emphasis on the dynamic capability theory and the strategic use of architectural knowledge conception. In the following, the interconnections between the different strands of literature are discussed and subsequently synthesized to form a basis for the derivation of the research questions and methodology in chapter four.

Initially, the study has shown that research regarding the strategic management of the firm is characterized by a long history but comparatively little progress (cp. chapter 3.1.). Generally, the difference between the existent concepts resides in the emphasis of internal and/ or external factors and the consideration of static versus dynamic environments. Although the established concepts are quite elaborated, they also suffer under a broad conceptual application which limits their potential use for interpreting the phenomenon within this work. Additionally, they have a heritage in the industrial economics literature and thus are fully rationality bound. This aspect further limits their application to the phenomenon due to the insights of sharing in chapter 2.1.3.. Nonetheless, all existent concepts refine the two step approach of environment analysis and firm adaption with the intent to create potentials for success, i.e. value creation, and use of these potentials for success, i.e. value appropriation. This proven structure may potentially serve as initial guidance for analyzing the underlying strategy of the phenomenon within this work.

Subsequently, the two big tents of modern strategic research have been presented in greater detail (cp. chapter 3.1.). In the first, Porter, e.g. [Porter, 1996] suggests the analysis of the industry as a basis to strategically position the firm. Based on these insights, he explicitly proposes to choose a valuable position in the value chain in comparison to rivals. This basic recommendation is also reflected in the concept of the strategic use of architectural knowledge, which explicitly proposes to position the firm at the bottleneck of the value chain. To Porter's understanding, strategy means to perform different activities than rivals do rather than to perform the same activities in a superior manner. This central aspect is illustrated by the introduction of the imaginary productivity frontier that marks the current state of best practice, with the two dimensions relative cost position and value delivered. With the help of this construct, Porter vividly explains why competition on operational excellence provokes a transfer of profitability towards the co-specialized assets, e.g. towards customers or suppliers respectively. Additionally, the author proposes three generic options for different activities, which are based on access, needs and varieties. Porter explicitly recommends deepening a valuable position rather than blurring a position for the sake of increased revenue. The concept well explains the basic construct of competition between single module innovators and the need to avoid the outcomes through differentiation. The negative effects of competition on value creation and appropriation are also a central theme in the strategic use of architectural knowledge conception. Porter concentrates on the analysis of the status quo and the reaction towards changes in the environment are considered as being not relevant. Albeit he specifically identifies the transfer of profitability towards co-specialized assets for example, the author only recommends avoiding this situation rather than adapting the firm's structure to embrace this new opportunity. To summarize, the industry architecture is regarded as fixed and given in this concept. The possibility of architectural innovations or other instruments to alter the architecture are therefore non-existent in this model. Last, the level of analysis within his theory is at the industry level, examining all competitors, suppliers, new entrants, etc. in detail. Albeit there is a strong connection between the industry architecture and the architecture of the dominant technology [Henderson and Clark, 1990], an analysis of the industry is far more complex than an analysis of the technological system. The observed phenomenon within this work is often not the dominant system in industry but rather a recently emerging alternative to conventional offerings. Thus, an analysis of the complete industry would exceed the scope of this work. This allows only for a limited application of the model to the detected phenomenon of this work in excess of his valuable basic ideas on strategic value creation and value appropriation.

The second big tent of strategic research is the concept of dynamic capabilities that emphasizes the reconfiguration of internal and external resources and competences as a reaction to the changing environment (cp. chapter 3.1.). This concept explicitly acknowledges that, in a Schumpeterian world of rapid technological change and creative destruction of existing competences, firms have to adapt continuously to capitalize on their demanding environment [Schumpeter, 1934; Wiggins and Ruefli, 2005]. In the core of the adaption are the firm's internal and external assets that include physical resources as well as intangible knowledge. One of the central constructs in this theory describes the path-dependency of a firm. The path-dependency illustrates the restrained options of a firm, which are limited by its current asset base, i.e. its current position in the technological architecture. Due to this path dependency a firm is forced to follow a certain trajectory and explore technological or market opportunities along its way [Teece et al., 1997]. This view is coherent with the discovery that incumbent firms often develop incremental or modular innovations in a stable industry with a dominant design and struggle to integrate radical innovations which require a highly divergent set of assets [Henderson and Clark, 1990]. The construct of path dependency is strongly connected to the notion of co-specialization as a common mode of reconfiguration. According to the dynamic capability theory, a firm may adapt to changes in the environment by integrating complementary assets along the value chain. Thus, due to its restrained options, a firm regularly co-specializes to create additional value. The constant adaption of the firm through co-specialization is also recommended in chapter 3.2 as a strategic instrument to create and protect value in complex industry architectures

[Jacobides et al., 2006]. Co-specialization in the concept of dynamic capabilities is restricted to bi-lateral dependencies and could therefore lead to problems of bargaining. For example, a high degree in complementarity between two co-specialized assets leads to limited mobility, i.e. limited alternatives available. A firm that owns one of the co-specialized assets is highly dependent on the bilateral relationship with the complement firm and vice versa, which forces both firms to share the created value or integrate the opponent. In contrast, in a complex technological system with multiple actors, a high complementarity as well as a high mobility of modules is possible, i.e. a firm can maintain several partnerships with different firms that are developing interchangeable, complements to the particular module. Thus, multilateral relationships reduce the dependence of the firm from a single complementor. Ultimately, they also facilitate the integration of the complement or the promotion of competition within the complement by the managing firm. As a result, the firm has expanded possibilities for value creation and appropriation [Jacobides et al., 2006]. Remarkably, the concept of dynamic capabilities and the strategic use of architectural knowledge are strongly connected due to their correlating literature base, e.g. [Henderson and Clark, 1990] or [Henderson and Cockburn, 1994]. This connection has also been found by [de Boer et al., 1999]. Recent publications discuss their exact interrelation and if the comparatively juvenile concept of architectural knowledge and its use is in fact a dynamic capability of a firm [Pisano and Teece, 2007; Jacobides et al., 2006]. Albeit the study has already presented some differing aspects, e.g. the evolution of co-specialization in complex systems, the discussion is still in progress. Nevertheless the concept of dynamic capabilities is highly qualified for a scientific starting point, because it is widely approved and based on an evolutionary approach.

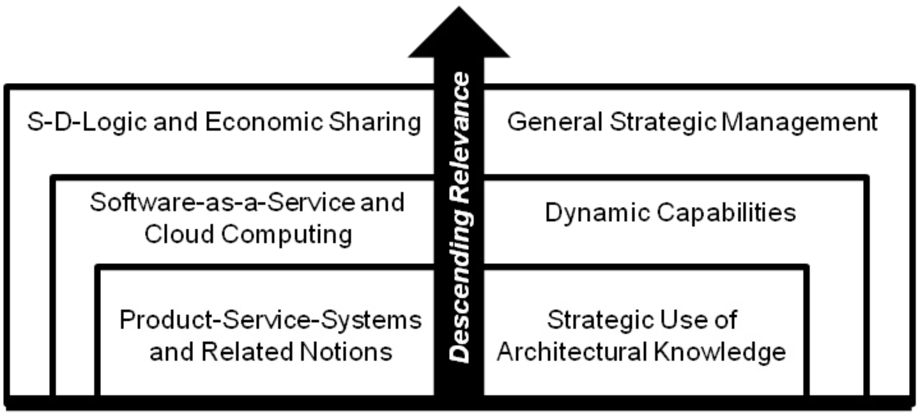
In contrast to the previous two conceptions, the strategic use of architectural knowledge as a concept is characterized by a comparatively short history and a narrow, applied focus. It has its origin in the engineering sciences and is based on insights from simple technological products which have been recently up-scaled as concept for industry analysis and firm adaption. The contributing authors propose analyzing the existing technology or established market, dividing the existing system into modules and identifying weaknesses, so called bottlenecks within the system. These bottleneck-modules constrain the performance of the system. In pursuing the strategy of concentrating on and supplying superior bottleneck-modules as well as outsourcing non-crucial modules, a firm may gain a competitive advantage in comparison with established companies. The reconfiguration of the industry architecture, modular diversification as well as the promotion of competition within complement modules are feasible instruments to alter the industry structure and relocate the bottleneck within the realm of the firm, as a firm is constrained by its current position which is often not identical with the bottleneck location. Subsequent modular innovations within the bottleneck module are a natural barrier for value protection that supplement external legal mechanisms [Baldwin, 2010]. In contrast to the dynamic capability theory, the strategic use of architectural knowledge will certainly provide insights that are more applied and thus, more appropriate for managerial praxis. The conception provides a connection between the identified three relevant levels for strategic analysis: the competence level within the firm, the technology level within and outside the firm and the industry level outside the firm. The connection between the latter two levels has already been previously examined by [Henderson and Clark, 1990] and [Christensen, 1997], whereas the connection between the former two, e.g. [Lawrence and Lorsch, 1967; Jacobides and Billinger, 2006], is still discussed extensively. The strategic use of architectural knowledge concentrates on analyzing the technological structure, and thus, the middle level, as a basis for the development of a strategy. The analysis of the technology architecture appears more practical than a complex industry analysis or an assessment of abstract competences or capabilities at this point. Further research examining this aspect will certainly qualify and expand the insights of this juvenile conception. Additionally, research regarding the strategic use of architectural knowledge has been mainly a theoretical, conceptual discussion with limited validation through practical case studies. The given examples are of a descriptive nature and have a heritage in the highly modular computer or IT industry. The application of the conception to the phenomenon within this work will certainly contribute to the existing strand of literature and provide a strategic perspective on performance-oriented systems.

4. Research Approach

The following chapter comprises the derivation of the research questions as well as the description of the selected qualitative research strategy. Chapter 4.1 connects the two strands of literature and accentuates the relevant publications for the respective research questions. Chapter 4.2 portrays the selected methodological foundation of Grounded Theory and the chosen methods for data sampling, data collection, data analysis and data presentation.

4.1. Derivation of Research Questions

In the previous chapters the study described the emerging phenomenon of performance-oriented systems and presented the relevant scientific conversations. The description of the phenomenon revealed that established firms which are selling their products or services on determined conditions are confronted with novel competition from firms that are implementing a system-platform offering the performance of products for shared use on flexible conditions. The observed phenomenon is not only based on the activity of entrepreneurial firms but also considerably adopted among incumbent firms (cp. chapter 1.1.).



Depiction 13: Research Fields of the Study

When reviewing the existent literature it becomes apparent that different areas of expertise have already acknowledged the phenomenon of performance-oriented systems. Depiction 13 provides an overview on the portrayed research fields and their relevance to the phenomenon within this work. The left side of the depiction comprises different areas of expertise that have already acknowledged the phenomenon of performance-oriented systems, ranging from the industrial economics [Baines et al., 2007] and environmental sciences [White et al., 1999] towards the engineering and design literature [Meier et al., 2010] as well as the computational sciences [Marston et al., 2011]. A broader perspective of the phenomenon is provided by the social sciences, e.g. [Belk, 2010; Vargo and Lusch, 2004]. The literature is fragmented and not yet synthesized. The emphasis of these contributions resides on the operational level and a coherent strategic management perspective in excess of single assumptions [Mont, 2002; Tukker, 2004] is absent.

The left side of depiction 13 comprises the second theoretical conversation within chapter three, the strategic innovation management literature, which complements this deficiency. The comparatively broad theory of dynamic capabilities [Teece and Pisano, 1994; Teece et al., 1997] plays a decisive role in this strand. The dynamic capabilities of a firm comprise the steady analysis of the changing environment and the coordinated response to attain and sustain value. A complementing and more applied approach to gain a strategic advantage is superior architectural knowledge of a technological system [Baldwin, 2010; Baldwin and Clark, 1997]. Dynamic Capabilities and the strategic use of architectural knowledge share a common founding literature base, e.g. [Henderson and Clark, 1990; Prahalad and Hamel, 1990]. Recent publications in this field of literature concentrate on their theoretical re-connection (cp. chapter 3.3.). Remarkably, there is also a direct connection between the latter conception [Baldwin, 2010] and the examined research from the computational sciences, e.g. [Cusumano and Gawer, 2002; Gawer and Cusumano, 2002]. Especially, [Baldwin and Woodard, 2009] have recently discussed the interrelations between these two strands before developing a unified view on the architecture of platforms. The general strategic management concepts presented in chapter three, e.g. [Porter, 1996], provide a broader context to the concepts used within this work. Their direct linkage to the dynamic capabilities theory, e.g. [Barney, 1991], or the strategic use of architectural knowledge conception, e.g. [Abernathy and Clark, 1985], already dates back several years. Thus, the selection of literature within this work is focused on evolutionary-based rather than fully rational-oriented approaches, as the former seem more appropriate to explain the phenomenon against the backlight of the described characteristics within economic sharing.

So far, the study introduced the recent trend on performance-oriented systems and presented the relevant conversations of performance-oriented systems and strategic innovation management that are not yet synthesized [cp. Grant and Pollock, 2011]. As performance-oriented systems are an emerging phenomenon with increasing relevance, e.g. [Millard-Ball, 2005], the incorporation of a strategic perspective should be of interest for practitioners and scholars alike. Therefore, the author assumes the strategic perspective will serve as guidance to management whether performance-oriented systems are a reasonable opportunity for implementation in the context of their business. In terms of scientific research, the results will contribute to applied knowledge that enhances the theoretical understanding of dynamic capabilities, the strategy of superior architectural knowledge as well as their interrelation. Last, the research strives to put the fragmented literature of performance-oriented systems into a more integrated perspective. Further, the study seeks to fill the identified research gap and explain the recent emphasis on performance-oriented systems from a strategic management perspective in greater detail. Therefore, the main research question within this study explicitly targets these aspects:

RQ: In what context are performance-oriented systems a viable strategy of a firm to gain competitive advantage?

This broad scope has to be operationalized into more precise sub-questions, clarifying whether the observed phenomenon comprises the characteristics of a strategy and which are the enabling factors. The former sub-question though represents the core of the study. All existent strategic concepts refine the two step approach of environment analysis and firm adaption with the intent to create potentials for success and the use of these potentials. Hence, if performance oriented systems are an explicit strategy the research first has to clarify whether an analysis and adaption has been executed in economic praxis.

The first aspect is concerning the analysis of the firm environment. [Porter, 1996] suggest the analysis of the industry as a basis to differentiate, but the detected phenomenon within this work emerges in four different industries with very diverse characteristics. A detailed industry analysis would certainly go beyond the scope of this work and would deliver only limited insight to explain the phenomenon on an aggregate level. The theory of dynamic capabilities remains short on explicit recommendations on how to identify opportunities in the firm environment. In contrast, the findings within the strategic use of architectural knowledge provide an initial direction. Reflecting on their insights, the study basically has to clarify whether there has been an identification of any bottleneck within the environment of the firm prior to the development of the system, e.g. [Baldwin, 2010]. A direct investigation of this aspect could be difficult to assess due to its conceptual character. An exploration of whether the examined firms explicitly used analytical tools or instruments dedicated for the modular industry analysis, e.g. [Baldwin and Clark, 2000; Crawley et al., 2004], would provide an initial hint. But the use of dedicated software is neither mandatory nor sufficient for proving an explicit identification of a bottleneck within the examined firms. There are many other possible techniques how a firm can compile an environmental analysis through a range of tools and methods. Subsequently, this aspect has to be investigated in a more open, indirect manner, which is clarifying the reasons or the motivation for the development of the respective system in general. Existing scientific research on the motivation, drivers and barriers to develop performance-oriented systems can be found especially in [Goedkoop et al., 1999; Mont, 2002; Manzini et al., 2001]. Although these results may help as a starting point for analysis, the underlying data is more than a decade old. An analysis of different bike-sharing concepts in the last thirty years by [Klaus, 2002] shows an evolutionary development of the concepts as well as a changing motivation over time. At a more aggregated level, the literature indicates that system innovations have the potential to combine user, economic and environmental benefits, but it still remains unclear which is the main driver for a firm's decision. For example, is the development of a performance-oriented system motivated by an economic bottleneck, an economic and ecologic one, e.g. [Porter and Van der Linde, 1995], or based solely on environmental reasons? Thus, the existing evidence on the motivation to develop a performance-oriented system is regarded as being not sufficient to explain the phenomenon.

To summarize, the research has to clarify whether there has been an identification of any bottleneck within the environment of the firm prior to the development of the system. As a direct investigation of this aspect could be difficult to assess due to its conceptual character, the study address' this facet in a more open, indirect manner, clarifying the reasons or the motivation for the development in general. The results can then be conceptualized into dedicated bottlenecks, e.g. economic or ecologic, if applicable. This leads to the first sub-question:

SQ1: What is the motivation for the development of the performance-oriented systems?

The second aspect concerns the adaption or reconfiguration of the firm. The established concepts of strategic management provide some initial direction in this aspect. [Porter, 1996] for example proposes a firm to execute different activities. To the author's understanding, strategy means performing different activities rather than performing same activities better than rivals do. If performance-oriented systems are a strategy, the research has to clarify what different activities have been performed in the examined systems in comparison to conventional alternatives. The concept of dynamic capabilities emphasizes the reconfiguration of internal and external resources and competences after the identification of opportunities as a reaction to the changing environment [Teece and Pisano, 1994]. Subsequently, the research has to focus on the differences in terms of internal and external resources and competences. The literature regarding the strategic use of architectural knowledge structures the reconfiguration into innovations for value creation, e.g. architectural innovations to alter the industry structure, as well as innovations for value appropriation, e.g. modular innovations to protect the internal knowledge. The theory suggests analyzing the system architecture at the technology level and comparing the examined systems with the technology structure of conventional offerings. The theory provides an initial guidance for analyzing and structuring the differences within two categories. Hence, the examined strategic innovation management concepts propose to compare the differences in system development at three levels, the competence, the technology and the industry level. The existing research on the differences of performance-oriented systems or its distinctive characteristics is scarce. In a recent literature review [Baines et al., 2007], the authors summarized that 40 publications until 2007 *"covered a range of topics, with approximately 20 per cent describing business benefits and drivers, 20 per cent reviewing the characteristics of PSS, and about 35 per cent focusing on case studies and examples. Other topics are related to product life cycle, service design methods, and service engineering."* Thus, there are eight dedicated contributions on the specific system characteristics, which have been included in the literature analysis in chapter 2.1. The emphasis of these contributions resides on the operational level, but the research attempts to identify the differences for strategic innovation management. Further, a closer analysis of the phenomenon, as described in the first chapter deepens the uncertainty about the novelty of performance-oriented systems. For example in the mobility industry, nearly all major car manufacturers and car rental companies are engaged in car-sharing. A closer analysis of the system components reveals that these companies are operating their systems with conventional cars instead of developing dedicated ones. Accompanying renting services, e.g. the booking via mobile internet, preexisted in conventional car rental agencies as well. This setting raises the question whether there is any innovation activity necessary at all for system implementation. And further, what is the exact innovation object and type? Does the transformation require the development of new components or is it rather a combination of existing resources? In addition to the identification of the innovations necessary for system implementation, the study also strives to identify those innovations that play a strategic role for value creation as well as value protection within the implementing firm.

To summarize, the second aspect concerns the adaption or reconfiguration of the firm respectively. Subsequently, the study has to focus on the differences in comparison to conventional alternatives in terms of internal and external resources and competences as well as new technological developments. Drawing on prior knowledge, the reconfiguration has to include innovations for value creation, e.g. architectural innovations, as well as value appropriation, e.g. modular innovations. This leads to the second sub-question:

SQ2: What is the difference between the performance-oriented systems and conventional offerings?

In addition to the former two aspects that verify whether performance-oriented systems incorporate the characteristics of a strategy, the research also seeks to provide initial enabling factors the illustrate the context of the strategy. Porter proposes that the success of a strategy is aligned with creating and deepening a determined set of activities with a high fit and clear scope, rather than the plain pursuit of growth through broadening or blurring of the initial position. Thus, the success of strategy is primarily related with increasing profit, rather than revenue. Albeit these clear indications, the profit of a firm cannot be used as an indicator to assess the success of the emerging phenomenon within this work. The availability of financial performance data is limited and distorted. Entrepreneurial firms are not obliged to publish their financial results due to size or legal form or are heavily funded by external financial partners, which impede the comparability of the financial reporting. Established firms that develop a performance-oriented system often conceal the financial results of the system operation in their consolidated accounts. Last, the financial success may not be the sole enabling factor. The concept of dynamic capabilities incorporates the weakness that a common understanding on the relation between dynamic capabilities and the firm's performance is absent and scientific results on this aspect differ, e.g. [Teece et al., 1997; Zott, 2003]. The strategic use of architectural knowledge conception recommends the integration of the identified bottleneck within the realm of the firm and the development of a dedicated 'bottleneck'-module as the central enabling factor. On a more granular level, the literature suggests that location and constriction of the bottleneck [Ethiraj, 2007] as well as industry legislation [Jacobides et al., 2006] are influencing factors in the firm environment. Internal factors affecting value creation are existing competences [Henderson and Clark, 1990], the concentration on component integration [Pisano and Teece, 2007] and necessary outsourcing of non-crucial modules [Baldwin, 2010]. In terms of value protection, the discrepancy to existent offerings [Henderson and Clark, 1990], the degree of user-collaboration [Christensen, 1997], co-specialization and decentralization [Pisano and Teece, 2007] play a crucial role. To the author's knowledge, prior scientific research on the phenomenon regarding the enabling contextual factors of performance-oriented systems is absent. The explanation for this circumstance is supposedly grounded in the novelty of the phenomenon as well. A direct question regarding the success of the respective system as well as its causes would probably lead to over-reporting of the informants, as most systems are in an eager growth phase. Therefore, only a passive and comparable generic assessment of the enabling factors seems possible at this early stage.

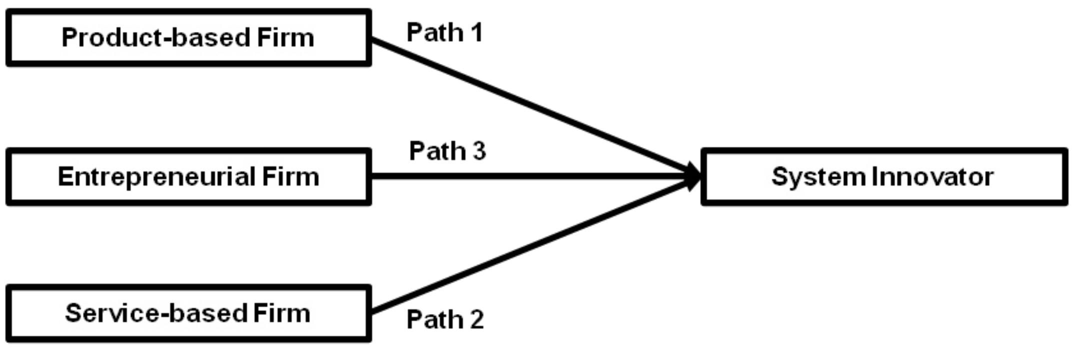
To summarize, the integration and protection of the identified bottleneck within the firm is considered as a first qualitative measure for economic success. Further, as solid financial performance data on this emerging phenomenon is scarce, the study attempts to consolidate and align the theoretically developed success factors in the literature with the primary data. The identification of relevant enabling factors strives to illustrate the context of prosperous performance-oriented systems. This leads to the third sub-question, which is only addressed indirectly in the study:

SQ3: What are the enabling factors in the development of performance-oriented systems?

