MANAGING COMPLEXITY IN SERVICE PROCESSES. THE CASE OF LARGE BUSINESS ORGANIZATIONS

Teză destinată obţinerii
titlului ştiinţific de doctor
la
Universitatea Politehnica Timişoara
în domeniul INGINERIE ŞI MANAGEMENT

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FOREWORD

Everything should be made as simple as possible, but no simpler!
Albert Einstein (Spencer, 1934).

This doctoral study was performed at the Politehnica University Timisoara, Romania. The university has provided the organizational framework that enabled the successful implementation of the research activities (pooling of theoretical and applied research), the publishing activities regarding the dissemination of results achieved.

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Managing complexity in service processes. The case of large business organizations / Managementul complexității proceselor de servicii. Cazul organizațiilor de afaceri mari

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Cuvinte cheie: managementul complexității, managementul proiectelor, externalizare, servicii IT, Casa managementul complexității afacerilor mari, Complexity Balance Scorecard

Rezumat: Teza de doctorat prezintă cercetări menite să evalueze și să caracterizeze direcțiile relevante ale preocupărilor actuale pentru managementul complexității. Pe baza concluziilor asupra cercetărilor bibliografice se prezintă, mai apoi, demersul de dezvoltare a unui model denumit generic „*Casa managementul complexității afacerilor mari*" și a unei metodologii specifice de utilizare (metode, mijloace și un cadru contractual specific). Cercetările experimentale prezentate validează modelul dezvoltat prin evaluarea cerințelor funcționale și non-funcționale ale acestuia și prin confirmarea fezabilității mijloacelor create („*Complexity Balance Scorecard*") în cazul unui proiect de externalizare de mari dimensiuni. Astfel, managerii organizațiilor, client și furnizor de servicii, sunt capabili să prevadă (să anticipeze) și să caracterizeze (evalueze) o situație complexă, precum și capcanele privitoare la managementul acesteia.

CONTENTS

NOTATIONS, ABBREVIATIONS, ACRONYMS

AKAD Lahr	AKAD enterprise group is an educational provider of distance learning courses
B2B	Business to Business
BCG	Boston Consulting Group
BMBF	Bundesministerium für Bildung und Forschung in Deutschland (translated: Federal Ministry of Education and Research in Germany)
BMWI	Bundesministerium für Wirtschaft und Energie in Deutschland (translated: Federal Ministry for Economic Affairs and Energy in Germany)
BPM	Business Process Management
BPO	Business Process Outsourcing
BSC	Balanced Scorecard
BSI	Balanced Scorecard Institute
BVL	Bundesvereinigung Logistik (translated: German Logistics Association)
CAS	Complex adaptive system
CEP	Complex Event Processing
CIP	Continuous Improvement Process
CNC	Coefficient of Network Complexity
CRM	Customer Relationship Management
CMMI®	Capability Maturity Model® Integration
CMO	Current mode of operations in Outsourcing (operation responsibility from customer)
CMO+	Current mode of operations in Outsourcing (operation responsibility from service provider)
ComIP	Complexity Improvement Process
ComMAR	Complexity Management Audits & Review
ComMBoard	Complexity Management Board
ComMBSC	Complexity Management Balance Scorecard
ComMBSCB	Complexity Management Balance Scorecard Balance
ComMC	Complexity Management Criteria
ComMCom	Complexity Management Communication
ComMMeasures list	Complexity Management Measures list
ComMStA	Complexity Management Stakeholder Analysis
DAX	Deutscher Aktienindex (translated: German stock index)
DMAIC	DMAIC is the core process of the quality management approach Six Sigma (Define – Measure - Analyze - Improve – Control)