4.2. Qualitative Research Strategy

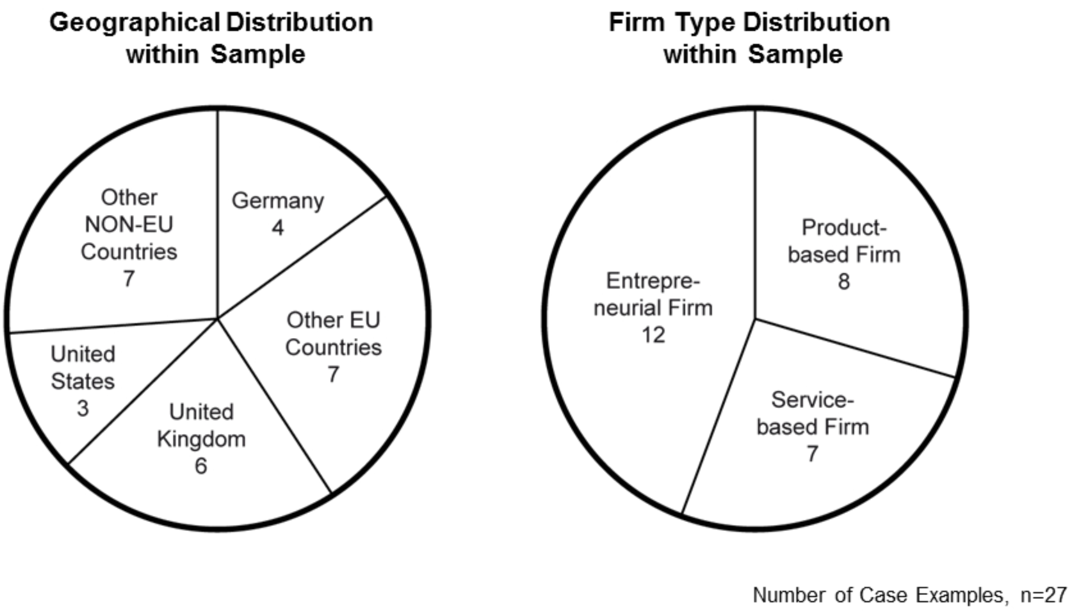
In the precedent chapter the study has highlighted the two research questions about the firm's motivation for system development, the differences of performance-oriented systems in comparison to existing alternatives as a basis to describe the strategic perspective of the phenomenon within this work. These questions correlate with the basic query of 'why' and 'how' in qualitative research [Eisenhardt, 1989; Yin, 2008]. Thus, the author opted for a qualitative management research at the firm level to answer the questions considering the knowledge situation as being shallow and fragmented [Punch, 2005]. The research strategy follows the recommendations of [Suddaby, 2006; Wimpenny and Gass, 2000; Baker et al., 1992; and Johnson et al., 2006]. Basically, the authors recommend choosing a distinct methodological foundation for the qualitative research, e.g. phenomenology, grounded theory, qualitative content analysis or mixed method approach, and select consistent methods for data collection and analysis. In the following, the chapter thus describes the selected methodology within this work, as well as the methods for data sampling, collection, analysis and presentation in greater detail.

Regarding the methodological foundation, the research is based on the methodology of Grounded Theory [Glaser and Strauss, 1967]. The focus is clearly on theory building from the data collected (inductive approach), rather than theory verification (deductive approach). Grounded Theory is therefore opposed to the positivist research that is oriented towards hypothesis testing. The objective within the approach is the subjective description and interpretation of 'reality' by the researcher. Though, the methodology is not focused on the subjective experience of the informant per se, as in the phenomenology, but rather on the abstraction of the experiences into theoretical statements and causal relations. Grounded Theory is developed in an interpretative process, which is conducted iteratively, and not through a logico-deductive one, e.g. as qualitative content analysis. Grounded Theory is built through qualitative data collection and comparative data analysis. Concerning data analysis, the research within this work follows the interpretation of [Corbin and Strauss, 1990]. Strauss' and Corbin's interpretation allows the researcher a theoretical perspective in mind to code empirical data. They explicitly state that *"all kinds of literature can be used before a research study is begun [...]"* [Corbin and Strauss, 1990: 56; cited in Kelle, 2007]. Albeit easier to execute by research novices, Strauss' approach may be criticized in a way that categories are 'forced' into data by the researcher, rather than 'emerging' by itself [Glaser, 1992]. There are two core concepts within the Grounded Theory approach: 'theoretical sampling' and 'constant comparison'. 'Theoretical sampling' requires a structured design of the data sample to systematically reduce a potential bias. The data analysis is conducted according to the paradigm of 'constant comparison', i.e. the simultaneous execution of data sampling, collection and analysis. In a less purist interpretation, 'constant comparison' means that the research steps of data sampling, data analysis and theory building have to be repeated until new data does not change the emerging theory anymore and so called saturation is achieved. Both understandings incorporate a tension for the researcher to reach a middle ground for his academic research between analytical rigor and pragmatism [Suddaby, 2006].



Depiction 14: Structure of the Data Sample

The design of the data sample within this work is based on the existing literature of performance-oriented systems, as it has already identified two primary starting points, depending on the firms' heritage as a product or service innovator [Tukker, 2004]. However, initial research revealed that firms with no prior history were established to explicitly develop a performance-oriented system, too. Hence, in addition to the two starting points suggested by the literature, the study rather considers three different types of firms as a basis for data sampling. Depiction 14 illustrates the three types of product-based, service-based and entrepreneurial firms that form the basis for the sample. For each of the three starting points the study selected recent performance-oriented systems from different industries. The empirical focus resides on four industries, the mobility, energy, IT and chemical industry. The study strived for two case-examples for each firm type within each industry, i.e. six examples per industry. The result is a rather heterogeneous dataset of twenty-seven case-examples, including three examples from an initial pre-study in the mobility industry [Tietze et al., 2012], that have been organized, i.e. the differences of cases are minimized, by starting point (forming three groups), by industry (forming four groups) or both (resulting in twelve groups). The structured case selection shall minimize a bias based on industry- or firm-type-specific characteristics. Additionally, the study strived for a diversity of the cases regarding their geographical location, to further reduce a potential country-specific bias, e.g. through legislations. Depiction 15 provides an overview of the data sample. A more detailed description of the data sample can be found in the appendix.



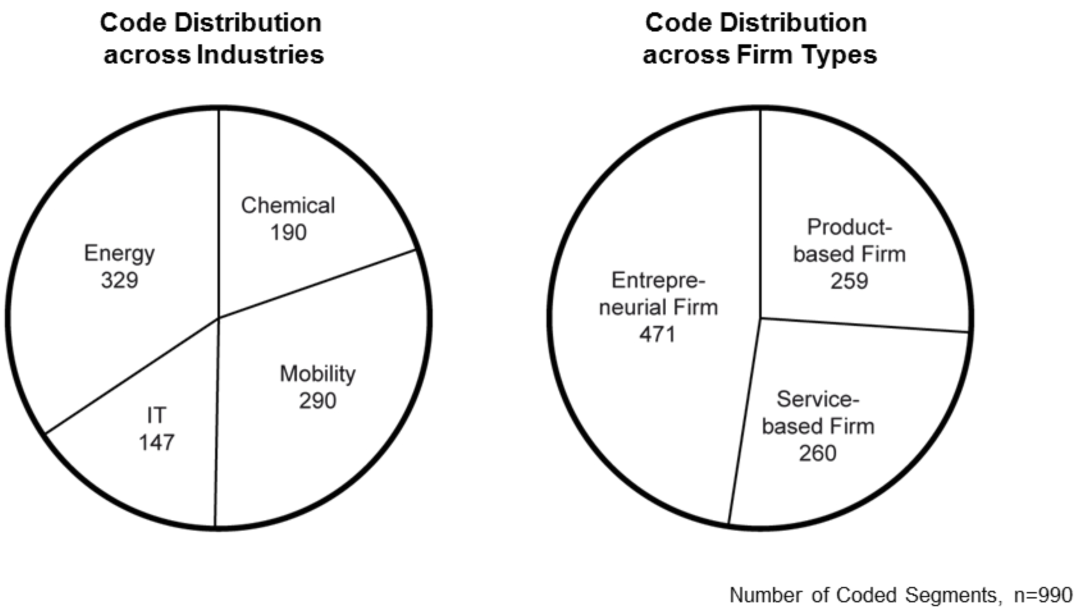
Depiction 15: Distribution of the Data Sample

The selected, structured design of the data sample is concordant with the core concept of 'theoretical sampling' within the Grounded Theory methodology as described by [Glaser and Strauss, 1967: 68ff.]. The chosen sampling strategy facilitates the discovery of categories and characteristics within a group as well as the interrelation and commonalities between the groups at a more abstract level to fulfill 'category saturation'. Further, the data sample is compliant with the multiple-case study approach; a research strategy proposed by Yin [Yin, 2008]. As already stated above, the study considers the knowledge situation as *"shallow, fragmentary, incomplete or non-existent"*. Particularly for such situations, [Punch, 2005: 147] recommends that case studies have a contribution to make. Case studies also *"enjoy a natural advantage in research of an exploratory nature"* [Gerring, 2004: 349]. While multiple case studies are more demanding than a single case they permit exploration of more reliable patterns [Leonard-Barton, 1990].

The data collection of this study has been completed within two generic episodes, comprising an initial pilot of three case-examples and a more comprehensive main study of twenty-four firms with a refined research scope. The data collection was conducted in both episodes with the help of complementary sources to strengthen the accuracy of findings [Jick, 1979]. Primary data was collected through semi-structured interviews with persons highly involved in the development activities of the specific system, e.g. the executive manager, project leader or responsible R&D manager. Interviewing key informants reduces the effect of informant bias [Kumar et al., 1993]. Additionally, only those highly involved persons are able to provide a holistic perspective on the initial motivation and the central differences in system development. The interview guidelines reflect the central items from existent 'substantive theory', which have been described in the previous chapter (cp. chapter 3.). To the author`s understanding, the broad but established concept of dynamic capabilities appears capable of providing initial insights. The narrower concept of the strategic use of architectural knowledge is regarded to enhance a more detailed understanding of the phenomenon albeit its limited scientific research of practical cases to date. Using substantive theory ensures *"an initial direction in developing relevant categories and properties and in choosing possible modes of integration"* [Glaser and Strauss, 1967: 79] during data analysis. To reduce the danger of prior knowledge influence, [Suddaby, 2006] explicitly recommends avoiding *"research that adheres too closely to a single substantive area and, instead, draw from the several substantive areas that are frequently reflected"*. The interviews ranged from 40 to 70 minutes. The interview guidelines covered three sets of primarily open questions: First, the question of the guideline asked the firms about their motives to develop a performance-oriented system, e.g. economic and ecological objectives, existing drivers or barriers. Secondly, the questions targeted the transformation process and the differences between the performance-oriented system and their prior conventional offering, if applicable, e.g. characteristic differences, changes in firms' resources or capabilities. Thirdly, the guideline focused explicitly on the managerial challenges during the development process of a performance-oriented system, e.g. during idea generation or adaption of the organizational structure. An exemplary questionnaire can be found in the appendix of this work. Additional data was collected from secondary sources to complement the interview data; particularly journals associated with the correspondent industries, but also universal newspapers, industry reports and individual press releases published by the selected firms. Data collection was conducted with the help of a research team of six people over six months to reduce observer- and a longitudinal time-bias. The telephone interviews were recorded and written transcripts of all interviews were prepared as a basis for data analysis.

Data Analysis in the pilot study started with writing individual case histories including all primary and secondary data sources. The case description has been triangulated with the literature of performance-oriented systems and the substantive theories and a concise cross-case analysis has been conducted [Tietze et al., 2011] resulting in four propositions, which remained rather shallow at that early stage. Nonetheless, the results have been used to refine the interview guideline for the second phase. Again, case descriptions were prepared for each industry. The next step in the research process was a systematic, in-depth cross-case analysis of the second phase case-examples from the author which forms the core of this work. The conducted analysis followed the core concept of 'constant comparison' within the Grounded Theory methodology. The different case-examples were compared by industry, firm type or on an individual basis. After two rounds of open coding to identify relevant categories and characteristics, a third round of analysis was conducted to develop more abstract, categorical or conceptual codes, e.g. the relation between the categories. In the latter round, the categories of the substantive theory, i.e. their central notions and characteristics, have been included explicitly into the coding.

The result is a coding tree divided into the three generic segments, 'analysis of firm environment', 'adaption of firm resources' and 'independent aspects', which are further separated into thirty-eight categories containing 990 coded segments in total. Depiction 16 portrays the distribution of the codes across the industries and firm types. Depiction 17 illustrates the structure of the coding tree and explains the categories briefly. The group 'analysis of the firm environment' examines the motivation of the firms for system development and comprises the subgroups 'economical motivation', e.g. 'changes in industry environment' and 'changes in user preferences', as well as 'ecological motivation'. The group 'adaption of firm resources' analyzes the differences of system development with an ascending degree of itemization as it contains the subgroups 'phases of reconfiguration', 'system development process', 'system resources' and 'system resource location'. The last group of 'independent aspects' comprises single, boundary-spanning characteristics. The interview data was coded solemnly by the author and results have been discussed regularly with other scholars. The software 'MaxQDA 10' has been selected as an appropriate tool to support the data analysis as it is widely used in qualitative social research. A research-logfile to capture the analytical and interpretative progress has been written throughout the analyzing process within the software as well as in external documents.



Depiction 16: Code Distribution within Sample

The study is part of the 'Green Innovation Project' at the Institute for Technology and Innovation Management Department of the Technical University Hamburg-Harburg. The project was co-founded by the author in 2010 together with Dr. Frank Tietze who also accompanied the study with his expertise in its early stages. The iterative and interpretative research approach selected within this work has substantially contributed to and consequently also uses insights from prior publications as well as the received feedback. All proceedings from the author are based on the same research-logfile that has been written by the author throughout the analyzing process and captured the analytical and interpretative progress. The publications [Tietze et al., 2012] and

[Schiederig and Herstatt, 2013] exemplary document the progress within the pilot and the main study at different stages together with their precedent versions as a working paper and conference proceeding. Other, less successful interpretative attempts with the innovation networks theory, e.g. [Hagedoorn, 2002; Chiu, 2008; Chetty and Stangl, 2010], or the framework for disruptive innovations, e.g. [Christensen, 1997], lead to dead-ends in the process and the related exposés thus remained internal. Albeit the study at hand followed a comparatively open research approach and thus benefitted from the practical support from four student assistants during data collection as well as an constant feedback from other experts during the whole research process, e.g. from research colleagues, conference discussions or methodological advise; their thoughts and advise have solely been used to challenge and validate the results of research-logfile at different stages. The research design, the research process management, the logfile and the interpretation of the data in the main study with the theory of dynamic capabilities as well as the strategic use of architectural knowledge are the work of the author alone. The presentation of the study is oriented at the positivist paradigm and framed sequentially to enhance advance clarity to the ready [Suddaby, 2006]. Nevertheless, the reader has to keep in mind that the introduction and the theoretical overviews already integrate the concepts that emerged from the study. Thus, the selection and presentation of relevant literature within the precedent chapters is oriented towards these constructs. Last, the presentation of the data follows a comparatively strict qualitative approach as it incorporates no quantitative indicators except for the depiction 15, depiction 16 and depiction 17 that illustrate the generic structure of the data sample. The number of quotes to verify a finding only has illustrative purposes and no impact on the accuracy of the specific result.

Coding Tree *(Category Name // Description of Category // Number of Coded Segments)*		
Analysis of Firm Environment	Statements about the Environmental Analysis and the Motivation for System Development	159
Motivation for Development		159
Economical Motivation	Relevance of Economical Aspects	139
Change in Environment	Statements about Changes in the Industry, e.g. Maturity Stage, Technology, Legislation, Activities of Competitors etc.	75
Industry Phase		28
Technology		8
Legislation		28
Competitors		11
Change in User Demand	Statements about Changes in the User Preferences, e.g. regarding the Deployment of Knowledge, Time, Capital	64
Know-How/ Skill		13
Time/ Effort		8
Cost/ Capital		29
Environment		14
Ecological Motivation	Relevance of Environmental Aspects	20
Adaption of Firm Resources	Statements about the Adaption of Firm Resources	744
Phases of Reconfiguration	Statements about the different Phases of Reconfiguration on an aggregate Level, e.g. regarding the Change in Perspective, the System Composition, the System Operation and the Future Orientation in System Development	144
Performance-Orientation		41
System Composition		45
System Operation		14
Future Adaption Goals		44
Decentralization		17
Integration		24
System Development Process	Statements about the Innovation Process and its distinctive Characteristics, e.g. User Integration or Iterative Development	159
Idea Generation Phase		36
Development Phase		34
Operation/Diffusion Phase		20
User Integration		45
Iterative Development		24
System Resources/ Component	Statements about the different Resources/ Components within the System, e.g. Products, Services, Infrastructure, Platform, Interfaces etc.	244
Product-based Resource		69
Service-based Resource		89
Integration Resource		68
System Interfaces		18
System Resource Location	Statements about the Architecture of the System and Location of Resources in Relation to Firm Boundary	197
External Resource		107
Internal Resource		90
Random	Collection of Cross-Category Statements, e.g. regarding the Elasticity of Resource Deployment, the Ressource Efficiency or the Organizational Flexibility	87
Elasticity		11
Operational Excellence		9
Resource Efficiency		27
Organizational Flexibility		12

Depiction 17: Simplified Coding Tree

5. Findings of the Study

The following chapter portrays the sequence of activities that the research has identified in the examined firms for implementing a performance-oriented system. The presentation of the findings is structured according to the prevalent two-step approach of environment analysis in chapter 5.1 and the adaption of the firm resources. The latter is divided into the two types of value creation in chapter 5.2 and value protection in chapter 5.3. The section closes with a description of relevant contextual factors in chapter 5.4. Each section comprises central results derived from the qualitative research. The quantity of quotes to verify a finding only has illustration purposes and no relation to the accuracy of the specific result. The chapter closes with the derivation of a comprehensive framework for performance-oriented system development in section 5.5.

5.1. Analysis of Firm Environment

The first section of the results comprises the analysis of the firm environment. Interviewing the key managers of performance-oriented systems about their motivation for system development, it becomes apparent that the dominant reason lies within changing user preferences. Exemplary, 'ICT 4' well illustrates this transformation in user demand: *"So we are strong in the desktop software space, we have some strong products and business models. However, in the UK, there are people, customers, that are starting to want to be able to use it online. An online solution, an online offering that is developed online. Benefits are such, as they don't need to buy infrastructure, they don't need to install the software. It is already installed and you get access to all data sections. You can access it from anywhere, anytime. So there are customers in the UK wanting that choice."* This excerpt clearly illustrates the perspective of an incumbent firm with an existent product portfolio who has detected new emerging user preferences as a reason to develop a performance-oriented system. In contrast, an entrepreneurial firm has no established users with altered requirements, but the founders were in most cases previously users themselves who have detected unmet needs or a problem in existing offerings. Ultimately, this circumstance led to the foundation of an entrepreneurial firm to resolve this shortfall. For example, entrepreneur 'Mobility 7' asserts that *"One of our first goal was, we were just solving our own problem, because we all needed a car but we didn't want to own a vehicle. So we were thinking of, we were really only using the* *car only once or twice a week, so we didn't see the need to own a vehicle just to have one-two trips a week. That was the original idea. Second one, we were thinking of a system, like a national system. At the early stage, we were thinking of a service that could provide vehicles to a broader, public arena."*The former two excerpts illustrate well on an aggregate level that incumbent and entrepreneurial firms have detected changing user preferences in the respective industry. This transformation in the environment of the firm has motivated the development of a performance-oriented system. In the following, the specific preferences that emerged will be discussed on a more granular level.

The majority of informants accentuates that the costs for acquisition and operation of comparable products or services has been the primary driver of system development. For example, 'Energy 2' explains that *"The idea came up initially, where we have clients who didn't have the capital to invest in the [prior] system."*Across all industries, the informants answer in a comparable manner. 'Chemical 1' points out the high acquisition costs of their new product that prohibits a conventional product sale albeit its superior characteristics: *"In terms of user value, this fluid is typically only used in very difficult and complex well operation where simpler and cheaper fluids will not do the job as well. [...] There were quite a lot of customer's resistance to the fluids mainly because initially it was approximately ten times more expensive than any fluid that they had previously experienced with. So that is a major leap for potential customers to make."*A central characteristic of a conventional product sale is that the user has to deploy his financial resources prior to the usage or operation of the product. The informants accentuate that users prefer the transformation of upfront capital expenses towards operational expenses in performance-oriented systems if the products are not core to their business. Talking about this aspect, 'ICT 1' asserts that *"You enable them [the users] to concentrate on their core competencies and reduce and transform their cost to variable cost."*To clarify this aspect, 'Mobility 8' explains in more detailed manner: *"Because car-sharing in the end, when you compare the costs of ownership for the customer, is car-sharing more or less designed to have the same cost as ownership. If you own the vehicle, if you would buy a vehicle and add everything together, fuel consumption, taxes, insurance costs, repair, maintenance, tires, winter tires, summer tires, all this stuff and you add them all together and divide that through the driven kilometer, you have a value of cents per kilometers. You know, and when you compare that to car sharing you should more or less end, I mean your car-sharing cost, in this level as if you owned a vehicle on your own."*Albeit the overall cost of ownership for product acquisition and operation are the same (or in some cases even higher) in performance-oriented systems in comparison to existing conventional alternatives, e.g. product sale, the users of the examined systems prefer a remuneration on variable terms rather than to deploy all financial resources in advance. This is especially true when the product or its delivered performance respectively is not core but rather contextual to their business (in the case of B2B offerings) or personal lifestyle (in the case of B2C offerings). To summarize, high product (or service) acquisition cost in conventional offerings facilitated the development of performance-oriented systems.

A second aspect that motivated the development of performance-oriented systems is changing user preferences in terms of effort or time necessary during the acquisition or operational phase. In coherence with the first aspect, this preference is especially emphasized by the user if the product is not core to their business or lifestyle activities. Exemplary for a B2B offering, 'ICT 3' summarizes: *“So the main motivation was not to loose on this trend and opportunity where companies are looking for externalised solutions where they can focus on the use of a software but not on the maintenance and on the installation and on the running of the infrastructure.”* The quote clearly accentuates the reluctance of the users to deploy their valuable (working) time resources for contextual activities. This disadvantage ultimately reduces the users confidence in conventional offerings and led to the development of performance-oriented systems, as illustrated by 'Energy 1', who asserts that *“[Company name] main drivers to develop the [system name] model are to make solar heating technology more accessible for people, to remove financial barriers, and to eliminate the problem of customer’s confidence.”* The former quote describes the motivation as an equal combination of effort and financial constraints. In comparison 'Energy 5' clearly carves out the barrier of operational effort in conventional offerings: *What I’ve found was that customers were very interested in solar and wind, but they did not want to put money up front to own or operate the power plant because it’s not just the money but also the responsibility of maintaining the power plant for the next 20 years. [...] I think, if [company name] had only been a financing company, it would not have been successful. It was successful because it gives the monitoring, maintenance, and all of the paper work and everything."* To summarize, a time-consuming operational effort for conventional offerings facilitated the development of performance-oriented systems.

A third aspect that led to the development of performance-oriented systems is a lack of user know-how for product acquisition and operation that constrains the consumption of conventional offerings. Exemplary, 'Energy 6' connects this user preference to the former two: "*And the other key ideas were that customers, they don't want to operate power plant. They don't wanna have to finance them. They don't wanna have to operate them, and they are not even good at operating them because they don't know what the best approach is and what the best techniques are.*"The disadvantage of advanced knowledge requirements for efficient product acquisition and operation is reflected in other industries as well, e.g. 'Chemical 3': *"This product, [product name], is a very high-price product. [...] You need a lot of know-how in order to keep it running and to keep it in use and to work with this chemical as long as possible."* Other informants support this analysis, as 'Energy 7', who concludes that "*We also discovered that the customers were interested in solar energy but they did not feel comfortable about owning the solar panel and solar heater for use because they were uninformed and they were fearful of equipment breaking down so they didn't want to take a risk of buying something that they did not understand but they wanted solar.*"Albeit the aforementioned quotes for this preference have a heritage in the chemical and energy industry with comparatively complex technologies, the results indicate its relevance to a certain extent also for the ICT and mobility industry. Therefore, a high demand of operational skill or knowledge in conventional offerings facilitated the development of performance-oriented systems.

To summarize the former three aspects, the key-managers of performance-oriented systems have identified changing user preferences concerning the deployment of knowledge, time and capital for product acquisition and operation in an analysis of the firm's environment. The examined users clearly prefer a high elasticity of resource deployment, i.e. a variable deployment of their financial, time and know-how resources distributed over the entire operational phase, rather than an extensive fixed commitment before use. These changes in demand motivated the development of the respective systems. This leads to the first finding:

> **Finding 1: Changing user preferences in terms of knowledge, time and capital deployment for product acquisition and operation have facilitated the development of performance-oriented systems.**

So far, the chapter has illustrated the economic perspective that facilitated performance-oriented systems. The existing literature indicates that there are also ecological reasons for system development (cp. chapter 2.2.2.). Some sources even emphasize this aspect as the dominant motivation. In contrast, most of the informants answer to this aspect quite frankly: *“Yes, yes. Environment benefit, you know, that is PR, that is public relations.”* ('Mobility 7'). First, this quote reveals that the firm is not intrinsically motivated to develop environmental-friendly innovations but is rather driven by user preferences in this aspect as well. Second, potential ecological benefits are integrated 'ex-post' after the development during market diffusion phase. This indicates 'green-washing' rather than an ecological benign innovation behavior.

Overall, the data sample does not provide a consistent pattern of ecologic user preferences despite this initial indication. Exemplary, 'ICT 3' explains that, based on their analyses, their users do not request the firm to consider environmental benefits: *"Well, I didn’t meet, I didn’t get customers on who told me that they are getting on the SaaS train for environmental reasons or greener solutions. None of them has told me that they want a SaaS solution, because they wanted to be more considerate of the environment."* There are also respondents that detected a significant preference of ecological aspects among the users of their system. Exemplary, 'Energy 6' points out: *“And then, from the customer point of view, all they really wanted was the green electron, so they want renewable energy's green electron instead of the brown electron. And really, they preferred to see those in less and lower cost."* This statement is supported by 'Energy 5': *"What I’ve found was that in general, whether it’ll be energy efficiency or solar or anything, the [system name] is actually quite powerful, because most people that you talk to are very much interested in the environment and saving money, but they are just not interested in using their money to do it. They really wanted a third party to do the work and take the risk."* Both informants indicate that there is a significant user demand for ecological benign solutions but nevertheless economic preferences dominate potential environmental benefits.

In contrast, some managers acknowledge the existence of environmental benefits as a side effect of system development, e.g. 'Energy 1': *“I mean, obviously, the technology has got a lot of environmental reasons, but the concept of [system name] is mainly to make it more accessible for the customers.”* This rather pragmatic point of view is also shared in other industries, e.g. 'Chemical 3' asserts that *“In 2006, we were certified in environmental management system according to ISO14000, […] if the customers have also environmental management system, they will welcome this idea. If not, it’s just a question of money and other benefits.”* The former two quotes indicate that the management is aware of potential environmental benefits of the systemic approach as well as latent user preferences in this aspect. These firms partially integrate this aspect into their innovation behavior, e.g. ISO-certification, but clearly rate them secondary in comparison with economic benefits or user preferences.

Additionally to this divergent pattern, most of the informants had to be asked explicitly about potential environmental advantages of their system offerings. The circumstance that most key-managers did not mention these characteristics by themselves as a motivational factor also makes a statement about its role for system development. Only very few, for example 'Mobility 6', equally named ecological and economic benefits as a motivation for system development without direct interrogation: *"I think our aim or our goals were to do something positive for the environment, to improve the local street, reduce traffic, reduce congestion, and I think the other one was very motivated to do a business."*

The hitherto portrayed range of quotes to clarify the relation of ecological and economic benefits as a motivation for system development is well aggregated by 'Mobility 8' who summarizes the dominant firm perspective: *"At the end, you need to earn money. So just dreaming and thinking is one thing, you need to earn money [...]."* Hence, the intrinsic motivation of the examined firms for system development is primarily based on economic benefits. Ecological benefits are regarded as a side effect, particularly when correspondent user preferences are existent. The data sample suggests an interdependency of the answers in firm type, as especially entrepreneurial firms are aware of ecological benefits of the system approach, as well as a bias towards the energy and chemical industry. This leads to the second finding:

> **Finding 2: The firm´s motivation to develop a performance-oriented system is predominantly economic driven; ecological benefits are regarded as a side effect.**

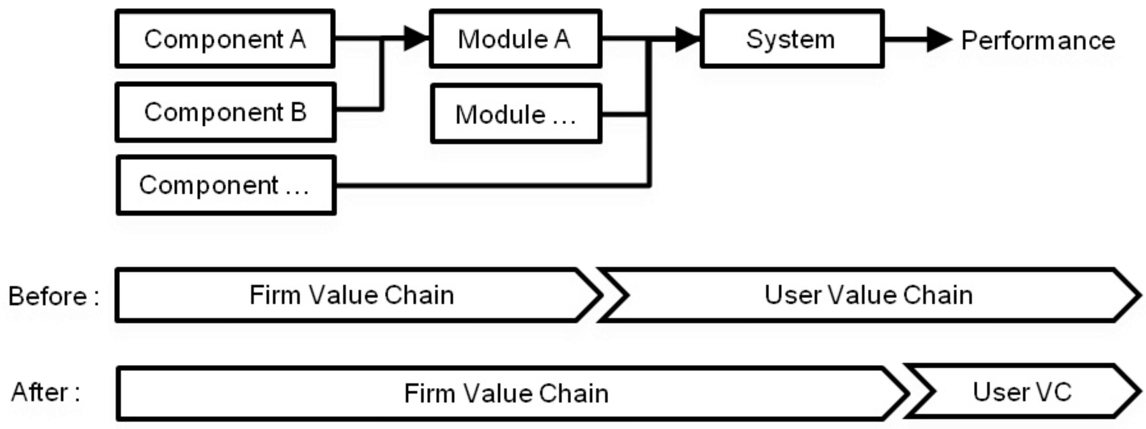
The first two findings indicate that the examined firms have detected primarily a transformation in the economic environment of the firm. The change concerns new, emerging user preferences. This novel set of preferences prohibits an increase in the sale of the existing, conventional product or service. Therefore, the productivity or performance of the industry is limited at the lower end of the value chain. The reluctance of certain users to acquire conventional products or services, which is based on their demand for a higher elasticity in resource deployment, forms a bottleneck downstream in the value chain. Subsequently, the examined firms have executed an analysis of the firm's environment and identified a bottleneck prior to the development of the respective performance-oriented system.

5.2 Adaption of Firm Resources for Value Creation

In the second part of each interview the study investigated the reconfiguration of the firm's assets during the development of performance-oriented systems. The importance of adapting the firm's architecture as a consequence of the environment analysis is highlighted as well by 'ICT 2' who serializes: *"Number one is knowing your market and knowing what the customers want. Number two is getting the architecture right [...]"* The theoretical section in chapter 3 highlighted the two central elements of value creation and value appropriation. The following chapter comprises the adaption of the resources for value creation.

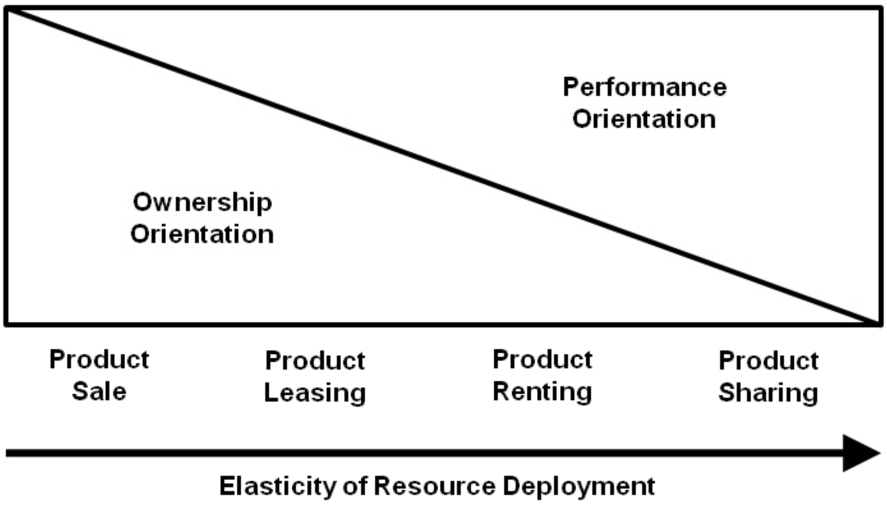
Reviewing the results it becomes very clear that the system development is accompanied by a major shift in perspective. Reflecting on the changing user preferences, "Energy 5" asserts that: *"[...] business owners didn't want to own the generation assets, what they really want was the commodity delivered from the generation assets and associated environmental benefits. It really did not make sense for the business owner to invest a lot of capital in the assets that are not core to their business.[..] Ultimately, customers don't care what the technical solution really is. They just want it to be safe, reliable, and not disruptive to their business at all [...]"* The former quote reflects well on the unwanted deployment of significant resources by the user in contextual activities. The personal engagement of the users in these products or services respectively is comparatively low, as these activities are not in the core of their professional or private interest. The users are much more interested in the performance delivered by these products or services in the least complex manner. 'ICT5' illustrates this aspect in an applied example of a small 'system' based on three components: *"So, if you have a [product A], in addition if you have [product B], and you have [product C] for example, you don't want to count on three partners. For example, if you have a problem with [product B]. You don't know if it is a connection or software application problem, whatever to call one or the other. You want to call one."* This quote well illustrates that most products deliver value or performance not on their own but need complementary product or service components. The individual management of the 'system' composition, their interconnection, as well as their operation adds complexity and needs the deployment of even further resources. The composition and operational management of several complementary resources to deliver a specified performance is the central aspect of performance-oriented systems, as explained by 'ICT 1': *"[System name], it is a solution where we are not only providing the functionality, but we are also providing the entire solution, the entire ecosystem. Whereby, we prevent the intention to have and implement or to deploy the operating environment, which can be the hardware, the expert, or a further partnership with another company to do that for them. So, we provide a kind of 'one-stop-shop' where you get the entire solution. The interest of that is not only that they [the users] can delegate the IT part to us, we are expert on that. So, they can focus on their business rather than trying to find the IT expert. It is not their competency."* The informant vividly describes the reduction of complexity and resource deployment for the user that characterizes performance-oriented systems. The responsibility for all necessary components to deliver the performance is shifted from the user to the innovating firm. This significant change in the industry's architecture in comparison to prior offerings is accentuated by managers across all industries. Exemplary, 'Mobility 8' states that *"[...] the mobility behavior for the moment is [that the] customer is purchasing a product and uses this product. And in future is, from our point of view, the direction that a customer does not necessarily need to purchase and buy a product. It is rather the he purchases mobility [...]"* This opinion is also supported by 'Chemical 2', being compliant that *"[...] you are not selling the kilos of products, you are selling the performance. And if the performance is better, your benefit is better."*

To summarize the actual change in the industry architecture in comparison to a conventional product sale, the data first illustrates that most products deliver value or performance not on their own, but need complementary product or service components. Thus, the performance is delivered in a 'system'. In a conventional offering in the mobility industry for example, the user not only has to invest in a vehicle but also deploy resources for fuel, taxes, repair, maintenance and seasonal tires to produce 'mobility'. Second, the individual management of the 'system', i.e. the interconnection of the independent components, as well as their daily operation adds complexity and needs the deployment of even further resources in excess of their acquisition. Exemplary, the individual system operator has to identify the cheapest gas station or the best garage etc. The results from the research indicate that the personal involvement from the user for system composition and operation is low when the related activities are not core to his business or lifestyle. In that case the user has a higher interest in the sole performance in the least complex manner. Performance-oriented systems explicitly meet this user demand as they integrate the composition and operational management of several complementary components to deliver a specified performance within their firm boundary. In a carsharing-system for example, the firm composes a system with suitable vehicles as well as fuel, cleaning and maintenance services etc. and manages these components during the operational phase for the user. This change can be visualized by a simple industry value chain with six generic steps (cp. depiction 18). As already discussed, in a conventional sale the user has to compose an individual system of several resources, e.g. car, maintenance, tires, etc., to produce the performance 'mobility'. Some of the resources are single physical components, e.g. tires. Others are more complex and consist of several components, e.g. the car maintenance. These elements form a module. Albeit the value chain in reality is probably more complex, the example is limited to three levels of analysis, i.e. component, module and system level. Each level consists out of single or multiple physical components and stands for a step in the value chain, characterized by the boxes in depiction 18. The aggregation of resources towards the next level, e.g. the combination of physical components towards a module, also forms a step in the value chain which is characterized by the arrows in depiction 18. The latter combinatory steps, e.g. the combination of spare parts in a car maintenance, are often characterized as a service element. Overall, the simple value chain comprises six steps including the final production of the system-performance 'mobility'. In a conventional offering, one or probably multiple firms sell the components, or modules respectively, to the user. Their firm boundary comprises in the example step one to three in the value chain. As already described, the user's responsibility or boundary includes the last three steps of the value chain. The transfer of system composition and operation from the user to the system provider in performance-oriented systems, i.e. step four and five in the exemplary value chain, results in a redefinition of the firms boundary and therefore in a change in the industry's architecture. In some cases, even the last step of performance production is included within the system boundary but normally the user has to participate to a certain extend in this step.



Depiction 18: Simplified Value Chain in Performance-oriented Systems

The hitherto described example illustrates the downward integration along the value chain that differentiates performance-oriented systems from a conventional product sale. In the following the difference between performance-oriented systems and conventional service offerings is described in greater detail. Interestingly, the change in architecture incorporated in performance-oriented systems is often compared by the informants to the development of a service offering, e.g. 'Mobility 9': *["...] actually, it was kind of a vision, we perceive it as kind of 'service of the future'. And I believe mobility is going towards more integrated systems, and more decentralized systems and less reliable on ownership."*In many cases, the informants draw a comparison to existing service offerings in their own or other industries. Exemplary, 'Chemical 1' explains the remuneration of their system in comparison to a car rental service: *"They would pay a rental charge per day per cubic metre for the duration of the time that they have it. Similar to, like you know, hiring a car, you pay for the minute you pick up the car until the minute you return it back. If during the course of operation they lose any, you always lose a small amount during the operation, they actually pay for that."*These constant comparisons have their eligibility as an absolute differentiation between the different offerings in an industry is difficult. For example in the mobility industry, a firm that provides a car rental service needs to compose and operate a system of several product and service resources similar to a car-sharing provider. The rental firm also provides mobility to the user. But the key aspect that differentiates the examined systems, e.g. car-sharing, from other existing offerings in the industry is the provision of the highest elasticity of resource deployment to the user. The high system elasticity, i.e. flexibility in resource use, is the result of a constant performance-orientation which affects the system architecture. For example, car-sharing systems incorporate the fuelling or the possibility to spontaneously book the vehicle through a scanner beneath the front window. These exemplary elements are not included in other system-based offerings. To clarify this aspect, all existing offerings in an industry may be organized on a scale regarding their elasticity of resource deployment for the user (cp. depiction 19). There are two extreme positions on the scale: On the left hand side is a pure product sale without any service elements that comprises a complete ownership orientation and provides the least elasticity. The user has to plan his demand for the entire lifespan of the product in advance and deploy most of his resource before acquisition, e.g. capital, knowledge and time for selection. The integration of a financing service into the product sale already increases the elasticity slightly, as the financial resources can be deployed on a fixed annual or monthly basis for example. Product leasing or product renting continue this trend of increased elasticity with decreasing planning horizons and declining fixed resource demands. Exemplary, a typical car rental period is on a weekly or daily basis and the vehicle type can be adapted to the day-by-day demand. Product sharing complements this series with the highest elasticity as provisioning and resource deployment is even more flexible. The user of a car-sharing for example can decide every hour or minute whether to use the system and its provided performance or to exit it. The performance orientation of the product(s) predominates the ownership. As there are no consistent definitions of the different notions, e.g. leasing, renting, sharing, across industries and absolute boundaries are blurred, performance-oriented systems are a relative construct. The data suggests that performance-oriented systems form the extreme point on the right hand side of the elasticity scale opposed to a pure product sale. It is a distinct position in relation to other existing system-based offerings, which incorporate hybrid characteristics, i.e. dual ownership and performance orientation. To summarize, performance-oriented systems are optimized towards performance and therefore 'bang the right corner' in terms of elasticity of resource deployment for the user.



Depiction 19: Elasticity of Resource Deployment in System Offerings

To summarize, the difference of performance-oriented systems in comparison to a conventional product sale is the downward integration along the value chain by the innovating firm. The downward integration incorporates the value steps of system composition and system operation. The result is a redefinition of the firm's boundary towards providing the performance of several joint resources instead of selling single complements. The redefinition of the boundary comprises the characteristics of an architectural innovation with the objective of value creation through value step integration. The previous findings described the changing user preferences towards a high elasticity that form a bottleneck in the respective industries. The informants indicate that the transfer of system composition and operation towards the providing firm significantly increases the elasticity for the user. Hence, the redefinition is an architectural innovation for the integration of the industry's bottleneck within the realm of the firm. In comparison to conventional service offerings, performance-oriented systems provide the benefit of the highest elasticity in the industry spectrum. These characteristic differences primarily created the notion of performance-oriented system within this work. This leads to the third finding:

Finding 3: A firm is redrawing its boundary towards offering the performance of several joint resources to the user, instead of selling single complements. This

downward integration of the value chain results in an increased elasticity of resource deployment for the user.

So far, the simple example above (cp. depiction 18) assumed that a firm has integrated all system components and modules within its boundary. For example, a carsharing provider has integrated and is responsible for the vehicles, the maintenance, the cleaning, the insurance etc. Albeit this is true for a minority of the examined cases, a single firm rarely has integrated the complete value chain of all resources in more complex industries. In the following, the research clarifies which resources are included within the firm boundary of performance-oriented systems except the previously described two elements of system composition and operation. Further, the study portrays the differences between firm type, e.g. entrepreneurial firm, product-based and service-based incumbent.

A detailed description of the specific system resources in excess of the generic notions product component and service module would be complex due to the differences in industry type and would add only limited insight beyond the single case. Nevertheless, on an aggregate level, the innovating firms were confronted with similar challenges during implementation, as the described phenomenon of performance-oriented systems was comparatively novel to all industries. Exemplary, 'Energy 5' describes their situation during implementation: *The benefits of being the early company in the process is that you define space. The downside is that other vendors can then look at what you did and try to replicate it and build it into the product offer.* 'The manager reflects in this quote on a common and widespread technology leader vs. follower situation which is not specific to the phenomenon of this work. But the informant differentiates the challenges of product-based and service-based incumbents in the course of the conversation: *For the advantages of the product companies, like [company name], since their products are well-known, well established entity, they will know with a high degree of reliability what the relative performance of their product is and how they can best service it. That's the big advantage. The downside for services companies is that you have to go and build the entire product infrastructure. And the product infrastructure in some way is much more complex. Wearing service infrastructure into a product company is relatively easy, but wearing a product infrastructure into a service company is pretty complex.*('Energy 5'). The manager reflects on the need to integrate product components as well as service modules in performance-oriented systems. He further differentiates between the prior resource base of the company, e.g. product- or service-based, which results in an advanced component knowledge, or module knowledge respectively. The third aspect concerns the relevance of technological component know-how to assess and optimize the performance of the system. Not astonishingly, 'Energy 5' has a product-based background. The relevance of the firm's prior resource base is emphasized by informants across all industries. Exemplary, 'Mobility 5' points out: *"There is some capabilities, some capacities, in house and some of them are outside of the company. The mother companies certainly support with their own capacities the joint venture, which is clear at these early stages. We have to see the development of the joint venture. I think there are some lessons to learn and after one year we can decide to insource maybe one or the other function or functionality."*The data reveals that all incumbent firms are transferring relevant prior knowledge and resources for system development. In a more detailed manner, 'Mobility 9' illustrates the transfer of prior knowledge from the parental service firm, asserting that *"[...] we knew how much money we were going to be spending, [...] of course we knew how to buy cars, and how to sell them and how to fix and how to manage a fleet. So that was very important."* And further *"[...] we are still trying to improve the solution always and we are always looking for, you know, how can we do this? What kind of, should we hire someone to do this for us? Should we do it ourselves?"* This quote indicates a constant search for necessary external competences besides the transfer of existing knowledge. On an operational level, 'ICT 3' describes the search for and integration of complementary resources from a product-based perspective: *"Most of the resources that we needed were available within the company in the development and technical side. What we have done is we have taken some developers that were working on the [prior product name] within [system name]. We asked them to develop a platform [...] to manage [system name]. That is on the technical side. Then, what we have to do is, we have to develop a sales strategy. For that we have to recruit [people] who were able to design a strategy and that have experience with the [system name] market and who know how to speak with the customers."*On an aggregate level the examined incumbent cases simply co-specialize in the complement resource base, i.e. a product-based firm integrates the necessary external service competences and vice versa. The co-specialization of intangible competences and tangible components is accomplished through external acquisition or internal development. Albeit entrepreneurial firms do not have a prior organizational knowledge base, they often comprise relevant individual knowledge from prior business experiences, e.g. financing knowledge or system management expertise, which is transferred accordingly. Additionally, these firms have to integrate all the essential resources, i.e. all necessary components and modules for performance provision. Exemplary, entrepreneurial firm 'Energy 3' describes the development and integration of relevant resources: *"At first, we just facilitated the investment. So, we would be able to do the business plan for customers. We were able to analyze their needs and their expenditures in water heating using gas or electricity. And we would do the business case to present them their benefits and return on investment and then we would hire the technical partners to do engineering and installation. This was the beginning, but then we came across the market here in [country name] which was poorly developed in that area. I mean we lack good engineers and good people to install the products, so we started to develop that capabilities internally. Five years from then we have the full resources internally to develop the project and engineer the projects, to do the business case, to do the installation and maintenance and everything that is needed to run the solar water heating plants."* The hitherto presented quotes indicate that all examined firms transferred their existing prior knowledge and identified essential complements to provision the performance. Complementing resources, or complements, refer to all tangible system resources that initially were located outside the firm boundary. These complements are directly necessary for system composition as well as system operation, i.e. they are situated at the previous step of the value chain. These complements and their related knowledge are either acquired externally or developed internally during the system development. Regarding the complements there is no evidence within the examined cases that the firms integrate more than one step upward in the value chain. Hence, a typical performance-oriented system boundary comprises the steps three to five or three to six respectively in the simple example presented above, as well as the incumbents' prior boundary, if applicable.