DSM	Design Structure Matrix
e.g.	exempli gratia, that means: for example
EMEA	Europe, Middle East and Africa Area
EPG	Enterprise Project Governance
EPM	Enterprise Project Management
FAZ	Frankfurter Allgemeine Zeitung (Name of the German newspaper)
FMO	Future Mode of Operation in Outsourcing
GeMoC	Generic Model of Complexity
GMN	General Management Navigator
GPM	Ganzheitliches Prozessmanagement (translated: Holistic Business Process Management)
i.e.	id est, that means: add explanatory information
IES	Intelligent Embedded System
Industry 4.0	name of a future project of the German industry and politics (translated: Industry 4.0)
IES	IT-Enabled Service
IESs	IT-Enabled Services
IS	Information Systems
ISG Outsourcing Index™	Quarterly review of the latest sourcing industry data and trends for clients, service providers, analysts and the media
ISSBS	International School for Social and Business Studies
IT	Information Technologies
ITIL	IT Infrastructure Library
LBCM	Large Scale Business Complexity Model
LFP	Light Footprint Strategy
MAV Innovation Forum	German Association of the metal cutting industry
NGO	Next Generation Outsourcing
PBL	Performance-Based Logistics
PM	Project Management
PMI	Project Management Institute
R&D projects	Research and Development projects
PLSSEM	Partial Least Squares Structural Equation Modelling
POS	Point-of-sale
SB	Service Blueprint
SEP	Strategic Success Positions
SC	Supply chain
SCM	Structural Complexity Management
TMT	Top Management Team
TO model	Technology Outsourcing model
USP	Unique Selling Point

VDI/VDE	VDI / VDE Society for Measurement and Automatic Control (GMA) is a professional society of the Association of German Engineers (VDI) and the Association for Electrical, Electronic & Information Technologies (VDE).
WI	Whitney Index (WI), which sets the dependencies of system elements in relationship to the number of system elements

List of Tables

List of Figures

1. INTRODUCTION

The preliminary source and ideas of the PhD topic were related to the complex reality of solving and develop big outsourcing projects, in the case of services domain. From the practical perspective, and from the theoretical one, there has been identified a strong need in solving complex situations, through an existing framework or approach, mainly defined to simplify the problem solving situation. The **topic importance and relevance** will be explained in the following.

Outsourcing is furthermore a relevant and important sourcing strategy. According to the report "*2nd quarter 2014 EMEA (Europe, Middle East and Africa Area) ISG Outsourcing Index*" of the ISG (Information Services Group), outsourcing activities in EMEA have reached a record high in the first half of the year. ISG is a provider of technology information, market research information and consulting services (Schuster, 2014). Such big projects need a common organizational project and program structure (Brehm& Hackmann, 2014). Major causes of increasing complexity are, among some others, strategic alliances, and outsourcing to third parties (Castellano, 2014).

Dealing with complexity is the central challenge of our time (Jischa, 2008). The socio-political and global economic development represents individual companies in the service industry before extraordinary challenges: globalization, penetration of new technologies, more dynamic product life cycles. Resource scarcity, demographic change, climate change and energy transition are only some selected megatrends that affect the company as external factors and the companies need to position their strategies (Spaeth, 2013). Due to the existing and further increasing global networking in economic, political and social areas complexity is, more than ever, an essential success factor for organizations (Schoeneberg, 2014). Due to the ongoing globalization, companies need to deal more than ever with new markets, competitors, and individual customer needs to remain on the market in the long term. In addition to the market requirements, the company must manage ever-changing needs of internal and external customers, for example because of new information and telecommunications technologies. Within a short time, the volume of business-related complexity has steadily increased and a large part of the company has evolved from a complicated to a complex system (Schoeneberg, 2014).

"*Complexity has received wide attention from practitioners and academics alike. We have made significant progress in understanding the different aspects of complexity in projects, programmes and portfolios*" (Oehmen et al., 2015, p.3). "*Future research should continue to investigate how to mitigate or manage the operational day-to-day uncertainties with the long-term strategy of a company [...]. There is also a need for more research into what alternative strategies are available*" (Nordigarden et al., 2015).

Within the framework of research, it will be examined how complexity can be managed in the service sector, if the external factors take over a dominant character. In an outsourcing situation, services (based on the contractual agreement) have to be designed at the customer interface and must be integrated and adapted to the internal processes of the service provider.

As outsourcing is usually associated with a takeover of an existing infrastructure, processes and personnel, the selected case study represents a suitable application to investigate the external factors

The motivation of the research topic is because complexity management is becoming increasingly important in science and industry. Thomas Bauernhansl (representing the cooperation between the University of Stuttgart and the Fraunhofer Institute) has published the topic: "*Manage complexity - the introduction of production systems in Industry 4.0*"at the MAV Innovation Forum 2014 and defined the management of complexity as a *new core competence*.

Thomas Bauernhansl presented the study results of the cooperation between University of Stuttgart and the Fraunhofer Institute from 2013, in which directors and executives of leading German industrial companies were interviewed (Bauernhansl, 2014, p. 1):

- 82% of respondents answered that the relevance of complexity will increase in the future;
- 56% of all respondents indicated that they do not have any method or IT system to deal with the complexity.

The participants were asked the question: *In what areas are high complexities handled inefficiently?* The Top 3 results were the areas of "*Processes and ordering processes", "IT"* and *"business organization"*.

In addition, Hans-Jürgen Klesse article: "*Komplexität - Mit schlankeren Strukturen zu mehr Profit*" in the German magazine "*Wirtschaftswoche*" refers to a study done by the consulting company "*A.T. Kearney*", that mention that the cost of complexity in DAX companies amounted to € 30 billion annually (Klesse, 2012). Despite the high demand on establishing a complexity management approach for business, there is still hardly any concrete IT support (as specific tools). Specific tools have been developed in different sectors and business environments, however, with many lacks, for example support for objectivity and reliability only (Ravishankar et al., 2014, p. 5).

Industry experts in Germany confirm that after the implementation of Industry 4.0 in their companies, the productivity gains are up to 50%, depending on the complexity of production use cases (Bauernhansl et al., 2015).

The aim of the PhD research program is to design a systematic approach of complexity management for industrial service creation in the wholesale environment.

Currently existing approaches of the science will be analyzed and developed. Furthermore, a suitable simulation model to identify the costs and benefits of existing and potential complexity will be developed. As an application case, the service design of various sub-processes in order processing will be analyzed. To prepare an application for the industry, appropriate working practices and recommendations for action will be developed.

In the last years, the state of science represents no standardized solution for the combination of industrial services and complexity, based on a use case with dominant influence on customers so far, despite the numerous large-scale projects in the service sector. An important argument comes from Peter Addor, a researcher of complexity management, which determines that complex situations cannot be controlled; only the application of a model, such as system dynamics, allows to master complexity (Addor, 2014).

The general objective of this PhD research is to evaluate and characterize the relevant business research directions of complexity management and develop a *Business Complexity model* for a large-scale business environment by using various interdisciplinary research of different management areas. For this purpose, a methodological, procedural and organizational approach for the scientific and practice will be developed to complete existing research gaps. The result will be

applied in a use case of a high volume outsourcing project, in which IT services are contractually agreed between customer and service provider.

The **operational objectives** of the research approach are:

OP1. Analysis and synthesis for building a bibliographic overview of the complexity of management with business relation and provide the scientific basis for the research on business Complexity Management;

- **OP1.1.** Analysis and synthesis for creating a bibliographic summary of relevant business complexity management, to represent a basis not only for the present research work, but also for further research in this area - **Chapter 2**;
- **OP1.2.** Analysis and synthesis (for creating a knowledge inventory) of further relevant and necessary research areas/topics of dealing with complexity and defining the requirements for a business management complexity model - **Chapter 3**;

OP2. Create (Design) a framework and a model (with an associated methodology) for the characterization, development and evaluation of business management complexity for the application in a large-scale business environment, in order to perform an adequate analysis and to establish systematic strategies and measures in form of detailed requirements. Appropriate management tools and methods are designed to concretize and fulfil the possibility to manage complexity - **Chapter 4**;