To summarize, the (re)configuration of modules and components for the development of performance-oriented systems is based on the firm's prior position and knowledge base as well as essential complements for system development. The co-specialization of complements is executed by the innovating firm through acquisition and internal development. This leads to the fourth finding:

> **Finding 4: To develop a Performance-oriented System, a firm is transferring its existing resources from prior business as well as integrating complementary external resources that are essential to initially provide the system performance.**

The former two findings indicate that the development of performance-oriented systems affects the firm boundary in two ways. The first type concerns the downward integration of the value steps of system composition and system operation. Performance-oriented systems therefore expand the firm boundary horizontally along the value chain into the use phase. The second type, concerning the transfer of valuable existing resources as well as co-specialization through integration and development of complementary resources summarized in finding four, indicates a vertical adaption of the firm boundary at the same step of the value chain. Both types fulfill the characteristics of an architectural innovation for value creation, whereas particularly the first type intends to integrate the identified bottleneck within the realm of the firm.

5.3 Adaption of Firm Resources for Value Appropriation

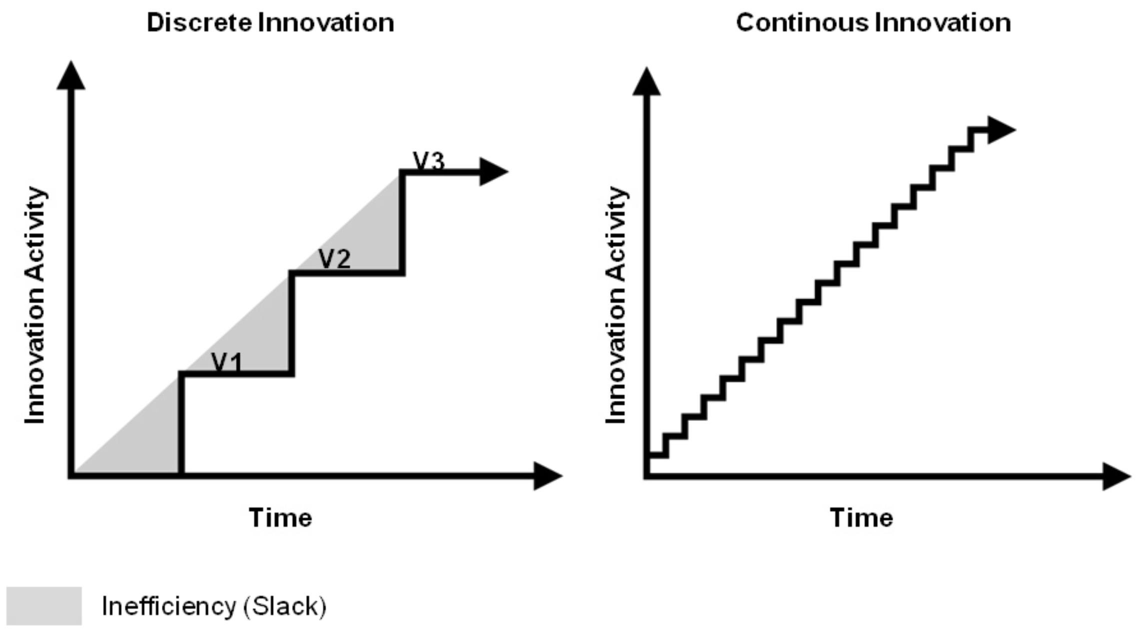
So far, the study has described the value creation of performance-oriented systems. Literature indicates that value appropriation is as important as value creation. Thus, the study investigated how firms offering a performance-oriented system with diverse resources secure the rents of the system. The following chapter is divided into four aspects, the development of a central integrating module, its impact on the firm's innovation behavior, the evolution of the resource composition as well as the further system optimization.

In the previous chapter the study has illustrated the complex structure of performance-oriented systems which comprise a variety of resources. In this context, the research investigated which resource(s) are key for value protection and which are contextual. Exemplary, 'Energy 5' explains this aspect: *"Core of the business is fundamentally asset management business, so you have to understand how your assets are performing, [...]"* This quote indicates that it is not one single complement which is important but rather the operational management of all components within one system. This is supported by 'Mobility 9': *"Internal is operational capacity. We have to have a good COO, Chief of Operational Office. You have in operations someone who knows how to operate. Because that is your business, so that is important. Because that is your business."* The operation of the examined systems is oriented towards providing performance. Therefore, the informants often emphasized the role of a constant monitoring to provide and secure the absolute performance level of the combined resources, as explained by 'Energy 6': *"We provide monitoring ourselves, so we have a monitoring system that comes back to our offices and our special monitoring station. And we monitor the performance, remark all the alarms, remark of the performance and based on that we can determine* *if there was the problem. And if there was a problem, we will then deploy the maintenance company to go fix it."* And further ('Energy 6'): *"Inside the company we have other systems that we used to track all the aspects, all of the systems. And everything about the system goes into this tracking system, the big database. So all of the documents, all of the contracts, all of the data, all of the maintenance history, all of the contact people, any alert and any future calendar events that require our actions, all track in that big system."* The quote extensively explains the role of a dedicated technical platform to connect, operate and monitor the diverse system resources. A central mission of the platform is data collection and evaluation to aggregate knowledge on and secure the performance of the system resources. The majority of the examined case examples use a technology-based 'integrating module' or platform that interconnects all necessary resources for operating the respective system. 'Mobility 4' illustrates the role of technology for the integrating module: "*You need to understand sort about the whole customer services environment and you need to have, you have to make the pre-sets of customer joining, using your facilities. You have to be really, really slick: Joining, checking the license, collecting the money. We made it too complicated in the early days, but eventually as the technology improved and the systems we used got better, you get people to join quickly. So that is about customer services and it is about smart use of the information technology."* Albeit performance-oriented systems comprise a diverse set of resources, recent technology developments allow the interconnection of the single components for an effective monitoring and operation. The connection technology, e.g. mobile internet, global positioning system, etc., enables the governance of the complex system by the provider. The technology provides a frame to generate and structure the system information and thus enhance the firm's knowledge. Complementing the hitherto described characteristics, the majority of informants identified the integrating module, or platform, explicitly as the key resource for value appropriation within performance-oriented systems. Exemplary, 'Mobility 7' points out: "*No, actually in Switzerland this is one of the key values of mobility, to run the system, to run the platform. And part of this platform is this technology of reservation, vehicle access and billing.*" 'ICT 3' explains the role of the platform for their system in a similar manner: *"We have to insure the stability of the system. So there has been a lot of work on the platform."* The development of the integrating module is done internally, because of its importance. For example, 'ICT 3' asserts that: *"We didn't ask external resources to help us on the development of the platform."* This statement is also supported by other informants, e.g. 'ICT 5': *The development team we are putting to run this is mainly focused on the* *platform, because there is a huge effort of integration initially to bring the platform to any country."*

To summarize, the key resource for value appropriation in performance-oriented systems is the integrating module that interconnects all system resources for an effective operational management. The development of the integrating module is done internally by the innovating firms. The advantage of the internal development of this module is that the system provider is able to build hidden information within the firm which can be easily protected. In a performance-oriented system the single tangible resources of the system as well as their composition are visible and in most cases also available to users and competitors alike, but the operational knowledge, e.g. the data on the absolute level of system performance, the single component capacity, the utilization rates etc., is only visible to the operating firm. For example, in a car-sharing system the single physical components, e.g. the type and number of vehicles, are visible to all industry participants. The utilization rate of the single vehicles, their running cost per kilometer or minute, the necessary distribution in a geographical area, etc., is only visible to the operating firm that constantly monitors the system through the platform. Thus, the aggregation of relevant operational experience over time through the platform secures an advantage of the firm within the industry which can be easily protected. This leads to the fifth finding:

> **Finding 5: The installation of a performance-oriented system requests the development of a dedicated module that connects the different components. The development of this integrating module is done internally as it is the key component.**

The previous section portrayed the importance of the integrating module for the operational management of performance-oriented systems. In the following, the innovation behavior within performance-oriented systems, the evolution of the system composition and the further system optimization are described in greater detail. The first aspect concerns the changing innovation behavior that accompanies the implementation of a performance-oriented system. The majority of the examined firms have shifted from a discrete innovation cycle towards an iterative innovation behavior on short innovation cycles. Exemplary, 'ICT 4' describes this transformation within their firm: *"[...] the existing way of working, when you want a new experience for the customer or a new function, that new function is designed at the start of the year and is provided to the* *development at the start of the year, and is delivered at the end of the year, and released as a part of an annual process. But with the new way of working, the design can be provided and one month later the design can be changed if it is not right and improved and it can be released frequently, […]. Things move quicker."* 'Energy 5' confirms this change in summarizing their system development in the following statement: *"So it was a very iterative process, it happened in real time and you have to do it in a very dynamic iterative way […]."* The previous two quotes exemplary demonstrate the higher innovation rate and speed as a noteworthy characteristic of performance-oriented systems. The advantage of this innovation behavior is visualized in depiction 20. The left side of the depiction describes the discrete innovation behavior within conventional offerings, where new versions of the product are developed on an annual cycle for example. The right side illustrates the continuous innovation behavior within performance-oriented systems that allows for shorter innovation cycles. The discovery-based, iterative development of the system is well supported across all industries, due to the managers insight that *"It is not useful to, you know, make researches and market research to understand if a person is going to use it or not, and you know, trying to make the best product as possible. That is not relevant. You need to put it out there, on the market, and people will use it and give you the feedback you need.*" ('Mobility 9'). The latter quote clearly emphasizes the role of the user for developing innovations that are appreciated during utilization. The examined firms have reportedly shifted their innovation behavior towards a discovery-based 'try-and-error' approach on short terms. This is possible because of the responsibility and governance of all system components through the integrating module by a single firm. The system provider continuously experiment with new resource configurations or modular innovations for a certain period of time during the operation of their systems and receive direct feedback via the performance-monitoring or the user-interface of the integrating module. Based on this feedback, they adapt the innovation permanently in their system offering or withdraw it. Nearly all interviewees confirm ongoing collaboration between user and firm with a varying degree of standardization: *"As I told you, we have a lot of collaboration tools. In addition, we also use a lot of customer feedback."* ('ICT 3'). Some of the examined firms not only source the feedback from the users on their internally developed ideas but rather profit from the users in terms of initial idea generation as well. For example, 'Mobility 6' accentuates "*[…] what I am saying is that we see new business idea not coming from us, not top down, coming from us and we develop and we present it to the* *customers, but it is the customers suggesting an idea and us resourcing that and developing that with the customer.*"



Depiction 20: Comparison of Innovation Behaviors

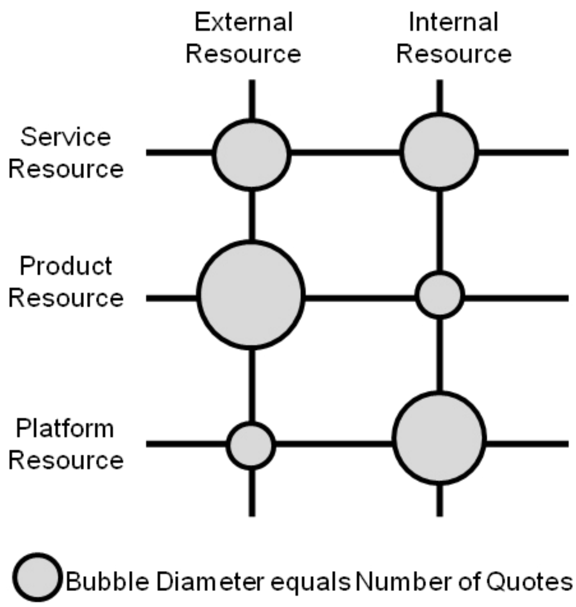
The research indicates that the degree of user-integration in the development or improvement of the respective system is dependent on the quality of the user-interface within the integrating module. The incentive for user and provider alike to strive for a high user-integration within the platform is explained by 'ICT1': "*So this software is like a platform that is enhanced every time one of the partners of the solution wants to make it evolving. That is why we call it a community solution. On the principle when one of the community members wants something, we build it for it and the other part of the community can also take benefit of that.*" In an indirect manner, this quote indicates that performance-oriented systems not only comprise a variety of complements on the upward side of the value chain but also an abundant number of independent users on the downward side. Their ideas and experiences are sourced on an individual, anonymous level and incorporated in the system through the user-interface of the integrating module. As a result, all users benefit from the following innovations. In the case of car-sharing, for example, the user may interact with the system provider through a hotline, an internet-based feedback form, a mobile application or the interface within the car. The user has the possibility to immediately comment on every aspect on the system with little effort, e.g. complain if the booking via mobile application is too difficult. Hence, the providing firm continuously develops knowledge on the subjective, individual user demand, i.e. the requested system performance, through the aforementioned innovation behavior. This knowledge also comprises the characteristics of hidden information which can be protected, comparable to the information on the provided system performance of the previous section.

To summarize, a complementary aspect of value protection results out of a changing innovation behavior, characterized by high user integration and an iterative, discovery-based development process. This transformation is feasible due to the responsibility and governance of all system components by a single firm. The result of this innovation process is a steeper learning and adaption of the system to the requested performance, i.e. subjective user demand, which complements the objective monitoring of the provided performance, i.e. system capacity. This leads to the sixth finding:

> **Finding 6: Close collaboration between user and firm allows discovery-based continuous development of the system rather than discrete innovation resulting in a higher innovation rate and speed.**

The last two findings identified two relevant aspects for value appropriation within performance-oriented systems. Finding five emphasized the role of the integrating module, whereas finding six accentuated the change towards a user-oriented innovation behavior. As previously described, the technical interconnection of the components within the integrating module allows objective monitoring and therefore information on the provided system performance. The novel innovation behavior is gathering information about the subjective user-demand, i.e. the requested performance through the user-interface of the integrating module. Both aspects incorporate the aggregation of hidden information within the firm which is neither accessible by the system suppliers nor the competitors. The hidden information comprises valuable knowledge regarding the resolution of the identified bottleneck on an operational level. Hence, the integrating module establishes an information filter as a measure to secure the advantage of the previously created value, i.e. the integration of the industry bottleneck within the realm of the firm. The following section describes the implications of this filter on the development of the upward interface, i.e. the connection of complements to the integrating module, in greater detail.

To recapitulate, performance-oriented systems are providing the performance of a variety of resources. The system offerings comprise a high elasticity of resource deployment as the key advantage for the user. This means on the downside, that the implementing firm has to deploy the necessary resources for system composition and operation. The informants of the examined case examples accentuate that especially the deployment of financial resources becomes a major problem for the providing firm with increasing system size. Thus, the managers of mature performance-oriented systems are forced to refocus and adapt the structure of their offering. This process is illustrated by 'Mobility 9': *"I believe you need to have very good service. [...] So what we do is we are constantly giving up the product part in order to provide that service. And I believe, strategic move is actually, constantly to give up the product and outsource it and focus on service, service, you know, good service. So, your interface with the client should be very good."* First, this quote underscores the role of the user-interface, which was discussed in the previous section. Second, the informant argues for outsourcing the physical complements, i.e. the product components of the system. Albeit this quote is clear about the minor relevance of product components in rising systems, the question remains why the examined system initially integrated these resources within their firm boundary at all. The answer is given by 'Mobility 7': *"We were just too small. We were solving our own problem. So we were not having this collaboration with other companies. The strategy to collaborate with other companies was a development strategy and a growth strategy. But the point is actually to use their customers to be your customers as well. That is the idea. Since they are close to their customers, you are getting close to those target groups as well."* And further *"You know, usually for those kind of systems, you have to start up, you have to figure out a startup setting. Then you have to find out your partners, as we were just talking about, those distributional partners to somehow amplify your system, to scale up your system. In the beginning, these partners, they probably ask you for exclusive partnerships, [...] and then in a third phase you have to overcome those exclusive partnerships."* ('Mobility 7') First, this quote illustrates that the providing firm initially has to compose and operate the system on its own. The firm needs to validate the capability of the system to resolve the bottleneck. The possibility to outsource physical complements through partnerships with suppliers correlates with the system size and therefore is relevant for comparatively mature systems only. Second, the manager describes the pursuit to source one single complement not from one supplier but several. This indicates that the providing firms strive to decentralize their sourcing. Third, the informant describes an advantage of outsourcing besides an increase of financial elasticity for the firm: the integration of new, related user groups within the system. The system evolution towards outsourcing the product components is also supported by informants from other industries. Exemplary, 'Chemical 4' asserts that: *"At the beginning, many things were separated like in pieces. Then we came into a situation where everybody is now cooperating with us, like chemical producers, like recyclers, like waste management people, like customers, everybody is cooperating to keep this will arising."*

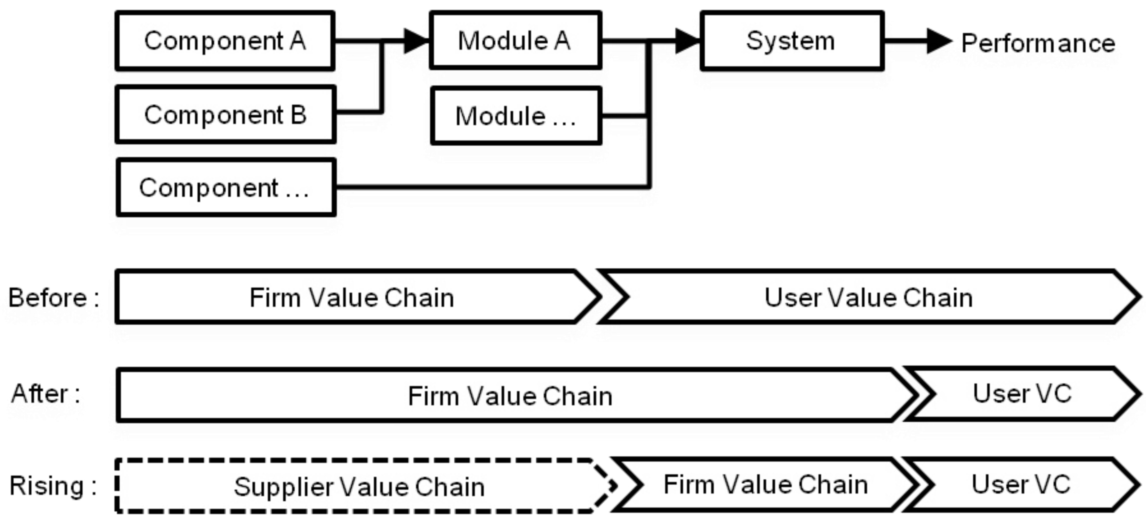


Depiction 21: Location of System Resources

Depiction 21 incorporates an excerpt from the code relations browser, a visual tool of MaxQDA to reveal relations between different codes. The illustration provides an overview of the generic system resources, e.g. product component, service module or integrating platform, and their location with regards to the firm boundary, e.g. internal or external resource. The bubble diameter equals the number of quotes within all interviews. The results support the portrayed evolution towards a constant outsourcing of the product components. The service modules comprise a divergent pattern. Directly platform-related services are kept internal, whereas platform-independent services are often outsourced as well. As already discussed, the vast majority of case examples keep the integrating module internal due to its importance. The depicted results are aggregated from all examined cases. Albeit the evolution to continuously outsource product components is especially relevant for the capital intensive systems in the mobility, chemical and energy industry, it can also be observed in the ICT industry to a certain extent. In the latter case, the higher elasticity for the firm in terms of time and know-how are rated as relevant as the financial advantages. The results further indicate that the central supplier for the systems that were developed by incumbents is the parental firm. Depiction 22 integrates the recent insights on the adaption of the firm boundary with growing systems size.

To summarize, the responsibility of the product resources is more and more relocated outside the firm boundary to ensure the flexibility of rising systems. The need for a significant resource deployment is shifted towards the suppliers. The providing firm's emphasis resides on the integrating module and its related interfaces. The further system evolution is characterized by decentralization on the upward side, i.e. several suppliers for one component, as well as on the downward side of the integrating module through the further integration of related user groups. This leads to the seventh finding:

Finding 7: Product resources are constantly outsourced by the firm with increasing system size. Only the platform and its directly related service resources are kept internal to remain flexible in rising systems.



Depiction 22: Simplified Value Chain in Rising Systems

In the previous findings the study described that the examined firms more and more outsource the physical components with increasing system size and concentrate solely on the value steps of system composition and operation through the integrating module. The data indicates that, albeit the outsourcing, the providing firm still governs the system complements as it controls the complement interface towards the integrating module, e.g. the board computer within the vehicles of a car-sharing system. Hence, the examined firms realign their focus on solely building hidden information and benefit from the characteristic of the integrating module as a filter. The derived data from the interviews suggests that the integrating module is not only used for the already discussed monitoring of the provided performance (performance capacity) and the identification of the requested performance (performance demand), but also for building processing knowledge to balance the former two and increase the system efficiency. This aspect is explained in greater detail in the following section.