OP3. Evaluation and application of the developed complexity model for a large-scale business environment, as the IT Outsourcing projects are;

- **OP3.1.** Theoretical and applied research of a business complexity model for the identification and evaluation of complexities in business situations, using a typical example of an IT Outsourcing project - **Chapter 5.1**;
- **OP3.2.** Evaluation and final review of the theoretical framework, the model and the application of the designed complexity model in large-scale business projects - **Chapter 5.2**.

In order to achieve the operational objectives, there have been valorized and exploited the theoretical knowledge acquired from the first Industrial Engineering programme at the *Hochschule für Technik und Wirtschaft Berlin, Germany* and the second programme of Master of Arts - Management at *AKAD Lahr Germany*, as well as the practical knowledge achieved from more than 15years of experience with management responsibilities in large-volume outsourcing projects.

The overall goal and operational targets are systematically developed and documented in the different chapters of the PhD thesis as shown in Figure 1.1.

The PhD thesis consists of six chapters with a total length of 137 pages (including the bibliographic list of articles, books and web pages that were used and adequate cite in the text). In addition, 13 annexes were defined in order to support the debates and explanations with supplementary details. In totally, the PhD thesis lengths on 169 pages and consists 29 tables, 27 figures, and 4 mathematical formulas.

The way on how each operational objective has been targeted is proved by the content of each PhD thesis chapter that described the developed research activities, the results achieved together with relevant conclusions. Briefly, each chapter content is described in the following:

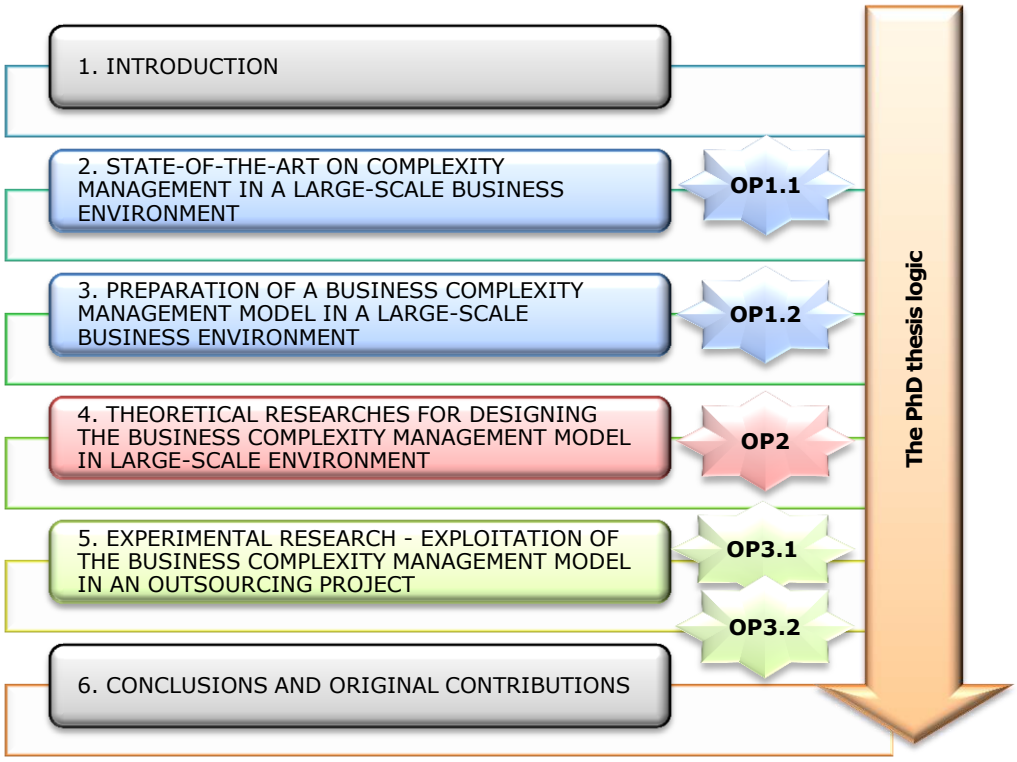

Fig. 1.1. The general overview of the PhD thesis associated with the research approach (own schema)

Chapter 1, INTRODUCTION, describes the problem of the research topic, the motivation and the scientific and practical importance. Using selected examples, the challenge and the current state of research is underlined. Furthermore, the objective of the entire PhD approach is briefly outlined.

Chapter 2, STATE-OF-THE-ART ON COMPLEXITY MANAGEMENT IN A LARGE-SCALE BUSINESS ENVIRONMENT, provides an overview of the current state of research, with bibliographic reference, regarding complexity relevant research results. A targeted categorization of the various sub-directions of complexity management supports the need for differentiation. The differences between the approaches are underlined and assessed individually and mutually. In addition, the practical oriented state of research is analyzed, discussed and compared with the (pure) theoretical scientific state of research.

Chapter 3, PREPERATION OF A BUSINESS COMPLEXITY MANAGEMENT MODEL IN A LARGE-SCALE BUSINESS ENVIRONMENT, examines additional management disciplines that include complexity relevant aspects for designing a complexity management model in large-scale business situations. Furthermore, results of two pre-studies are presented, in order to characterize the comprehensive requirements management, to identify complexity

relevant assumptions and define a framework for the following design phase. The result of this chapter is a holistic list of functional and non-functional requirements for a large-scale complexity management.

In **Chapter 4**, **THEORETICAL RESEARCHES FOR DESIGNING THE BUSINESS COMPLEXITY MANAGEMENT MODEL IN LARGE-SCALE ENVIRONMENT,** a framework for a holistic approach for a Business Complexity Management is developed, named "*Large Business Complexity Management*". Within this section, the different elements of this comprehensive approach to manage complexity are described in detail. The challenges of outsourcing projects are clustered and structured. Starting from the previous state of research, complexity criteria are developed for large-scale business environments and these criteria are linked with management tools.

In **Chapter 5**, **EXPERIMENTAL RESEARCH - EXPLOITATION OF THE BUSINESS COMPLEXITY MANAGEMENT MODEL IN AN OUTSOURCING PROJECT,** a typical business situation in an IT Outsourcing project is described (research context), which serves as a basis for applied research and for testing and validation of the designed model.

In sub-chapter 5.1 are presented the research results and debates of a simulated use case (IT Outsourcing project of large scale) in order to exploit the defined model (methodology with specific methods and tools) of the "*Large Business Complexity Management*". The simulated application results of the proposed model are discussed and the appropriate conclusions are made (regarding the application edited for usage in the cooperation between the involved parties of the project).

In sub-chapter 5.2, the functional and non-functional requirements for a large-scale complexity management case, which are listed in Chapter 3, are analyzed and evaluated within the context of the theoretical approach presented in Chapter 4 and the findings of the framework application, in sub-chapter 5.1.

In **Chapter 6, CONCLUSIONS AND ORIGINAL CONTRIBUTIONS,** the results of the research are summarized and the core messages of the findings are presented. In addition, the results interpretation is shown together with the meaning for the various research complexity-related disciplines, in a consolidated form. Reference to the previously identified gaps in the research is made together with their complete description.

Finally, the thesis ends with a **BIBLIOGRAPHY** which contained 176 cite titles (articles, books and web pages) and a list of **ANNEXES** with supporting documents of the research. These include:

- Overview of the current status of research regarding business complexity management in large business projects;
- Detailed information of various complexity management models presented in literature;
- Supplementary information and details of the present thesis;
- Details of the proposed contractual model to establish complexity management for service provision.