Performance-oriented systems comprise a variety of resources. The previously identified two steps of system composition, i.e. the interconnection of resources, as well as their operation incorporate several possibilities for optimization. Before the implementation of a performance-oriented system in the respective industry, the user composed and operated his individual system. In terms of system composition, the user had to decide whether he wants to provision his system capacity to peak, average or minimum demand. For example, the decision of a family with five people and three drivers, whether they need to acquire one, two or three vehicles. Furthermore the user has to plan the operational phase, i.e. who may use which vehicle at what times. In most cases, the individual system provisioning incorporates only limited possibilities for optimization and comprises several inefficiencies, e.g. shortfalls or over-provisioning in certain times. The individual systems incorporate slack, i.e. single components or the whole system are not used to their capacity. In comparison, the system provider has its professional business focus on these two specific steps of the value chain. Hence, a central mission of the firm is to secure a high utilization rate during operational phase, i.e. balance the system capacity with the demand as well as the internal balance of system components. The less slack a system with given resources comprises, i.e. the higher the system and component capacity utilization, the better the profit for the providing firm. The outcome of this dependency is a constant effort to optimize the system's resource efficiency. Exemplary, 'Energy 6' describes the optimization of their system: *I' would say, probably the most important thing in terms of innovation is that it's* *not finished. It's still ongoing. It's figuring out how to streamline the whole process, really reduce the cost in every step of the process. For us, from the time we first start contacting the customer to the time that it's finished, installed, and it's operating, there are many steps in that process. So, what we have do to is, go to every step in that process and figure out, ok, how to reduce the cost and how to make this go faster. So increase the velocity. That's the key pieces of what we do to our company and I stress that we're not finished.'*This quote well supports the previously described iterative innovation behavior to constantly improve the system efficiency. In this example, the operational processes are optimized serially in each step to identify and remove slack at the component level. This approach is also executed by informants from other industries, e.g. 'Mobility 4': *'You know, generally you have to understand how each element of the business is working and measure your success. And then get back to it each year. And I think that is why [system name] is a very successful company, which hasn't required huge amounts of capital to get where it got to. And I think that, in terms of understanding your processes and measuring how well you are doing, makes it a successful car-sharing scheme.'*Both quotes underscore the relevance of the internal operational processes to increase the capacity utilization rate. The latter informant also emphasizes the constant performance monitoring as relative benchmark. As the providing firms concentrate their business activities specifically on the composition and operation of their respective system they systematically collect processing knowledge and thus experience over time. The firms realize economies of scope.

A second aspect to increase the efficiency of the system is located within the central governance of the resources through the integrating platform, as circumscribed by 'ICT 6': *'I was selling different standalone applications. My firm confusion in this time is, if you work with installed software you will have a lot of cost in support, integration, education, upgrading, bug fixing. And it is a much more efficient business model to provide software as SaaS. In [system name] one person is supporting 750 customers whereas in my old company, seventy-five percent of the company was directly networking with the customers in helping customers with their system. So the economic impact is for both customers and the company.'*In contrast to a conventional offering the providing firm is connected to all system resources through the integrating module which constantly monitors the system performance and provides direct interaction with the user for problem solving and demand identification. Second, the system components are standardized and balanced to each other to minimize the emergence of problems and reduce slack. These characteristics enhance the development of relevant processing knowledge as well as simplify the operational management significantly. And last, the quantity of the single resources used in performance-oriented system in comparison to an individual system is higher, e.g. several hundred or thousand vehicles in a car sharing system. This aspect can be summarized under the notion of economies of scale.

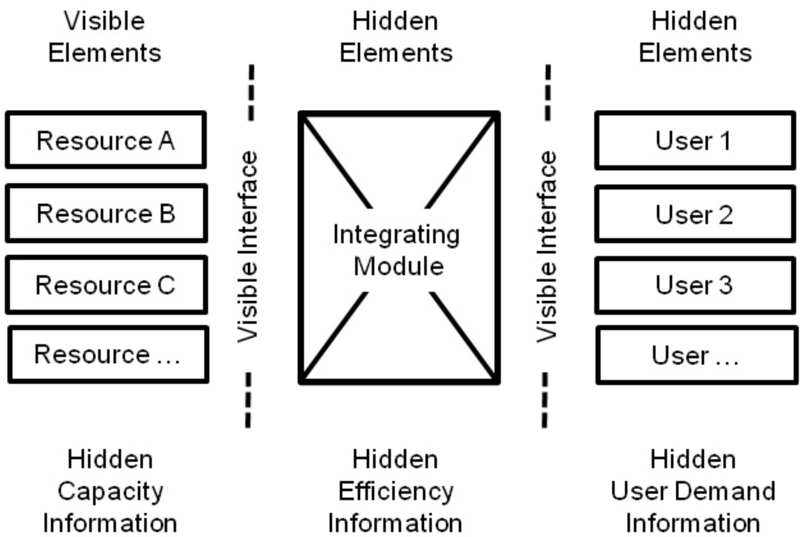
The third aspect concerns the resource durability, i.e. the duration that a single component is used within the system. Exemplary, 'Chemical 1' describes this aspect: *"Over the first few years we were doing, we had to develop a few techniques to manage the fluids to minimize the losses because the customers and ourselves have an interest in not losing these fluids. Because then again we are like a rental car, you don't want to rent your car once and have customers crash it. You rather rent it, brought it back and use it again and again to get the maximum value from the item before it is consumed."* This quote indicates that the implementation of a performance-oriented system is accompanied in a change in the incentive regime for the firm as well as the user towards higher resource efficiency. This aspect is supported by 'Energy 7' who assert: *"When somebody buys solar water heater for their own home, their immediate question is, how long will it take to pay for itself? What is the simple pay back? That's what they want to know. So, they want them to make a lot of heat and save a lot of money as fast as possible, but with the [system name], that's not the case. We want them to be out there for as long as possible. We want to make these things so that they last a long time. And that might mean you don't want them to make too much heat but just enough to make them last a long time. So we want them last for a long time without too much maintenance. So there is a difference about somebody who buys their own and a utility who has them like we do. That a big difference."* The interest of the user within a performance-oriented system is the delivery of a specified performance over a determined lifespan as he is released from the responsibility of buying the single components. The usage of performance, i.e. 'work done over time', is the basis for remuneration. Therefore, the providing firm has an interest to deliver a steady performance and increase their profit trough higher resource efficiency. In contrast, in a conventional product sale the firm has an inherent interest to increase revenues or profit through a decrease in performance steadiness, e.g. shorter product lifetime or component quality. This change in the innovation objectives is also described by 'Energy 2': *"You have to look now at designing long term. So it's no longer about what's best for us today, but what's best for us in next 20 years without scarifying the profit today."* Hence, the development of the system and its components is oriented towards providing steady performance, increase resource durability and resource efficiency. The change in the incentive regime also contributed to the notion of performance-oriented systems that has been coined within this work.

To summarize, the implementation of a performance-oriented system initiates a change in the incentive regime towards higher resource efficiency rather than decreased product lifetimes. The data indicates that the examined firms have identified several possibilities to increase the resource efficiency that are coherent with the established concepts of economies of scale and scope. First, the firm is balancing the performance capacity with the performance demand. This measure reduces the slack on the system level. Second, the firm systematically reduces slack on the component level by building detailed processing knowledge. Both of the aforementioned improvements in capacity utilization can be realized through constant data collection and evaluation with the help of the integrating module. Thus, the extent of processing experience determines the efficiency of the system and ultimately the firm’s profit. The information on the performance efficiency is also hidden by the integrating module, similar to the firm's knowledge on the absolute performance and the information on the user demand. This leads to the eighth finding:

> **Finding 8: The incentive regime of a performance-oriented system is oriented towards resource efficiency. Thus, the implementing firm needs to develop processing knowledge and systematically reduce slack of the system components.**

In the precedent findings the research investigated how firms offering a performance-oriented system with diverse resources secure the rents of the system. The results described the central role of the integrating module, the design of its two interfaces as well as the constant module optimization. Depiction 23 illustrates these elements. In a performance-oriented system the single resources of the system are visible and often also available to users and competitors alike, but their performance information, e.g. the absolute system capacity and the single component capacity, is only visible to the providing firm. Additionally, the examined systems not only comprise a variety of complements on the upward side of the value chain but also an abundant number of single users on the downward side. Their individual demand, ideas and experiences are also sourced as hidden information and incorporated in the system. The resources as well as the users are connected with a central integrating module through visible complement- and user-interfaces which are governed by the firm. The central mission of the internal integrating module is to secure a high utilization rate during operational phase, i.e. balance the total system capacity with the demand from the users as well as the internal balance of system components. The extent of processing experience determines the efficiency of the system and ultimately the firms profit.

Thus, the governance of the integrating module secures three types of hidden information, the performance, the user demand and the efficiency information. The constant collection and evaluation of this hidden information generates valuable knowledge regarding the resolution of the identified bottleneck on an operational level. The integrating module serves as a 'filter' or 'gatekeeper', e.g. an external complement provider has no direct access to information about the user demand or the other complements performance. The filter impedes competition at the bottleneck of the value chain. Hence, the integrating module and its interfaces protect the value that has been created through the integration of the industry bottleneck during system composition. The innovation activities of the examined case examples for value appropriation comprise the characteristics of dominantly modular innovations and to a certain extent also architectural innovations, e.g. the outsourcing of complements.



Depiction 23: Simplified Structure of Performance-oriented Systems

5.4 Contextual Factors for System Development

In the following chapter the study briefly discusses three initial contextual characteristics of performance-oriented systems regarding the organizational flexibility, the industry structure as well as the legislative environment.

The first aspect concerns the organizational flexibility. The majority of the examined case examples emphasized the firm size as being influential to the development of the performance-oriented system. Exemplary, 'ICT 2' compares the structures of his previous incumbent employer with the current system providing firm: "*The size of company has also a big impact, the previous company is very big and the line of command is big, but here it is the opposite and so the procedures here are flexible. The specifications for example do not have to be written in detail before they are sent to the next level. In a small company we can pass down the control quite easily and we know at which level something can be specified and how much can be delegated to the developer or whether it should be designed at a more senior level. So in a big company these procedures are more structured.*"Obviously, 'ICT 2' is an entrepreneurial firm. The quote reflects on the advantages of flexible organizational structures inherent in a small firm, which are not specific to performance-oriented systems. This insight is also shared by other entrepreneurial informants across all industries, e.g. 'Chemical 5' describes the circumstances of their innovation activities as: "*We are trying these things. We are running a small business; the big constraint is time to do these things. We do have budget and our cash flow and we bill into things we would like to do over the following 12 months [...] but it's not really as detailed as you get in some big multinational companies because we are not big enough to do that. But the small company has advantages: that we can adapt very quickly to changes in circumstances which big companies can't do.*" The former two quotes indicate the advantage of flexible organizational structures to adapt quickly to changing environments. The reason for this advantage lies within the novelty of performance-oriented systems in the examined industries. The prior knowledge base on how to implement such a system in the respective industry was scarce, if existent at all. As previously described, the firms implemented a discovery-based, user-driven innovation behavior to quickly develop a relevant knowledge base. Additionally, the precedent findings have emphasized the role of hidden modular knowledge. Thus, the more flexible the organizational structure, the faster the firm can implement changes and secure an advantage. The organizational structure therefore determines the ability of the firm to constantly adapt their system structure according to the generated information. This advantage, that is inherent in entrepreneurial firms, has also been detected by incumbent firms, who attempt to copy their structures. Exemplary, incumbent firm 'Energy 1' asserts that: *"[Product company name] established [system name] as a new business unit particularly for this model."* The data indicates that the incumbent firms of the data-set organized the activities regarding their performance-oriented system at least in a novel, independent divisional unit to ensure flexibility. Others implemented a legally independent firm to duplicate the entrepreneurs. 'Mobility 5' with a heritage from an incumbent firm describes the advantages of this variant: *"First of all, a strong support from the mother company is needed. As I said, you need a clear commitment. Secondly, it is a start-up company. I don't know if you have seen any start-up companies so far. You need to develop some specific management capabilities for this specific situation also as a company. I think you need enthusiasm, which is also extremely important. Also, you need to be flexible. You need to develop new solutions."* The founding of a legally independent unit has been the preferred mode of the incumbent firms within the examined cases.

To summarize, the results from the examined cases suggest that the majority of firms, independent of their background, strived for flexible organizational structures through the founding of an independent entrepreneurial firm or at least a divisional unit. The flexible structures support the constant iterative adaption of the respective system. This leads to the ninth finding:

> **Finding 9: The implementing firms create an independent organizational structure to facilitate the continuous adaption of the performance-oriented system.**

The second contextual factor concerns the industry structure. The four examined industries, i.e. mobility, energy, chemical and ICT industries, are all established industries that are characterized by a comparatively high competition in the value chain and high market saturation. Exemplary, 'Energy 5' describes the recent development and situation in his industry: *"If you look at the value chain of the industry, somebody provides ingots which then turn into wafers, which then turn into cells, which is then collected and turned into a module. And from there it is sold to the integrator who then installs the system and is operated probably by the same integrator for 20-30 years. The problem is that every step in the value chain, people were expecting twenty or thirty percent gross margin. [...] So, what happened is, as incentives decline, it forces the* *conversation to 'Ok, we've got a decline of incentives. So not everybody can get twenty to thirty percent gross margin as supposed to'. So you ended up aggregating the value chain, you don't just supply cell to somebody or you don't just supply wafers to somebody. [...] You buy everybody else out. You completely collapse inside the value chain, so you consolidate the industry. If you look at what [parental company name] has done or [competitor name] has done or all these guys have done, they have bought up all the other vendors in space that they can so they're delivering not just modules or not just cells but they're delivering everything, all the way from the raw ingots to the delivered panels.'*'The quote clearly describes the situation of a mature industry with declining incentives due to saturated markets. The illustrated industry characteristics provide an additional reason for the examined firms to integrate two further steps downward and control the complete value chain. Across all industries, the informants indicate that the competition and market saturation amplified the implementation of performance-oriented systems.

A complementing aspect of the industry structure concerns the impact and role of performance-oriented systems in comparison to existing alternatives in the industry. 'Energy 5' gives his view on the future role of his system in the industry: *I' think the future for electricity generation is going to be highly fragmented.'*The former evaluation indicates that performance-oriented system are not a dominant model that will displace the existing offerings but that it is rather a complementary system or a sub-system in the industry. This view is also shared by informants from other industries, e.g. 'Mobility 8': *I' mean this is really difficult to answer, because it will not be in the future that you have a complete change from a traditional form, let's say, current behavior and scheme, to a completely new scheme, [...]'*'The coexistence of multiple, complementary offerings in the respective industry is often emphasized. Exemplary, 'Mobility 9' assesses the future development in the following statement: *S'o that is maximizing decentralization, so I believe we are going to see. The future of car-sharing we are going to see a lot more solutions and services where you just access with your smart phone, use the car next to you and you have a solution.''*Albeit the research has highlighted the advantages of performance-oriented systems in the previous chapters, the majority of informants assert that their system's role in the industry is rather complementary than dominant. A combination with the previous aspect about the industry phase of saturation suggests that performance-oriented systems are targeted at a remaining or newly emerging user group within the industry that is not reached by existing offerings.

The third aspect of the industry structure concerns the environmental legislations in the examined industries. Albeit the levels of environmental legislations are hardly comparable in the four industries, the data suggest that their existence facilitates the acceptance of performance-oriented systems, especially in the chemical and energy industry. Exemplary, 'Chemical 1' describes the early days of the market diffusion phase in the following: *"Probably the thing that got it going in the first place was probably its environmental benefit in the North Sea because the regulation on environment became increasingly strict. And that helped us to get going."* Several informants mentioned the influence of environmental legislation supporting the acceptance of performance-oriented systems in the industry to a certain extent, e.g. 'Mobility 8' who explains: *"And the second area where we use it, is rather smaller cities where we have a green consciousness, you know, [...] which are now led by a green party, and they of course have then some taxation advantages for vehicles or even for people that change their transportation and mobility behavior in the future, which might be a trigger [...]."* On an aggregate level, strict environmental legislations prefer performance-oriented systems due to the inherent change in the incentive regime towards resource efficiency discussed in the previous section. The former three aspects regarding the industry structure lead to the tenth finding:

> **Finding 10: An industry phase of saturation as well as environmental legislations facilitate the installation of performance-oriented systems as a complementary offering in the industry.**

5.5. Derivation of a Framework for System Development

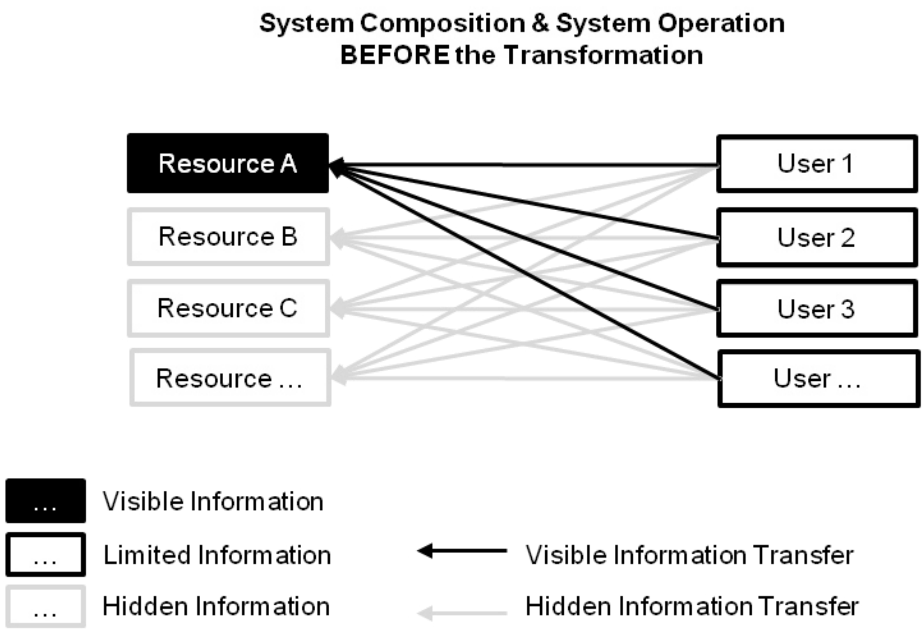
The findings in the previous chapters suggest that the examined firms operate in mature industries characterized by a high saturation of market demand and competition. Additionally, the products and services in these industries deliver the final value or performance not on their own but in concurrence with other components. The findings indicate that the case examples of this study detected first and foremost a transformation in the economic environment of the firm. The change concerns an emerging set of novel user preferences regarding an increased elasticity of necessary resource deployment, e.g. capital, time, know-how. The users prefer a delivery of the integrated component's performance on flexible conditions rather than being obliged to compose and operate a complex individual system themselves. This applies especially to products or services with a low involvement, i.e. those that are contextual to the business or the personal lifestyle of the user. These novel preferences prohibit an advance in market saturation or a successful differentiation to competitors through conventional offerings. Hence, the productivity of the industry is limited at the lower end of the value chain. The reluctance of an emerging user group to acquire conventional products or services due to the associated deployment of significant resource forms a bottleneck downstream in the value chain of the respective industry. The bottleneck location is based in the use phase including the value steps of system composition and operation. The hitherto described characteristics motivated the development of the examined performance-oriented systems.

The difference of performance-oriented systems in comparison to a conventional product sale is the downward integration along the value chain into the use phase by the innovating firm. The result is a redefinition of the firm's boundary towards providing the performance of several joint resources instead of selling single complements. In comparison to a conventional service offering, which is often system-based as well, the case examples provide the benefit of a higher elasticity of resource deployment as they are optimized towards performance. The data suggests that the examined performance-oriented systems are located on the maximum right end of the elasticity scale within the industry spectrum opposed to a pure product sale on the minimum end. It is a distinct position in relation to other existing system-based offerings, which incorporate hybrid characteristics. The consistent performance-orientation requires an adaption of the prior service-firm boundary as well. The entrepreneurial firms within this research initially defined their organizational boundary through the implementation of a performance-oriented system with no prior dependencies in the industry.

Thus, for all firm types, the identified concordant alteration of the firm boundary comprises the characteristics of an architectural innovation with the objective of value creation through value step integration. Performance-oriented systems explicitly meet the identified user demand as they integrate the composition and operational management of several complementary components within their firm boundary. Hence, the described architectural innovation comprises the integration and resolution of the industry's bottleneck within the realm of the firm. A complementary aspect of value creation concerns the constant (re)configuration of essential system modules and components during the development phase. This co-specialization is dependent on the firm's prior position and internal knowledge base. Necessary external complements are acquired or developed internally and therefore comprise the characteristics of modular innovations. The hitherto described innovation types for system composition and operation are developed by the majority of the examined firms in a flexible organizational unit.

The examined systems not only comprise a variety of complements on the upward side of the value chain but also an abundant number of single users on the downward side. The single physical components of the respective system are visible to third party, whereas the individual users are often not visible. This complexity of the systems requests a central operational management to secure value appropriation. Hence, the system resources as well as the users are connected with a central integrating module through visible complement- and user-interfaces which are both governed by the firm. The individual demand of the users, their ideas and experiences are sourced as hidden information and incorporated into the knowledge base of the system through the user-interface. The enduring user integration allows for an iterative discovery-based innovation behavior resulting in a higher innovation rate and speed. The complement-interface transfers data regarding the system and component performance into the knowledge base. This monitoring information is also exclusively visible to the providing firm. The central mission of the internal integrating module is to secure a high utilization rate during operational phase, i.e. balance the total system capacity with the demand from the users as well as the internal balance of the single system components. The extent of processing experience determines the efficiency of the system and ultimately the firm’s profit. Thus, the governance of the integrating module secures three types of hidden information, the capacity, the user demand and the efficiency information. The constant collection and evaluation of this hidden information generates valuable knowledge regarding the resolution of the incorporated bottleneck on an operational level. The amount of knowledge that has been built in the integrating module determines the firm's advantage regarding the resource efficiency of the system. This efficiency-based advantage impedes competition at the bottleneck of the value chain. Hence, the integrating module and its interfaces protect the value that has been created through the integration of the industry bottleneck during system composition. This is the reason why the firms internalize the integrating module and the related services. The physical assets of the system are rather contextual for value protection, but they bind the majority of the firm's financial resources. The data suggest that the firms therefore externalize them during the course of system evolution, at least to their parental firm.

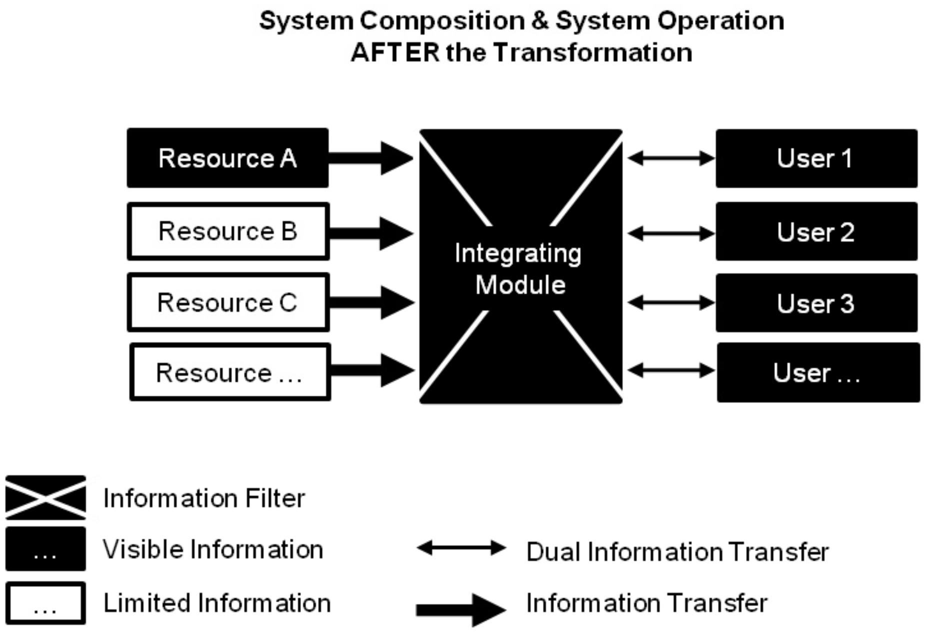
A central characteristic that coined the notion of performance-oriented systems and lead to its distinct position on the elasticity scale concerns the inherent change in the incentive regime. The development of the system and its components is oriented towards higher resource efficiency rather than decreased product lifetimes. The data indicates that the examined firms have identified several possibilities to increase the resource efficiency that are coherent with the established concepts of economies of scale and scope. Resource efficiency is often linked to environmental advantages. The research suggests that ecological benefits influence the firm's intrinsic decision for development only to a limited extent. The firms put an emphasis on environmental advantages during the market diffusion phase when correspondent user preferences are existent. Additionally, some industries within the sample comprise environmental legislations that foster the implementation of performance-oriented systems due to its specific characteristics. Overall, economic reasons dominated the environmental aspects as a motivation for the development of the examined systems.



Depiction 24: Industry Structure before Transformation

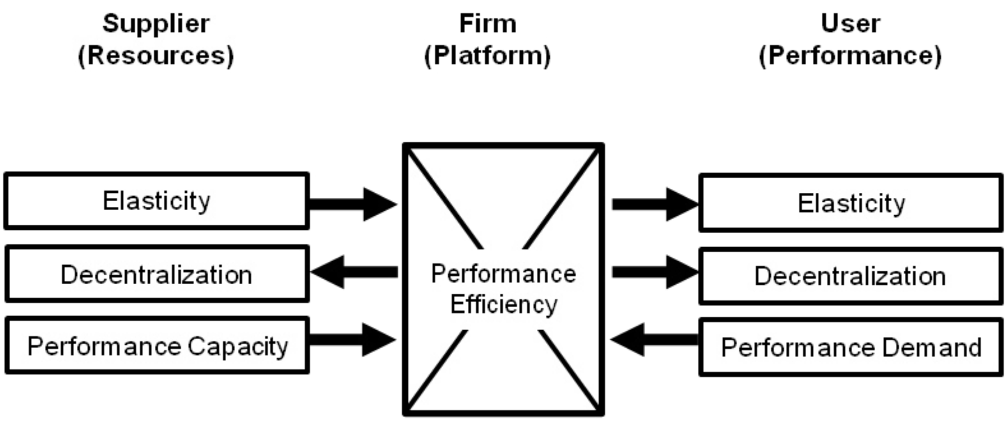
The following depictions 24, 25 and 26 visualize the change of the firm's position within the respective industry through the implementation of performance-oriented systems. Depiction 24 illustrates the industry structure before the transformation. The users have to compose and operate their individual system based on several unrelated conventional offerings, e.g. product sale. The conventional offering is characterized by an occasional relationship between user and firm where component and capital are exchanged in sporadic intervals. In the mobility industry for example, the user is obliged to purchase the vehicle, insurance, fuel, maintenance, cleaning service etc. from different firms and ‘produce’ mobility by himself. This leads to a complex pattern of relationships between users and firms in the industry. All firms that contribute a complement to the individual system have an equal position. They have no system information available apart from that on their own component.

In contrast, a firm that implements a performance-oriented system integrates several complements and offers their performance through a dedicated module. The firm fosters enduring user collaboration in providing a specified performance on flexible conditions in exchange for capital and feedback for system improvement. The single system components and their contributing firms resemble those of the individual system. The firm that implements the system gains an advantage through its forward position in comparison to the formerly equal competitors or complementors. The governance of the integrating module including the two interfaces allows the aggregation of information about all other component capacities, the user demand as well as their interdependencies. The creation and protection of this valuable information leads to a sustained superior position within the industry (cp. depiction 25).



Depiction 25: Industry Structure after Transformation

To summarize, the core concepts of performance-oriented systems are elasticity, decentralization, capacity and demand, as well as efficiency. First, the implementation of a performance-oriented system provides the user a higher elasticity of resource deployment for using the system components. The firm has to deploy the necessary resources instead. In a later stage of the system evolution, when the offering firm outsources the physical component resources, the inelasticity is shifted further upward to the component suppliers. The second concept concerns the decentralization within performance-oriented systems. On the user side, the (geographical) availability of the system is decentralized over time and more and more related user groups are included. On the system resource side, additional complements as well as different sources for each component are constantly included. Third, the constant collection and evaluation of each component's capacity as well as the user's demand forms a central task for the offering firm. The amount of information equals the experience or knowledge of the firm in operating the system. The firm's processing knowledge on the system efficiency defines its economic success, i.e. the higher the capacity utilization rate the better the profit. Depiction 26 illustrates the portrayed core concepts.



Depiction 26: Core Concepts of Performance-oriented Systems

The higher the advantage of elasticity for the user, the higher the degree of decentralization in sourcing and provisioning and the higher the knowledge on capacity, demand and efficiency, the more profound the competitive advantage of the performance-oriented system in the industry. In comparison, the supplier(s) is in a comparable weak strategic position. The supplier comprises limited elasticity, he is put under competitive pressure through increasing competition, the detailed information on his components is constantly transferred to the platform and he has no direct end-user demand information.

6. Discussion of the Results[10]

In the previous section the study has portrayed the motivation of firms to implement performance-oriented systems and highlighted the specific characteristics of their development. Subsequently, the findings were summarized into a comprehensive framework. In the following, the results are discussed with regard to the existing theory. The chapter is structured into a discussion of the results with regard to the established strategic management theories (cp. chapter three) in chapter 6.1 and with the existing scientific research on the phenomenon of performance-oriented systems (cp. chapter two) in chapter 6.2. Each section recapitulates the key aspects from the existing theoretical conversations to facilitate the understanding and readability of the chapter. Based on this discussion the study derives in chapter 6.3 nine propositions that determine the enabling context of performance-oriented systems. The last section of this chapter summarizes the central aspects of the discussion. Hence, the study discusses the main research question in the following chapter: In what context are performance-oriented systems a viable strategy of a firm to gain competitive advantage?

6.1 Discussion against prior Strategic Innovation Management Research

The hitherto described framework briefly summarizes the motivation of firms to implement performance-oriented systems and highlights the specific characteristics of their development. The motivation for and the differences in the development are concordant with the basic questions of 'why' and 'how' in qualitative research as highlighted in the research approach (cp. chapter 4.2). Additionally, the research attempts to close the identified research gap in chapter 4.1 and explain the recent emphasis on performance-oriented systems from a strategic innovation management

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[10] The discussion section regularly references back to the research findings in chapter 5. The full findings will neither be repeated within the text nor the footnote to enhance the readability of the chapter. A concise summary of the research findings can be found in the appendix for consultation.

perspective in greater detail. Thus, the section discusses whether the observed phenomenon comprises the characteristics of a strategy.

In the following, the findings are discussed with regard to the strategic innovation management theories presented in chapter three. The subsequent section mirrors the structure of chapter three as it is framed into the tree segments of general strategic management (chapter 6.1.1), the dynamic capabilities theory (chapter 6.1.2) and the strategic use of architectural knowledge (chapter 6.1.3). The central aspects are summarized in chapter 6.1.4.

6.1.1 Strategic Management and Dynamic Capabilities

To recapitulate, modern strategic management concepts constantly refined the two-step approach of an analysis of the firm`s environment (external factors) and the adaption of the firm (internal factors) for value creation and value appropriation [Eschenbach et al., 2008]. Early concepts, e.g. [Ansoff, 1969], put an equal emphasis on the internal and external factors but remain on a static level. Subsequent frameworks concentrated on the relevance of the external factors, e.g. [Porter, 1980], or the internal factors, e.g. [Barney, 1991] and increasingly considered dynamic market environments into their concepts, e.g. [Porter, 1996] or [Teece and Pisano, 1994]. The underlying research approach from these authors is the conversion from a theoretical or conceptual towards an applied level.

The findings within this work revealed that the examined firms executed an analysis of their environment as well as an adaption of the firm. The results of the analysis are changing user preferences indicating that the firms operate in a dynamic environment. Regarding the claims within [Porter, 1996], the implementation of a performance-oriented system results in a dedicated position on the right side of the elasticity scale within the industry spectrum opposed to a pure product sale. The further findings indicate that the examined firms align their activities to fit the performance-orientation and thus deepen the selected scope, e.g. concentration on platform, outsourcing of complements, and development of processing knowledge. The illustrated transformation into the use phase clearly differentiates the implementing firms from their competitors. Performance-oriented systems are a complementary offering within the respective industry focused on a novel emerging user group (cp. finding one and finding ten). The former two aspects are compliant with the characteristics of a focus strategy based on differentiation. Finding eight revealed a change in the incentive regime towards increased resource efficiency rather than decreased product lifetimes. Hence, this finding describes a distinct trade-off. The identified conflicting activities between performance-oriented systems and conventional offerings are requested by the author as prerequisite for a sustainable position. Albeit the results of the research reflect the basic characteristics of the established concepts, the high aggregation levels of these conceptions impede a detailed strategic assessment of the phenomenon. Additionally, the underlying research approach within this work comprises the reverse order from an applied to a conceptual level. To summarize, the findings are coherent with these concepts on an aggregate level and contribute, at least to a certain extent, to their understanding on a more granular level.

A central framework in strategic innovation management research is the theory of dynamic capabilities [Teece and Pisano, 1994; Teece et al., 1997; Eisenhardt and Martin, 2000]. It highlights the importance of new opportunity identification and efficient organization for economic firm success rather than concentrating solely on external competitive forces. Thus, the dynamic capabilities of a firm are interpreted as a constant analysis of the changing environment and the coordinated response to attain and sustain value. It is foremost a behavioral orientation embedded in processes that is in constant pursuit of reconfiguration [Wang and Ahmed, 2007]. The constant adaption incorporates the firm`s resources, i.e. the physical assets, and its intangible competences, i.e. the ability to deploy resources to attain a goal. The theory of dynamic capabilities is an aggregated multidimensional construct. The operationalization of the single dimensions as well as their interrelations remains one of the weaknesses and requests further research [Barreto, 2010]. Some studies in the past circumnavigated this disadvantage by using qualitative case studies, e.g. [Galunic and Eisenhardt, 2001].

The results in the previous chapter portray the opportunity identification in the changing environment and the examined firms' response for value creation and value protection in greater detail. The findings are explicitly structured into the three steps: bottleneck identification, bottleneck integration and bottleneck resolution. A concordant interpretation of the findings into the core categories of the dynamic capability theory, sensing opportunities, seizing opportunities and reconfiguration of the resource base, is feasible. The bottleneck identification equals the notion of 'sensing opportunities'. The bottleneck integration, i.e. the incorporation of the value steps 'system composition' and 'system operation', within the firm boundary are coherent with the category of seizing, i.e. solving the problem of changing user preferences. The iterative innovation behavior as well as the concordant adaption of the system resources illustrates the constant pursuit of reconfiguration within the firms to resolve the bottleneck. The inherent change in the incentive regime towards resource efficiency, summarized in finding eight, emphasized the role of processing knowledge within performance-oriented systems. The orientation of the firm towards an efficient organization is also assumed by the dynamic capability theory. Additionally, the finding underscores the role of knowledge and competences to build a competitive advantage rather than the ownership of physical assets.

The results within this research are derived from a dataset containing three positions, i.e. product- and service-based incumbents as well as entrepreneurial firms. The existence of a path dependency within the firms is supported especially by two findings. First, finding four summarized the transfer of existing resources from prior business into the newly established organizational unit. Second, finding seven indicated that the outsourcing of system components in the course of system development is affected by the firm's prior position as well. Thus, all examined firms have taken different paths during the implementation of their performance-oriented system depending on their respective position. Additionally, finding four illustrated the incorporation of missing system resources through the acquisition of external complements, i.e. integration, or internal development of competences, i.e. learning. Hence, a co-specialization of essential complements has been executed during the development of performance-oriented systems. To summarize, the applied findings within this work, derived from a newly emerging phenomenon, reflect on the common elements of the established dynamic capability theory and therefore contribute to its theoretical understanding and validity. Beyond that, the findings provide a comprehensive example how firms construe the abstract dynamic capability in economic praxis. The results do not add any clarity regarding the interrelations between the single constructs, e.g. the effect of the dynamic capability on the firm's performance. The reason lies within the selected qualitative research design and scope which is also used widely by other scholars in this strand of literature.

6.1.2 The Strategic Use of Architectural Knowledge

The theory of dynamic capabilities is closely connected to the strategy of superior architectural knowledge due to their correlating founding literature, e.g. [Henderson and Clark, 1990], [Henderson and Cockburn, 1994]. Recent publications discuss the interrelation between the former two concepts and if the conception of superior architectural knowledge and its strategic use is in fact a dynamic capability of a firm, e.g. [Pisano and Teece, 2007]. Despite some differing aspects, e.g. the evolution of co-specialization based on multilateral dependencies in complex systems [Jacobides et al., 2006], the discussion is still in progress. The strategy of superior architectural knowledge is a comparatively narrow concept with a heritage in the computer industry and is based on insights from simple technological products which have been recently up-scaled as concept for industry analysis and firm adaption [Baldwin, 2010; Baldwin and Clark, 1997]. Prior research already showed the strong connection between the architecture of the industry and the architecture of the respective technology or product [Henderson and Clark, 1990; Christensen, 1997]. [Baldwin, 2010] defines architectural knowledge as “knowledge about the components of a complex system and how they are related”, whereas “industry architectures characterize the nature and degree of specialization of industry players (or 'organizational boundaries') and the structure of the relationships between those players” [Pisano and Teece, 2007]. The contributing authors propose analyzing the existing technology or established market, dividing the existing system architecture into modules and identifying weaknesses, so called 'bottlenecks'. These bottleneck-modules constrain the performance of the system, e.g. [Ethiraj, 2007]. In pursuing the strategy of concentrating on and supplying superior 'bottleneck'-modules as well as outsourcing non-crucial modules, an (entrepreneurial) firm may gain a competitive advantage [Baldwin, 2010]. In contrast, an established firm that seeks to exercise this strategy is constrained by its current position in the system which often diverges with the bottleneck location. The re-composition of the offering, modular diversification or co-specialization as well as the promotion of competition within complement modules are feasible instruments for incumbents to alter the industry architecture and relocate the bottleneck within the realm of the firm for value creation. Subsequent modular innovations of the bottleneck are a natural barrier for value appropriation that supplements external legal mechanisms [Jacobides et al., 2006] [Merges, 2004].

The results of the research portray a modular analysis of the resources within twenty-seven system examples in four industries. As the results have already been presented in detail with the help of the vocabulary of the strategy of superior architectural knowledge, a repetition of the findings would not enhance their understanding at this stage. Hence, the study forbears in presenting another iteration. Generally, the conception is regarded to be well suited for a comparison and abstraction of diverse case examples from different industries. The particular findings describe step-by-step the identification of the bottleneck in the firm environment, its integration within the realm of the firm as well as the methodic reduction of slack in the systems components to increase the efficiency. Obviously, the results support the connection between the technological and the industry structure that has been found in previous studies, e.g. [Henderson and Clark, 1990; Christensen, 1997]. Merely the definition of the bottleneck implies certain conceptual limitations. First, existing contributions are based on two divergent definitions, which may only be united on an abstract level as chapter 3.3 has illustrated. Second, the location of the bottleneck can only be investigated indirectly in applied research as it is a highly theoretical construct.

Regarding the aspect of system re-composition, it becomes apparent that the implementing firms initially integrate complementing resources on the same level in the value chain as well as modules that are located downward along the value chain (cp. finding three and four). This rearrangement in the architecture is based on the insight that the examined products within the conventional offerings do not deliver value on their own, but are dependent on other products and services. This is in line with [Jacobides et al., 2006] who asserts that a firm can *“'envelop' its sector by connecting to a broader 'bundle' of services and products that would leverage its own strengths while muting those of its competitors”* During the course of system development, the offering firm outsources the complement modules on the same level and concentrates on the steps of system composition and operation. This aspect supports the mathematical derivation of [Baldwin, 2010] who concludes that a focus on delivering a superior bottleneck module, e.g. the integrating module, results in a higher return on invested capital (ROIC). The findings suggest that the examined firms further strived for a decentralization of the sourcing, i.e. the interaction with several suppliers on each system resource, as well as an integration of additional complement resources to expand the scope of the offering. The portrayed constant adaption of the system architecture comprises the characteristics of the theoretically postulated concepts of architectural redesign, co-specialization, modular diversification and the promotion of competition within complements. Hence, the outcomes vividly illustrate the theoretically identified possibilities of a firm to change its position in the industry for value creation and value appropriation.

Another relevant aspect concerns the central role of the platform for the system examples within this work, which has been accentuated in other, related research as well, e.g. [Gawer and Cusumano, 2002]. For example, [Baldwin and Woodard, 2009] divide 'platform systems' in their unified perspective in three parts: *"(1) the complements, which exhibit high variety and high rates of change over time; (2) the core components, which remain stable as the complements change; and (3) the interfaces, which are the design rules that allow the core and the complement to operate as one system."* The latter two elements are stable components that are incorporated into the core-platform, whereas the firm constantly experiments with the former to create additional value. The authors suggest that solely the interfaces are essential to control the system. This unified platform perspective is also reflected by the findings within chapter five and, thus, is applicable to a certain extent. Nevertheless, in contrast to the unified view, the findings within this work accentuate the role of the integrating module as a database and information filter. To the author's understanding, the interfaces and the platform must be governed by the firm to secure an advantage. Thus, this aspect has to be addressed specifically in future research. The role of the interfaces has especially been described in finding six. The positive influence of a close firm-user-relationship on innovation rate and speed has also been found in [Shapiro and Varian, 1998] who detected that these so-called 'network externalities' *"can propel the platform to competitive success"* [cited from Baldwin and Woodard, 2009]. To summarize, the illustration of commonalities within the twenty-seven case examples validates and enhances the understanding of the theoretical concept of architectural knowledge and its further use for managerial praxis in the examined as well as other industries. The focus of the research and, hence, the major contribution has been on technological sub-systems in the industries that are situated below industry dominant systems but above firm-internal product-systems.

The hitherto described, coherent interpretation of the findings with the dynamic capabilities theory as well as the compliance with the strategy of superior architectural knowledge supports their interdependency. The examined firms have developed an architectural innovation to create value with subsequent modular innovations to protect the created value. The emphasis of their innovation activity resides on the integrating module that is located at the bottleneck of the industry and its role as a knowledge base and information filter. Ultimately, the knowledge and competences of a firm to resolve the bottleneck, i.e. the hidden processing knowledge kept within the module, determines the competitive advantage of the system. This aspect illustrates the interrelations between the knowledge-oriented or competence-based analysis within the dynamic capability concept and the technology-oriented analysis within the theory of superior architectural knowledge. The detailed quotes given within the findings section reflect this aspect on a more granular level. Especially in quotes leading to finding four and finding five, the informants constantly switched between describing the tangible technological components and the related intangible knowledge when talking about the same system resources. This circumstance indicates that the knowledge and competence structure in a firm is closely connected to the technology structure which ultimately defines the industry configuration. Thus, a firm may well create a competitive advantage through unique knowledge and competences as proposed by the dynamic capabilities theory; especially, if the knowledge is suitable to resolve the bottleneck in the industry. The technological architecture of the system, and particular the bottleneck-module, provides the tangible frame to generate and secure this information. A modular analysis of the system or industry technology therefore forms a reliable starting position for strategic decisions, as the analysis of the tangible technology architecture is more practicable than the assessment of intangible knowledge and both comprise the same structure on different levels. Hence, the results indicate that the examined firms demonstrated their dynamic capability during the system implementation through a strategic use of their architectural knowledge of the industry. The research within in this work underscores the assumption that the strategic use of architectural knowledge is one possible approach to translate the abstract dynamic capability of a firm into a sustained competitive advantage [cp. Pisano and Teece, 2007]. The strategic use of architectural knowledge provides an applied receipt to convert the theoretical construct of dynamic capabilities into economic praxis.

The vertical interdependency between knowledge, technology and industry level appears to be a promising field of future research as their relation not only suggests a connection between the dynamic capabilities theory with an heritage in the evolutionary economics and the strategic use of architectural knowledge from the engineering sciences, but also provides an initial point of contact between the latter concept and the competitive advantage theory, which has an industrial economics origin. In this context, the use of superior architectural knowledge might also serve as a complementary method to analyze the opportunities within an industry at a comparatively simple technological level. The conception provides a simple to execute starting point for management, which can subsequently be broadened by including detailed industry characteristics, e.g. the number of firms in each step of the value chain, or core competences, e.g. non-imitable capabilities of each firm in each step. The result would be an extensive industry map that far exceeds the analysis of the basic five forces. This interdependency has not been discussed to date, despite the strong evidence between technology and industry structure. Hence, the study suggests vertical research regarding the interdependencies between the tree levels knowledge, technology and industry, the sequence of the analyses, as well as their different impact on the firm's innovation behavior as an interesting field of future research.

6.1.3 Closing of the Strategic Innovation Management Discussion

To summarize, the findings are coherent with the conceptual strategy of superior architectural knowledge for entrepreneurial firms. The results also reflect on the theory of dynamic capabilities as a constant mode of opportunity identification and pursuit of reconfiguration as discussed in the previous section. The research even broadens the juvenile insights from the former concept through the implementation of incumbent firms and qualifies it through evidence from twenty-seven applied examples and the connection with the established latter theory. Thus, based on the findings, the study concludes that the implementation of a performance-oriented system is an explicit strategy of a firm to obtain and sustain value, as their analyzed development comprises the central characteristics of the strategy of superior architectural knowledge, the dynamic capabilities theory as well as the core elements of general strategic management research to a certain extent.

6.2. Discussion against prior Phenomenological Research

So far, the study has illustrated the strategic perspective of performance-oriented systems against the background of existing strategic innovation management concepts. The following chapter discusses the derived findings with regard to the different areas of expertise that have previously acknowledged the phenomenon under different notions as well as the related environmental aspects. The purpose of this chapter is the integration of the findings into a larger theoretical perspective.

6.2.1. Discussion of Existing Research on Phenomenon

To recapitulate, the concept of 'product-service-systems', e.g. [Goedkoop, 1999], [Mont, 2002], [Manzini and Vezzoli, 2003], and its related notions ('product utility services', e.g. [White et al., 1999]; 'product of service', e.g. [McDonough and Braungart, 2009]; 'industrial product-service-systems', e.g. [Meier et al., 2010]; 'hybrid products', e.g. [Berkovich et al., 2009] put an emphasis on the operational level, analyzing specifically the different components of the system and their contribution to the value proposition. The research in this field highlights the importance of ecological benefits of the systemic approach, e.g. [Manzini et al., 2001]. Unfortunately, the concepts fall short of a common understanding what phenomenon the terms should embrace and which to exclude, e.g. [Tukker, 2004] vs. [Zaring et al., 2001], thus limiting the coherence of findings. Nevertheless, this strand of literature provides initial evidence that the detected phenomenon is a well defined sub-system within the respective industry with full life-cycle responsibility of the operating firm for the included components [Brezet et al., 2001]. These components may be physical and/ or non-physical [Tietze et al., 2011], with a central service component [Kowalkowski, 2010]. The last aspect specifies the need for a reconfiguration of the firm`s business model. Existing reviews in this research area conclude that the literature base is still shallow and further research needed [Baines et al., 2007].