The research results dissemination consists of the following articles that were presented and published during the PhD programme (2013 – 2016):

1. **Rennung, F.,** Paschek, D., Draghici, A. (2014). A Complexity Management Model for Industrial Services. *Review of Management and Economic Engineering, 4th International Management Conference, "The Management between Profit and Social Responsibility"* (pp. 439-449). Cluj-Napoca: Todesco. *(ISI Thomson WOS:000367105500058)*
2. Luminosu, C., **Rennung, F.**, Draghici, A. (2014). Efficiency measurement of human resources integration methods in outsourcing situations. *Annals of the Oradea University- Fascicle of Management and Technological Engineering Vol. XXIII (XIII)/1,* 187-190. DOI: 10.15660/AUOFMTE.2014-1.2988*(Ulrich's web, Google, Crossref, Copernicus, CiteFactor, Scipio etc.)*
3. **Rennung**, **F.**, Luminosu, C., Draghici, A. (2014). Human resources integration methods used in big organizational change projects. In: (n.d.) *Human Capital without Borders: Knowledge and Learning for Quality of Life,Proceedings of the MakeLearn 2014 International Conference*, Bangkok, Celje, Lublin: ToKnowPress (pp. 775-784) *(EconPaper-Ideas, Google)*
4. **Rennung, F.**, Luminosu, C., Draghici, A. (2014). Evaluation of methods for customer integration to the quality of IT services. *CENTERIS 2014 - Conference on ENTERprise Information Systems, Procedia Technology 16/2014*, 101 – 109, DOI: 10.1016/j.protcy.2014.10.073 *(Springer, ISI Thomson WOS:000360404800012)*
5. Gogan, L.-M., **Rennung**, F., Draghici, A. (2014). A proposed tool for managing intellectual capital in small and medium size enterprises. *CENTERIS 2014 - Conference on ENTERprise Information Systems, Procedia Technology 16/2014,* 728-736. DOI:10.1016/j.protcy.2014.10.022 *(Springer, ISI Thomson WOS:000360404800081)*
6. Olariu, C., Gogan, L.-M., **Rennung**, F. (2014). Switching the Center of Software Development from IT to Business Experts Using Intelligent Business Process Management Suites, *Proceedings of the 6th International Workshop Soft Computing Applications (SOFA 2014), Advances in Intelligent Systems and Computing, Vol. 357,* 993-1001. *(Springer, to be index in ISI Thomson)*
7. **Rennung**, **F.**, Luminosu, C., Draghici, A. (2015). Strategic Management – Managing the Potential Complexity-Risks in Outsourcing. *4th World Conference on Business, Economics and Management (BEM-2015), Procedia Economics and Finance, Vol. 26,* 757 – 763. DOI: 10.1016/S2212-5671(15)00835-7 *(Springer, ISI Thomson WOS:000381990300110)*
8. **Rennung, F.**, Luminosu, C., Draghici, A. (2015). Service provision in the framework of Industry 4.0. *SIM 2015: 13th International Symposium in Management, Procedia - Social and Behavioral Sciences, Vol. 221,* 372–377. DOI: 10.1016/j.sbspro.2016.05.127. *(Springer, ISI Thomson WOS: 000381938100044)*
9. **Rennung, F.,** Luminosu, C., Draghici, A. (2015). Importance and Evaluation of Complexity-Causing and Increasing Factors as a Determining Success Indicator in Outsourcing Operations. In: (n.d.) *Managing Intellectual Capital and Innovation for Sustainable and Inclusive Society: Managing Intellectual Capital*

and Innovation; Proceedings of the MakeLearn and TIIM Joint International Conference 2015 (pp. 257-264). Bangkok, Celje, Lublin: ToKnowPress. *(EconPaper-Ideas, Google)*