The results within this work first and foremost contribute a strategic innovation management perspective to the scientific literature on product-service-systems and its closely related notions which has been absent prior to that. The executed abstraction and aggregation of resources towards components, modules and the system level facilitates the analysis and comparison of different case examples in and across industries. This perspective is opposed to the detailed distinction and description of the single components in one specific system and their individual contribution to value creation that characterizes the research on product-service-systems. The findings rather indicate that the system as a whole, i.e. the architectural innovation, creates the desired value. Additionally, the delivered value originates from the two value-steps 'system composition' and 'system operation'; a differentiation that has been overlooked to date.

The results of this work suggest that the system development of the examined cases is driven by a general performance-orientation rather than a focus on a single service component (cp. finding three and eight). Albeit the author admits that the final performance is delivered through a central service to the user, as also stated by [Vargo and Lush, 2008], the service element is heavily dependent on other system resources for value creation. Moreover, the detailed characteristics of the central service and other product elements within the examined systems vary, especially across industries. To the author's understanding, an in-depth segregation of each element of a system, as executed by the scholars of product-service-systems, does not provide any valuable insights that can be transferred to other beyond the respective case. The abstraction and standardization of system components compiled in this work permits for the first time a substantial transferability of the results.

The analysis of this work further contributes to the body of literature through incorporating the important aspect of value protection within its scope that has been neglected in prior contributions on product-service-systems. The findings indicate that the integrating module or platform respectively, plays a central role in these system offerings, especially for value protection (cp. finding five). The mission of the integrating module is the development of processing knowledge. On an operational level this aspect emphasizes the role of constant process innovations for value protection. The level of processing experience determines the efficiency of the system and thus the system rents. This hidden information can and must be protected by the firm as it forms the core of their competitive advantage. The importance of process innovations to capitalize on and protect the created value of performance-oriented systems sheds new light on the phenomenon and adds a new aspect to this strand of literature. Last, the research provides a novel attempt to differentiate performance-oriented system in relation to other existing offerings in the industry. To the author's knowledge, the distinction by the elasticity of resource deployment has not been used in this strand of literature.

A second area of expertise, the computational sciences, precisely recognized the detected phenomenon within their emerging research on 'cloud computing' and 'software-as-a-service' while not providing universal evidence for all cases included in this work. The contributing authors attempt to characterize the physical and non-physical resources of the systems as precise as possible without consensus, ranging from technology-oriented, e.g. [Buyya et al., 2009], [Wang et al., 2010], towards more economic-driven definitions, e.g. [Takai, 2012], [Marston et al., 2011]. This strand of literature is confronted with similar problems regarding a clear definition of system components and system boundary. The detected phenomenon is more than a simple product bundle or an in-house development strategy but less than an industrial platform or standard [Cusumano, 2010a; Cusumano and Gawer, 2002]. Commonly, the authors emphasize the role of a platform for interconnecting the single components and providing a central utility-like service. The business model is altered towards an on-demand, self-service model that is independent of device or location. The dominant service is remunerated as an operational expense requiring any initial capital investments. Last, the systemic approach allows elasticity and a lower risk in resource provisioning [Armbrust et al., 2010]. Cloud Computing also allows for green computing [Marston et al., 2011].

Regarding the research on cloud computing and software-as-a-service, the research also contributes a strategic perspective on an aggregate level. Additionally, the results of this study emerged from four industries and thus reduced a potential industry bias. Furthermore, the findings indicate that performance-oriented systems are a sub-system in the respective industry that complements existent offerings. In contrast, [Cusumano, 2010a; Cusumano and Gawer, 2002] with a heritage in strategic management research neglect the strategic perspective of the examined systems explicitly because of their lack of industry dominance. This is quite remarkable, because other aspects, e.g. the importance of the central platform to govern the system, are also reflected in their research. It is not quite clear at this stage where the absolute boundary between industry dominance and sub-system is located and what are the consequences or differences in strategy on each side of the boundary. To the author's understanding, a new offering in the market is rarely dominating the industry from day one, but rather gaining momentum gradually over time, if appreciated by the users. The restriction of strategic analyses to systems that already dominate the industry leaves the question unsolved, how the firms can reach this adorable position with reasonable resource deployment. Therefore, the novel perspective as a complementary offering in the industry explicitly acknowledges the relevance and role of a distinct strategy during the early phases of system development, no matter whether the system is designed for industry dominance or not. A further contribution of the research concerns the role of the integrating module, or platform respectively, as a carrier for the different types of hidden information. This relation between knowledge and technology, enhances the understanding of the electronic platform components, e.g. software applications, server, GPS, etc., in excess of the technological level. The examination of the interdependencies between these two levels in future research can potentially set new stimuli to technological innovation behavior in knowledge-based industries or societies. The system-inherent higher elasticity and lower risk of resource provisioning that has been found in the computational sciences has also been reflected in the other examined industries. Thus, this concept has the potential to form a future research basis for analyzing other offerings that integrate into the use phase. Last, the adaption of the business model has not been within the scope of this research. It is rather seen as an outcome or operationalization of the constant performance-orientation which is based on the detected changing user demands.

Regarding the other examined social sciences, the service-dominant logic has been used as well to explain the phenomenon in the market diffusion or operational phase. The theory accentuates the importance of the service component in the system offering [Vargo and Lusch, 2008; Kowalkowski, 2010]. An even broader frame is provided by [Belk, 2010] who describes sharing as an economic behavior that comprises mixed characteristics of gift giving and classic commodity exchange. The concept accentuates the benefits of jointly using common resources within a defined boundary. Remarkably, the behavior of sharing has been revitalized with the emergence of the internet.

The precedent sections already discussed the role of the service component in performance-oriented systems extensively. Thus, the study concentrates in this section on the discussion of the results in relation to sharing as a basic economic behavior. The findings support the initial assumption that especially the second type of 'sharing out' with a clear economic intention reflects on the phenomenon within this work. The recent notion of 'shareconomy' [CeBIT, 2013] that inherently merges sharing and economy, is capable to serve as an umbrella term for this research, as it already provides a link to the notions of software-as-a-service and cloud computing. Further, the findings indicate that not only the emergence of the internet, but also the widespread adoption of IT technologies, e.g. wireless metering devices or mobile phones integrating, internet, GPS and software applications, supported the diffusion of performance-oriented systems. These technologies are creating a virtual network effect between the individual users that is reflecting the structure and advantages of the traditional physical commons, e.g. family refrigerator. To clarify this aspect, finding one identified changing user preferences towards less deployment of knowledge, time, and capital. Finding ten revealed that performance-oriented systems are suited for saturated markets as they request less resource deployment by the user. These novel preferences prohibit an advance in market saturation or a successful differentiation to competitors through conventional offerings. Against the backlight of a tense economic situation after the financial debt crisis, it becomes apparent that particularly the acceptance to deploy capital for the ownership of commodities is decreasing. In the mobility industry for example, young urban users are currently oriented towards less materialization and more (online) community. Thus, the acquisition of a car is not high on their priority list, e.g. [Kaufmann, 2010]. The social context becomes more relevant to them than the possession of goods. [Belk, 2010] points out that this human behavior is quite rational, as sharing is the most economic behavior as it is creating community as well as a decent level of materialization. Thus, the integrating module creates a commons that allows for an innovative reactivation of the traditional behavior of sharing when resources are scarce.

This line of argumentation is supported by finding six which illustrates the firm-user-collaboration in performance-oriented systems that is leading to a higher innovation rate and speed. The users of the system communicate their detailed performance demand and suggest system improvements through the user-interface. This valuable information is only partially remunerated directly by the firm, e.g. free minutes of usage in car-sharing, and partially it is a 'gift' by the user. In the latter case, the user benefit is indirect, e.g. a more tailored offering. Hence, the author has to acknowledge also certain elements of 'sharing in' in performance-oriented systems that, as a result, create social bonds between user and firm. To summarize, performance-oriented systems integrate characteristics of gift giving and commodity exchange. The phenomenon reflects the findings by [Belk, 2010] about sharing in general. The hitherto described interpretation based on anthropological studies sheds a novel perspective on the phenomenon, especially on the firm-user-relation and -collaboration. It therefore raises prospective research questions about interface and incentive design in performance-oriented systems. Additionally, this rather evolutionary approach may provide a novel perspective in explaining the non-monetary motivation for other user-driven or collaborative innovations, e.g. open source software communities or open content communities. A recent overview about the open source participation behavior and motivation is given by [Ehls and Herstatt, 2013] and [Krogh et al., 2012], both accentuating the relevance of non-monetary aspects as well.

6.2.2. Discussion of Environmental Benefits

Chapter 2.2 highlighted that all examined notions reflect to a certain extent on potential environmental aspects of the systemic approach. The examined literature review on environmental innovations revealed that it is a fuzzy concept based on relative constructs [Schiederig et al., 2012]. A precise distinction between 'green' and 'non-green' innovations request a thorough analysis of all resources for the complete life-cycle; an extensive task to perform. The ascending complexity of performance-oriented systems in comparison to a single product even deepens the challenge of an accurate impact assessment. Subsequently, the evaluation of ecological benefits implied in a systemic approach comprises the weaknesses of general green innovation research and remains on a conceptual level. The central theme of dematerialization [Baines et al., 2007], i.e. the possibility to decouple economic success from material consumption, is sparsely supported by scientific evidence. The majority of single constructs or effects are based on the insight that economic-driven resource efficiency has ecological side effects [cp. Porter and van der Linde, 1995]. Drawing on prior studies, [Tietze et al., 2011] attempt to structure the identified constructs in system inherent, e.g. [Loose, 2008], and system independent, e.g. [McDonough and Braungart, 2009], ecological benefits. Profound evidence for ecological advantages of performance-oriented systems based on a detailed resource analysis is scarce and further investigation needed [cp. Firnkorn and Müller, 2011].

Regarding the environmental benefits of the phenomenon, finding two indicated that the motivation for a firm to develop a performance-oriented system is primarily economic based, ecological benefits are regarded as a side effect. This finding contrasts the research on product-service-systems for example, which suggest a dominance of ecological benefits, e.g. [Manzini et al., 2001]. Finding eight highlighted the change in the incentive regime towards resource efficiency that is inherent in performance-oriented systems. The higher resource efficiency within the examined systems is based on established concepts of economies of scale and scope. The results of this work are therefore in line with the arguments of [Porter and van der Linde, 1995], which are proposing that an economic driven resource efficiency has also ecological side-effects. There is undeniable a strong relation between the change of the incentive regime and the theme of dematerialization, i.e. decoupling economic success from material consumption. But, as finding ten revealed, the examined systems are a complementary offering in the respective industries rather than a replacing one. For example in the mobility industry, it is questionable whether and to what extent car-sharing replaces existing offerings or whether it is even broadening the use of a vehicle to a wider audience. Thus, the results support the central theme of dematerialization due to the system inherent incentive regime, but only provide qualitative evidence from twenty-seven system examples. A bias in the results might be possible because of the selected industries. For example, the data indicated that the ecological affinity is higher in the energy industry than the IT sector. Profound evidence can only be provided through a large scale, industry wide quantitative resource analysis of all existing alternatives. The last ecological aspect concerns the integration of the firm into the use phase, i.e. the incorporation of system composition and operation. In a conventional offering, the innovating firm is well aware of the exact resources locations during the production phase through elaborated IT-systems, e.g. just-in-time delivery. In contrast, the use phase is a black box to the innovating firm. Thus, the detection and reintegration of valuable resources after usage is difficult. The implementation of ecological and economical reasonable closed loop systems [McDonough and Braungart, 2009] is nearly impossible. Albeit the research highlighted the downward integration into the use phase and the role of an IT-based platform to govern the system, the informants did unfortunately not provide any evidence that the examined firms strive to install such closed loops into their systems in the future. This question needs to be addressed explicitly in future research, clarifying, for example, whether performance-oriented systems are a potential antecessor for the introduction of a closed loop system, e.g. the cradle-to-cradle concept.

6.2.3. Closing of Phenomenological Discussion

As the study has already shown in chapter 2.1., the existent literature on the phenomenon is fragmented and not yet synthesized into a larger perspective. None of the above-mentioned notions describes the detected phenomenon from a strategic management perspective. Therefore, the research derived the notion of performance-oriented systems for this purpose within this work which integrates the central aspects of the findings as well as related prior research. The study concludes the prior insights in its definition that:

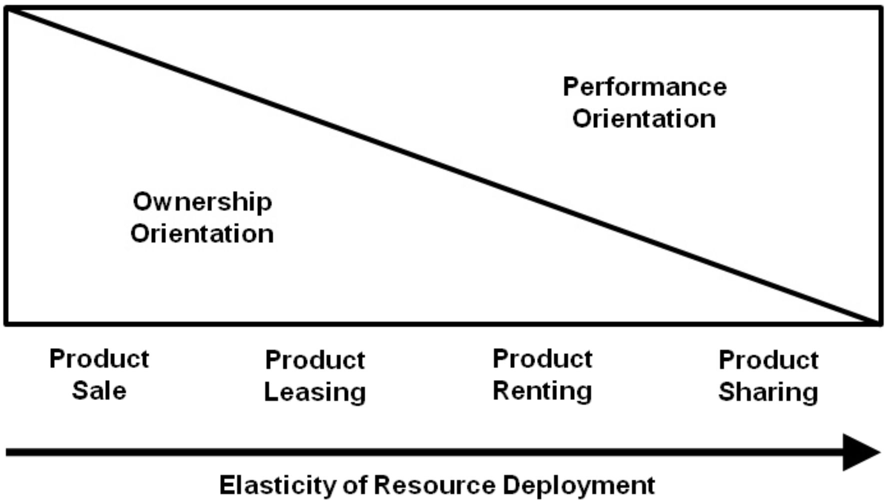
'A performance-oriented system is a well-defined sub-system in the respective industry combining different resources, e.g. physical and non-physical components, for shared use. The single resources are organized through an integrating module, often

referred to as platform. This module provides the performance of the integrated components on flexible, usage-based conditions and does not request partial ownership of any resources by the user. Hence, a performance-oriented system features maximum elasticity of resource deployment for the user. The integration of the use phase within the system boundary results in an increased resource efficiency in comparison to existing alternatives."

Resembling bundles of components, e.g. renting, leasing or pooling services are not included under the notion performance-oriented system due to different characteristics that result in a reduced elasticity, i.e. inflexible contractual conditions, or the partial ownership of system-components by the user. Thus, elasticity describes in this study the user's flexibility in his resource use. Depiction 27 exemplary compares the four generic models product sale, leasing, renting and sharing according to their elasticity. In a product sale, the user is forced to plan his demand for the entire physical product lifespan and deploy necessary resources, e.g. financial, time and know-how resources, before usage. The ownership of the product and the related status is a relevant aspect for the user in this case. In comparison, product leasing already decreases the planning horizon significantly, e.g. half the product lifespan, and allows for a monthly resource deployment after an initial fixed payment. Product renting continuous this trend and allows a pure variable resource deployment on an even shorter basis. The highest elasticity is provided by product sharing, where the user may decide in some of the observed cases every minute whether he wants to deploy further resources. In this case the usage and the related performance play the central role in the user's considerations. To summarize this aspect, as no consistent definitions across industry sectors for the differing notions/ models are existent and intersections are blurred, performance-oriented systems always 'bang the right corner' in terms of elasticity of resource deployment relative to existent offerings. They are optimized towards performance, i.e. in this study 'work done over time', and its related costs. Likewise, it is neither an industrial standard nor platform that provides the core for complementing firm`s offerings because of the system governance by a single firm and its limited adoption within the industry.

Ecological characteristics are only indirectly included in the definition of performance-oriented systems under the notion of resource efficiency. The resource efficiency, that forms the basis for being an ecological benign offering, may well be motivated solely by economies of scale and scope during system composition and operation phase [cp.

Henderson and Gälweiler, 1984; Hirschmann, 1964]. The rationales behind this conservative decision in the working definition are the underlying challenges in precise assessment, as well as the divergent results in the existing body of literature whether a managerial motivation for environmental benefits is existent.



Depiction 27: Elasticity of Resource Deployment in System Offerings

So far, the study has discussed the findings with regard to established strategic management theories as well as the existent literature on the phenomenon and answered the central research question whether the observed phenomenon is a strategy. The results synthesize the existing literature into the larger perspective of performance-oriented systems and link this strand to the conversation of strategic innovation management research. Thus, the research contributes a strategic perspective on the phenomenon to the emerging research community around the notion of product-service-systems. The work further enhances the understanding and spread of the novel strategy of superior architectural knowledge through twenty-seven applied system examples. Last, the research contributes to the understanding of the interrelation between the strategic use of architectural knowledge and the theory of dynamic capabilities by illustrating the connection between the technology and the knowledge structure within the examined systems.

6.3. Discussion of Enabling Factors for System Development

So far, the precedent discussion has verified whether performance-oriented systems incorporate the characteristics of a strategy and what the results within this work contribute to the existing scientific conversations. In the following, the research seeks to answer the sub-question three of this study in providing initial enabling factors that illustrate the system context. As financial performance data on this emerging phenomenon is scarce, the research attempts to consolidate and align the theoretically developed success factors in the literature with the primary data. Hence, the subsequent section presents a comprehensive list of nine enabling factors for the implementation of performance-oriented systems, which are based on the consolidated insights from the previous chapters.

Depiction 28 provides an overview of the identified enabling factors. The first three propositions describe relevant factors in the industry environment that foster the success of performance-oriented systems. The propositions four to six comprise influencing characteristics with a focus on value creation. The last three propositions incorporate relevant aspects with an emphasis on value protection. Regarding the influencing factors in the firm environment, i.e. the industry state, the data suggest that location and constriction of the bottleneck as well as industry legislation are relevant aspects. First, the existence of an economical bottleneck downstream in the value chain of an industry positively affects the development of a performance oriented system, e.g. changing user preferences in a stable, mature industry with a dominant design. This aspect correlates with the results in finding one, finding two and finding ten as well as the insights of [Ethiraj, 2007], who is specifically examining the 'allocation of inventive effort' in complex systems. Second, the constriction of the industries' bottleneck positively affects the probability of system implementation. The constriction of the bottleneck aggregates the detected lack of elasticity for the user, the perceived complexity of the individual system and the degree of personal involvement. Exemplary, the higher the level of resource deployment for the products, the more numerous and interdependent the individual components and the more contextual the products for the business or the personal lifestyle, the higher the constriction and thus, the higher the probable success of a potential performance-oriented system. This characteristic is aligned with the results of finding one and finding three as well as the findings of [Ethiraj, 2007]. The third proposition concerns the role of existing legislations in the respective industry as enabling factor. This characteristic applies especially for environmental regulations. It correlates with the results of finding two and finding ten in this work as well as the findings in [Jacobides et al., 2006], who are discussing the 'role of authorities in industry architectures'.

Enabling factors for the development of performance-oriented systems are …	
P1	… the existence of an economical bottleneck downstream in the value chain
P2	… the constriction of the bottleneck
P3	… environmental legislations in the industry
P4	… the capabilities for integrating the complementary resources
P5	… existing component or modular knowledge of system resources
P6	… the elasticity of resource deployment during the system operation
P7	… the discrepancy between system and existing industry architectures
P8	… the degree of user-integration and -collaboration
P9	… the degree of component integration and decentralization

Depiction 28: Enabling Factors of Performance-oriented Systems

Relevant internal factors with a focus on value creation include the concentration on the integrating capabilities, the existence of prior competences and the potential to outsource non-crucial modules. First, the (exclusive) availability of relevant technology and knowledge for integrating the diverse range of complementary resources through a platform positively affects the development of a performance-oriented system. A firm needs to develop or acquire the associated capabilities prior or during the system development phase. The central role of the integrating module has been illustrated in finding three and finding five. In addition, especially [Pisano and Teece, 2007] are emphasizing the role of 'integrating capabilities' in complex systems. Second, existing firm knowledge of the relevant system resources are fostering the creation of performance-oriented systems. The 'usefulness of existing competences' in an incumbent firm during a change of the industry architecture is described by [Henderson and Clark, 1990] and also illustrated in finding four. Third, the elasticity of resource deployment for the implementing firm also affects the success of the system, i.e. the (financial) flexibility of the firm during system operation and evolution. For example, [Baldwin, 2010] emphasizes the 'outsourcing of non-crucial modules' as an enabling factor of complex systems as well as the results that lead to finding seven of this work.

In terms of value protection, the discrepancy to existent offerings, the degree of user-collaboration, as well as co-specialization and decentralization are influencing the creation of a performance-oriented system. First, the discrepancy between the novel system architecture and the dominant industry architectures positively affects the system development. The more distinct the position of the system on the elasticity scale in comparison to conventional alternatives, the more difficult the imitation for competitors. The 'difficulties in adapting to architectural innovations' for incumbent firms are described by [Henderson and Clark, 1990] and are also reflected by finding three and finding eight of this work. Second, the degree of user-integration and -collaboration has a positive impact on the development of the respective system. On the one hand, this approach accelerates innovation rate and speed. On the other hand, it includes the full spectrum of user demand to secure the firm's position. This aspect is addressed specifically in finding six as well as in [Christensen, 1997]. Third, the extent of component integration and decentralization enables the system creation. The more components and component suppliers are integrated into the system, the more stable the implementing firm’s position. The potential to 'capture value through complementary assets' is emphasized by [Pisano and Teece, 2007] and initially indicated by finding four within this work. Additionally, this last aspect is supported by recent developments of the examined cases. Exemplary, the Daimler AG has expanded its car-sharing platform lately towards a mobility platform including a taxi-service, private ride-sharing and public transport. Other, like the Deutsche Bahn AG, follow this evolution and combine bike-sharing and car-sharing with their commuter and mainline passenger services into an end-to-end mobility platform [Becker, 2013].

The hitherto briefly described nine enabling factors of performance-oriented systems are synthesized from the empirical findings within this work as well as the insights from existing prior research. The propositions are structured into the three groups according to the generic steps of environmental analysis as well as firm adaption for value creation and value protection, each containing three aspects. To the author's understanding, the propositions well illustrate the context of system development and are capable to serve as a guideline for future quantitative research in the area of performance-oriented systems. In terms of managerial praxis, the enabling factors provide initial managerial guidance for the implementation of prospect performance-oriented systems.

6.4. Closing of the Discussion Chapter

Based on the findings the study concludes that performance-oriented systems incorporate the basic characteristics of a strategy, as their implementation comprises the identification of a bottleneck in the environment of the firm as well as the adaption of the firm's resources to integrate and protect the bottleneck. The optimization towards maximum elasticity of resource deployment for the user results in a distinctive position within the industry spectrum of alternatives. The strategy is particularly qualified for (mature) industries characterized by a bottleneck downstream in the value chain, i.e. changing user preferences for product acquisition and operation. The concentration on and supply of a superior bottleneck module, i.e. the integrating module or platform respectively, are the central tasks to perform by the implementing firm. Additionally, the study has identified initial enabling factors that are aligned with existent literature and illustrate the context of system development. The findings are coherent with the conceptual strategy of superior architectural knowledge for entrepreneurial firms. The results also reflect on the theory of dynamic capabilities as a constant mode of opportunity identification and pursuit of reconfiguration. The research even broadens the juvenile insights from the former concept through the implementation of incumbent firms and qualifies it through evidence from twenty-seven applied examples and the connection with the established latter theory. Last, the study has synthesized the fragmented literature that already perceived the phenomenon into the more integrated perspective of performance-oriented systems.