10. Gogan, L. M., Borca, C., **Rennung, F.,** Sîrbu, R. (2015). Intellectual capital management - A possible approach. (n.d.) *Managing Intellectual Capital and Innovation for Sustainable and Inclusive Society: Managing Intellectual Capital and Innovation; Proceedings of the MakeLearn and TIIM Joint International Conference 2015* (pp. 1321-1327). Bangkok, Celje, Lublin: ToKnowPress. *(EconPaper-Ideas, Google)*
11. **Rennung, F.,** Borca, C., Luminosu, C., Draghici, A. (2015). Evaluation model for success factors in large industrial projects. *Proceedings of the 7th International Conference on Manufacturing Science and Education - MSE 2015,*pp. 26-31, Sibiu:ULBS.
12. Costescu, I., Duran, D., **Rennung, F.** (2015). Some Considerations about Outsourcing Strategies. *Scientific Bulletin of Politehnica University of Timisoara, Romania; Transactions on Engineering and Management; Vol. 1, Issue 1, 2015,* 16-19. *(CNCSIS index C+D)*
13. **Rennung, F**., Borca, C., Luminosu, C., Draghici, A. (2015). Economical Engineering Via Evaluation Model in Large Industrial Projects. *Review of Management & Economic Engineering, Vol. 14(3),* 609-616. *(Ulrich's, Copernicus, Cabell)*
14. **Rennung F.**, Luminosu C., Draghici A., Paschek D. (2016). An Evaluation of Strategic Methods of Complexity Management to Manage Large Outsourcing Projects Sucessfully. In: (n.d.) *Managing Innovation and Diversity in Knowledge Society through Turbulent Time, Proceedings of the MakeLearn and TIIM Joint International Conference 2016* (pp. 79-88). Bangkok, Celje, Lublin: ToKnowPress. *(EconPaper-Ideas, Google)*
15. Paschek D., Draghici A., **Rennung F.,** Trusculescu A., (2016). Individual risk early warning systems as a management instrument to handle crises, *RMEE - Review of Management and Economic Engineering*, 140-147.
16. Paschek D., **Rennung F.**, Trusculescu A., Draghici A. (2016). Corporate Development with Agile Business Process Modeling as a Key success factor. *CENTERIS - Conference on ENTERprise Information Systems 2016 in Porto, October 05-07, 2016, Procedia Computer Science, 100/2016,* 1168-1175. DOI:10.1016/S1877-0509(16)32534-0. *(Springer, to be index in ISI Thomson)*

Timişoara, October 2016 M.A. Eng. Frank Martin RENNUNG

2. STATE-OF-THE-ART ON COMPLEXITY MANAGEMENT IN A LARGE-SCALE BUSINESS ENVIRONMENT

In the first part of this chapter, the results of research on current bibliographic references are presented, with respect to the conceptual framework of the thesis. The relevant identified management disciplines (complexity perspectives) will be synthesized (schema). This will serve as a guide for the present status of research on ***complexity management for service provisioning in large volume environment***. Second, the relevant complexity management researches will be overview in order to define and delimit the research context of the PhD program.

2.1. Conceptual definitions and contextual description of this research

At the beginning of the research, the priority themes are discussed in order to fix and describe the scope and clarify the delineation of this research. **Annex 1** presents the overview of the relevant and touched on research disciplines.

2.1.1. Complexity management

In science field there exists a variety of approaches and sub-disciplines of complexity management. There is a scientific understanding that complexity means *new ways* to go where traditional strategies have reached their limits. The complexity of a complex phenomenon cannot be fully described, since a large number of system components exist and they interact in a non-reproducible manner. Complex problems are characterized by high uncertainty, conflicting objectives, different forms of information, multiple interests and perspectives. The scientific references synthesis has underlined that there is no clear definition, description and interpretation of complexity (perception), as well as of the methodological approach of the complexity itself (Keune & Dendoncker, 2014, p. 169). Therefore, many researchers recommend two basic strategies: *reduction* and *manageability complexity* (Weinreich et al., 2014, p. 459). As part of the present research, complexity approaches and methods are considered in the business context. Here there is also, a common understanding that complexity is business-supportive to a certain degree and above a certain degree, the negative effects are detrimental to the business (Grebe & Danke, 2013, p. 3).