7. **Contribution and Implications for Academia and Praxis**

In the following, the study at hand closes with the contributions and limitations of the research as well as future research recommendations. Section 7.1 comprises the theoretical contributions and section 7.2 briefly illustrates the managerial contributions. The limitations and future research recommendations are described in chapter 7.3. The chapter draws a final conclusion in the fourth part.

7.1. Theoretical Contributions

In the following, the theoretical contributions of the study are summarized. The chapter first illustrates the contributions for the strategic innovation management literature and subsequently the contribution of the work for the existing phenomenological research.

First and foremost, the study has answered the central research question whether and in what context the observed implementation of performance-oriented systems in different industries is a viable strategy to gain a competitive advantage. The study concludes that the implementation of a performance-oriented system is an explicit strategy of a firm, as their analyzed development reflects the central characteristics of several relevant strategic innovation management conceptions. Further, the study presents a comprehensive list of nine enabling factors for the implementation of performance-oriented systems, which is capable to guide future quantitative research in this strand of literature.

In terms of the strategic innovation management literature the discussion section has shown that the findings are compliant with the conceptual insight from the strategy of superior architectural knowledge for entrepreneurial firms. The study extends the insights from the theoretical concept through the incorporation of service- and product-based incumbent firms and qualifies it through evidence from twenty-seven case examples from four industries. Additionally, the selected case examples reflect the theoretically postulated concepts of architectural redesign, co-specialization, modular diversification and the promotion of competition within complements. Hence, the study contributes applied evidence on the theoretically identified possibilities of a firm to change its position in the industry architecture for value creation and value appropriation.

Further, the findings are also coherent with the theory of dynamic capabilities. The results underscore the role of knowledge and competences to build a competitive advantage rather than the ownership of physical assets. A major and timely contribution of the study at hand is the connection and dual interpretation of the examined system examples with the strategic use of architectural knowledge and the established dynamic capabilities theory. The previous sections illustrated that the knowledge and competence structure in a firm is closely connected to the technology structure which ultimately contributes to the industry architecture. Thus, the study supports the proposition of the dynamic capabilities theory that a competitive advantage can be built through unique knowledge and competences. The study has illustrated that this is especially applicable, if the knowledge is suitable to resolve the bottleneck in the industry. The technological architecture of the system, and particular the bottleneck-module, provides the tangible frame to generate and secure this knowledge. Hence, the results indicate that the examined firms demonstrated their dynamic capability during the system development through a strategic use of their architectural knowledge of the industry. The examination of twenty-seven system examples within in this work underscores the theoretical assumption that the strategic use of architectural knowledge is one possible approach to translate the abstract dynamic capability of a firm into a sustained competitive advantage. Thus, the study provides practical evidence on a variety of theoretical constructs in this strand of literature which has been scarce to date.

Last, the focus of the study and, thus, the focus of the contribution reside on technological sub-systems in the industries that are situated below industry dominant systems but above firm-internal product-systems. So far, the existing literature has largely neglected this intermediary level albeit the ground realities comprise a vast amount of practical case examples. In addition to the insights of the unified platform perspective that incorporates all of the aforementioned systems, the findings within this work accentuate the role of the integrating module as a database and information filter.

In terms of phenomenological research, the study has synthesized the fragmented literature from a diverse range of disciplines that already perceived the phenomenon into the more integrated perspective of performance-oriented systems. Further, the research provides a profound rationale to the recent emphasis on the phenomenon through the selected linkage to the strategic innovation management literature.

Thus, the study contributes a strategic innovation management perspective to the scientific literature on product-service-systems and its closely related notions which has been absent prior to that. The executed abstraction and aggregation of resources towards components, modules and the system level permits for the first time a transferability of the results beyond the single case. This novel approach advances the detailed distinction and description of individual components within one system and their specific contribution to value creation that dominated the existing research in this strand of literature. Further, the study rather indicates that the whole system creates the desired value through the integration of the value steps 'system composition' and 'system operation'. This differentiation has been unnoticed to date. The study further contributes through the incorporation of value protection within its scope that has been neglected in prior contributions on product-service-systems. The study well illustrates the importance of the integrating module for the development of processing knowledge. Thus, the importance of the integrating module and constant process innovations to capture and protect the created value contributes a novel aspect to this strand of literature. Last, the study provides a novel classification of performance-oriented systems and conventional offerings in the industry according the elasticity of resource deployment for the user which has not been used to date in this strand of literature.

Regarding the existing literature in the computational sciences, the study contributes a strategic innovation management perspective as well. The novel perspective as a sub-system in the industry, i.e. a complementary offering, explicitly acknowledges the relevance of a distinct strategy during the early development phases; no matter whether the intention of the system is industry dominance. In addition, the insights of this study emerged from four industries and thus reduced a potential industry bias. Further, the study revealed the importance of hidden information about the physical components within performance-oriented systems. This contribution enhances the understanding of the relation between technology and knowledge as well as the important role of electronic platform components, e.g. software applications, server, GPS, etc. Last, the higher elasticity of resource provisioning in performance-oriented systems that has been initially found in the computational sciences, has also been detected by the study in the other examined industries. Thus, this concept may potentially form a basis for the analysis of other offerings that integrate into the use phase.

The conceptual interpretation of the study based on anthropological studies sheds a novel perspective on the phenomenon, especially on the firm-user-relation in performance-oriented systems and their collaboration. The study highlights that performance-oriented systems integrate characteristics of gift giving and commodity exchange, a characteristic which further distinguishes them from conventional offerings. The integrating module creates a commons that allows for an innovative reactivation of the traditional behavior of sharing when resources are comparably scarce. This novel perspective raises further research questions about interface and incentive design in performance-oriented systems.

Last, regarding the environmental literature, the study contributes applied insights from executives of twenty-seven firms concerning their intrinsic environmental motivation, which is rated secondary in comparison to economic motives. Thus, the study contrasts and complements established research, on product-service-systems for example, which suggest a dominance of ecological benefits.

7.2. Managerial Contributions

In terms of managerial praxis, the study at hand first and foremost provides a concise overview of relevant literature regarding the phenomenon of performance-oriented systems and the shareconomy as well as appropriate strategic innovation management concepts for interpreting the ground realities in their respective industry. Thus, the study enables interested management to swiftly inform themselves about the topic and understand as well as analyze the emergence of performance-oriented systems from a strategic perspective.

The novel strategic perspective that derived from this study has the potential to serve as managerial guidance whether performance-oriented systems are a reasonable opportunity for implementation in the context of their business. Especially the illustrated consistent framework as well as the described enabling factors provide explicit managerial guidance for the implementation of prospect performance-oriented systems. To further illustrate this aspect, a simple exemplary checklist has been derived from the research results to support the management of an incumbent firm in their decision prior to the system development. The numeration of the questions in the example correlates in this case with the numeration of the propositions. Positive answers are enabling the system development in the industry:

1.) Firm operates in saturated industry?

2.a.) Significant user group prefers high elasticity (i.e. less cost, time, know-how)?

2.b.) Firm’s product/ service is interdependent on other products/ services?

2.c.) Firm’s product/ service is contextual to user’s business/ lifestyle?

3.) Industry legislations foster prospective system implementation?

4.) Firm has necessary competence for system integration/ platform development?

5.) Firm has relevant knowledge on crucial system components?

6.) Firm has possibilities/ partners to outsource non-crucial system components?

7.) The prospective system comprises significant differences to existing offerings?

8.) Firm has experience in user-integration and –collaboration?

9.a.) Future system development plans include additional products/ services?

9.b.) Future system development plans include geographical decentralization?

Further, the study enhances the understanding of relations and commonalities of performance-oriented systems across different industries. This allows the management not only to benchmark direct competitors in the same industry but also to learn from firms that have implemented such a system in other industries.

Last, the insights from twenty-seven system examples provide an applied 'best practice' information on the development and implementation of a novel offering and the priority of different aspects, i.e. information on how incumbent and entrepreneurial firms developed a performance-oriented system as well as on their alteration over time.

7.3. Limitations and Future Research Recommendations

In the precedent sections, the study has shown that performance-oriented systems are an emerging phenomenon with increasing relevance and portrayed the executed qualitative research according to a profound methodological approach. The results of the research provide a novel perspective on the phenomenon as well as a novel strategy including initial enabling factors. But there are also certain limitations to the study which are described in the following chapter.

The first limitation concerns the general character of the selected research approach. Albeit the selected case examples comprise a consistent pattern, which has been extensively described in the results section, the study solely provides qualitative evidence from twenty-seven system examples and no quantitative evidence. Thus, the validity of the findings should be contested in a future quantitative study. This seems especially reasonable as the number of case examples constantly increased during the course of this study and an appropriate number of cases in and across industries is now available. Further, the selected methodological foundation of Grounded Theory comprises certain limitations. First, Grounded Theory is not a strict methodology but rather an iterative 'try-and-error' approach. This is a methodological-inherent limitation. Second, the case selection, data collection and analysis have been conducted rather sequentially than simultaneously, as requested by a very purist rendition of the Grounded Theory. The preference of the author to reduce a potential longitudinal bias, the promptly emerging consistent pattern in the selected cases on an aggregate level and the fact that the author prioritized a thorough analysis, led to pragmatism in this aspect. Last, the selected interpretative approach comprises a bias in the data analysis phase, as the interview data has been coded by the author alone. This bias has been reduced through constant presentations and discussions of the findings with other researchers. Additional measures to reduce the bias, e.g. the application of an inter-coder-reliability-rate, which is habitually used in prominent research projects of decent size, have been considered pragmatically as too complex in a study of this scope. Other potential biases, e.g. during data sampling and collection, have been reduced more rigorously, as described in chapter four. Thus, a repetition of a similar research from another researcher with a different mindset and a comparatively strict methodology, e.g. qualitative content analysis, would certainly enrich the discussion.

A complementing limitation concerns the comparability of the case examples in and across the four examined industries. All the analyzed firms certainly comprise a different degree of innovativeness especially across industries. The selected compact data collection phase strived to reduce this bias as far as possible. Nonetheless, there are still differences between the cases, most of which have been described in the results section. To summarize, not all firms comprise the same level of system evolution, but, according to the informants, all strive along the same, described path. This limitation is existent in all multi case-study research and can hardly be eradicated.

There is also a limitation regarding the contribution of the study to the strategic management literature. The results certainly do not add any clarity concerning the interrelations between the already existing constructs, e.g. the effect of the dynamic capability on the firm's performance. The reason lies within the selected qualitative research design and scope which has also been used previously by other scholars in this strand of literature. Chapter four already discussed the circumstance that financial performance date on the emerging phenomenon is scarce. Thus, the prospect potential to examine this aspect is quite limited as well.

The last limitation concerns the environmental benefits of performance-oriented systems. The study has shown that some of the informants have acknowledged ecological benefits of the system approach and rate them as complementary drivers for system development. These judgments are considered highly subjective, as profound scientific evidence of ecological benefits in performance-oriented systems is scattered and further investigation needed in this area. Additionally, the results support the central theme of dematerialization due to the system inherent incentive regime, but only provide qualitative evidence from twenty-seven system examples. Last, the preference of ecological benefits might also be dependent on the selected industries in the data sample. Thus, the author encourages other researchers to conduct a large scale, industry wide quantitative resource analysis of all existing alternatives over the whole life-cycle, to verify if these system comprise and objective ecological benefit at all and in a second step compare the results with other industries.

In the following, the chapter presents the remaining future research recommendations which are not directly linked to a limitation but rather emerged from the discussion of the results with the existing literature. First, the discussion section revealed a discrepancy between the unified platform perspective and the results of study, whether solely the interfaces of the system or the interfaces and the platform itself must be governed by the firm to secure an advantage. This aspect has to be addressed specifically in future research. Additionally, such research could clarify, whether there are distinct differences between systems for industry dominance, sub-systems and firm-internal systems and whether there are absolute or gradual boundaries.

Second, the vertical interdependency between the knowledge, technology and industry level appears as an interesting field for future research as the study has supported prior evidence on their strong interrelation. Albeit conventional research often limits itself to horizontal research at one level, e.g. individual, firm or industry level, according to the scope of the respective institute, there might also be some promising insights for innovation management from analyzing the vertical relations between these levels and the related conceptions.

Third, the study has highlighted the downward integration into the use phase and the role of an IT-based platform to govern the system. These two characteristics eradicate the lack of information about the product resources in the use phase. In conventional offerings, the lack of information during the use phase impedes the detection and reintegration of valuable resources after usage and thus, the implementation of economic reasonable closed loop systems. Unfortunately, the informants did not indicate whether their firms strive further and integrate the end-of-life or recycling phase in their systems. This aspect needs to be addressed explicitly in future research, clarifying, for example, whether performance-oriented systems are a potential antecessor for the introduction of a closed loop system, e.g. the cradle-to-cradle concept.

Last, the comparatively generic interpretation of the results based on anthropological studies raises prospective research questions about future interface and incentive design in performance-oriented systems. Further, this rather evolutionary-driven perspective may serve as a complementary explanation for the non-monetary motivation of other user-driven or collaborative innovations, e.g. open source software communities or open content communities.

7.4. Conclusion

The last conclusion of this study concentrates on three final remarks. First, the intention of the study was to stimulate the interest of the scientific community towards the emerging phenomenon of performance-oriented systems. Remarkably, the described transformation in diverse industries has constantly gained momentum during the course of this study, providing nowadays hundreds of case examples. The widespread availability of mobile internet, the rapid interconnection of physical resources with the internet and the creation of platforms to capture value in this complex virtual network have become major drivers in the worldwide economy. From today's perspective, a decline in these developments is not in sight. The study at hand firstly synthesizes the existing body of scientific literature on the phenomenon of performance-oriented systems and provides a strategic rationale why firms (should) transform their organization towards providing numerous users one product for shared use instead of selling each single user one product. Thus, the qualitative study marks a beginning in this strand of research rather than an end and raises a variety of prospective research questions. The author strongly encourages other scientists to contribute to this promising field of research.

Second, the study has been part of the green innovation research at the Institute for Technology and Innovation Management Department of the Technical University Hamburg-Harburg. The emphasis of the research project resides on novel, environmentally benign concepts that incorporate the adaption of the organizational structures, e.g. the integration of the use phase and/ or the end-of-life phase, to align ecologic and economic objectives for an exceeding number of resource types. The study has shown that the selected direction of the project is reasonable with regard to innovation management, as the firms are intrinsically motivated by economic motives rather than ecological ones. The study puts prior research into relation that assumed a complete transformation of incumbent firms towards idealistic and ecological-oriented organizations. Thus, the selected approach of the project should be further pursued.

The last aspect of the conclusion concerns some basic assumptions about the future evolution of performance-oriented systems. The study has shown that the examined systems constantly outsourced the physical resources and concentrated on the platform. Further, performance-oriented systems are nowadays regarded as a complementary offering in the industry. But assuming that the examined systems just have been the early adopters to a widespread trend that will be the prospective common case rather than the exception; assuming that the relevance of the internet for the economy as well as its innovation rate will sustain; assuming that all physical resources will be connected to the internet in the near future; will there be a clear distinction between firms that concentrate on the governance of the platforms and firms that concentrate on providing the physical resources? Is it possible for the former to rule their industry without real assets, as it is already partially the case with firms like Google? Will it be economically reasonable for the latter to implement elaborated closed loop systems and constantly recycle their products? How will the user behavior change when all assets are shared and widely available for usage? Will a mature shareconomy also affect the behavior within its society and create more community?

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Appendix

Exemplary Questionnaire:

Part I: Motivation (Clarification of the 'Why?')

1. What motivated the development of the performance-oriented system?
   1.1. How did the business idea come up?
   1.2. Was the business idea developed within or outside the company?
   1.3. What were the opportunities in terms of market and technology feasibility?
   1.4. What were the expected outcomes? In terms of user value, economical value and environmental value?
   ...

Part II: Transformation Process (Clarification of the 'How?')

2. What were the key internal and external resources and competences needed to develop the performance-oriented system?
   2.1. How did your company develop missing competences throughout the development process?
   2.2. How does your company's previous operating business facilitated or constrained the development process of the performance-oriented system?
   2.3. And how did you overcome the barriers created by the company's past?
   ...
3. With whom and how do you or did you collaborate to develop the performance-oriented system?
   3.1. Why did you choose to collaborate with the partners?
   3.2. What competences and resources are those partners contributing?
   3.3. How did you select your partners? Or were those firms your partners before?
   3.4. How did your partnerships changed during the evolution of the system?
   ...
4. What were managerial aspects for the development of the performance-oriented system that were different from other innovation projects?
   4.1. Regarding Innovation Process Management ?
   4.2. Regarding Idea Generation Phase? Development Phase? Prototyping Phase?
   4.3. Who was involved in key decision making along the innovation process?
   ...

Appendix

Overview of Research Findings:

Analysis of the Firm Environment:

Finding 1: Changing user preferences in terms of knowledge, time and capital deployment for product acquisition and operation have facilitated the development of performance-oriented systems.

Finding 2: The firm´s motivation to develop a performance-oriented system is predominantly economic driven; ecological benefits are regarded as a side effect.

Adaption of Firm Resources for Value Creation:

Finding 3: A firm is redrawing its boundary towards offering the performance of several joint resources to the user, instead of selling single complements. This downward integration of the value chain results in an increased elasticity of resource deployment for the user.

Finding 4: To develop a Performance-oriented System, a firm is transferring its existing resources from prior business as well as integrating complementary external resources that are essential to initially provide the system performance.

Adaption of Firm Resources for Value Appropriation:

Finding 5: The installation of a performance-oriented system requests the development of a dedicated module that connects the different components. The development of this integrating module is done internally as it is the key component.

Finding 6: Close collaboration between user and firm allows discovery-based continuous development of the system rather than discrete innovation resulting in a higher innovation rate and speed.

Finding 7: Product resources are constantly outsourced by the firm with increasing system size. Only the platform and its directly related service resources are kept internal to remain flexible in rising systems.

Finding 8: The incentive regime of a performance-oriented system is oriented towards resource efficiency. Thus, the implementing firm needs to develop processing knowledge and systematically reduce slack of the system components.

Contextual Factors for System Development:

Finding 9: The implementing firms create an independent organizational structure to facilitate the continuous adaption of the performance-oriented system.

Finding 10: An industry phase of saturation as well as environmental legislations facilitate the installation of performance-oriented systems as a complementary offering in the industry.

Appendix

Overview of Data Sample

Pilot Study:

Name	Industry	Type	Country	Parental Company	Year	Description	
Car 2 go	Mobility	Product Innovator	Germany	Daimler	2008	Free-Floating Carsharing	Station-based or free-floating Carsharing provide the performance of cars, 'mobility', on-demand to the user.
Connect by Hertz	Mobility	Service Innovator	Germany	Hertz	2008	Station-Based Carsharing	
Better Place	Mobility	New Entrant	Israel	NA	2007	Vehicle Battery Sharing	

Main Study:

Name	Industry	Type	Country	Parental Company	Year	Description	
Cabot Speciality Fluids	Chemical Management	Product Innovator	United Kingdom	Cabot Corporation	1997	Cesium Formate Brine Leasing	Chemical Leasing and Printers Cloth Services provides the performance of the respective chemical to the user. Functional Units, e.g. applied surface area, are used for remuneration instead of volume or weight of the chemical. Production, distribution and withdrawal of fluids as well as their reclamation lies within the stewardship of the firm. A range of technical services complements the offering.
SAFECHEM	Chemical Management	Product Innovator	Germany	Dow Chemical	2005	Cleaning Solvent Leasing	
Tiefenbacher	Chemical Management	Service Innovator	Austria	Tiefenbacher	2006	Paint Stripping Solvent Leasing	
Amvitech	Chemical Management	New Entrant	Greece	NA	1983	Cleaning Solvent Leasing	
Print Cloth	Chemical Management	New Entrant	United Kingdom	NA	1992	Cleaning Cloth Service	
Printers Cloth Company	Chemical Management	New Entrant	United Kingdom	NA	1991	Printers Cloth Service	
City Car Club	Mobility	New Entrant	United Kingdom	NA	2000	Carsharing Scheme	Station-based or free-floating Carsharing provide the performance of cars, 'mobility', on-demand to the user. Available vehicles in the vicinity can be located and booked online, via phone application or visually on the street. The remuneration is based on minutes or hours. Additional Services as fuel, maintenaince, incurance, etc. are included
DriveNow	Mobility	Product Innovator	Germany	BMW; Sixt	2011	Carsharing Scheme	
GoGet	Mobility	New Entrant	Australia	NA	2002	Carsharing Scheme	
Mobiltiy Car Sharing	Mobility	New Entrant	Switzerland	NA	1997	Carsharing Scheme	
Mu by Peugot	Mobility	Product Innovator	France	Peugot	2010	Carsharing Scheme	
Zazcar	Mobility	Service Innovator	Brazil	Brasil Car Leasing Corp.	2009	Carsharing Scheme	
Amadeus	ICT	Service Innovator	Spain	Lufthansa, Air France et al.	2010	SasS - Hotel Booking Platform	Software-as-a-Service or SaaS provide the performance of a dedicated software through a platform via the internet on demand, anywhere and at anytime to the user. System implementation, upgrade, security, maintenance and advancements are included in the offerings.
Aqilla	ICT	New Entrant	United Kingdom	NA	2006	SaaS - Accounting Software	
Open ERP	ICT	Product Innovator	Belgium	OpenERP	2009	SasS - Enterprise Resource Planning	
SageOne	ICT	Product Innovator	United Kingdom	Sage Group	2009	SaaS - SME Finance Software	
Telfonica Aplicateca	ICT	Service Innovator	Spain	Telefonica, NEC	2009	SaaS - Small Applications Platform	
Webforum	ICT	New Entrant	Sweden	NA	1997	SaaS - Project Mangagement	
SunTank	Energy	Product Innovator	South Africa	Sun Tank	2004	New Energies Solar Heating Program	Solar Heating Programs or Power Purchase Agreements deliver 'thermal heat' or 'electricity' generated through decentralized renewable energy sources. Users are charged for the system performance on a fixed monthly basis instead of purchasing solar-technologies. The providing firm installs, operates and maintains the technological system.
Kayema	Energy	Service Innovator	South Africa	Kayema	2009	Power Purchase Agreement (PPA)	
CBE Solar	Energy	New Entrant	Brazil	NA	2007	Solar Water Heating Program	
SunEdison	Energy	New Entrant	USA	NA	2004	Power Purchase Agreement (PPA)	
Tioga Energy	Energy	New Entrant	USA	NA	2007	SurePath Solar PPA	
Lakeland Electric	Energy	Service Innovator	USA	Lakeland Elektric	1999	Solar Hot Water Program	

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Education

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