What is Complexity?

Greg Satell discussed this topic in a scope, which fits to the context of this research. He pointed out some highlights business aspects as following:

- *Nonlinearity:* Many business aspects are non-linear and this fact is difficult to manage. Nonlinearity can be extremely dangerous for a company or a business situation. What first looks relatively small and inconsequential can indeed become a big, fast and dominant negative topic or aspect.

- *Emergent Complexity:* This is a confusing form of complexity, because unlike nonlinearity, it is not a simple matter of accounting for rates of change, because of the emergence interactions and the unexpected occurrences of the phenomena. Managers need to manage complex information and work in a particular context define by a unique combination of people, processes and competitive environment, and they need to develop future strategies and evaluate options in uncertain situations.
- *Micromotives and Macrobehavior:* A particularly difficult aspect of emergent complexity is that interactions between factors are not transparent and can often lead to phenomena that are sometime impossible to foresee. That means, managers cannot think in and about nodes, but about networks.
- *Becoming Less Wrong Over Time:* Managers are used to deal with "*hard facts and data driven*". Unfortunately, in the initial phase of a decision making process, a lot of supposed information is not complete and/or sometime wrong estimated. Later (following the system of process dynamics), the uncertainty is reduced, together with the level of false judgements.
- *Seek Simplicity, But Distrust It:* Satell does not believe managers will ever embrace complexity to a great extent. Complexity is messy and uncomfortable. It is fine and well to enjoy thinking about complexity as an intellectual exercise, but when someone is accountable for results, it is a nuisance. Furthermore, complexity is something uncomfortable for the decision makers. There must be a willingness to deal with it intellectually; not only dealing with topics that are controllable is necessary, but also with the issues that are uncontrollable (Satell, 2013).

Another complexity classification takes into consideration the separation if the system under assessment is predictable on a long-term prognosis or not. In foreseeability, the input and output variables are known and regarding their effect, are estimated in the long term. In systems where no predictions about the time are at all possible, only the level of uncertainty can be reduced (Helbing, 2012, p. 57). Complexity management experts sustained that understanding complexity means that it is most controllable, but hardly still manageable (Amann & Krumm, 2013, p. 6).

Generally, complexity has two aspects*: the structure of the complex and the complex behavior of a system*. Both aspects are considered in the present research.

- Complex structure means that the system has many or multi-various elements, which have intensive interactions. Each element is linked to another; the nature of the links may themselves be non-trivial. Due to the interdependence of the elements, complex internal structures are formed.
- Complexity is reflected in the complex behavior. Among them is, first, an understanding of the variety of response options. Depending on the perspective and to the question posed to the system, different, conflicting sides may be revealed (Dittes, 2012, p. 3).

Complexity offers immense opportunities for those companies that are able to properly address it and which are able to offer robust processes and solutions to deal with it (Czinki & Hentschel, 2016).The focus of this research excluded a mere decision-making character of complexity management based on existing framework of information, e.g. as a discipline of complexity management, like in (Budde et al., 2015).

2.1.2. (IT) Outsourcing

In outsourcing, certain operating units are transferred to an external provider in order to strengthen the competitive position of the company. Here organizational structures of the parent company are separated and transferred to another undertaking. For this reason, outsourcing projects of strategic importance

will be finalized at least for a few years, with the possibility to extend (Breński, 2015). During the transition phase of an outsourcing project, the relationships between the companies involved, with their roles and responsibilities and many interfaces, are redefined (Hedman &Xiao, 2016).

In recent decades, the importance of outsourcing has grown in research. Concomitantly, the number of studies increased which is why many outsourcing projects failed or often targets are missed. These new and different lines of research have been repeatedly applied and further developed (Vetter et al., 2012).

A multidimensional definition provided by (Bravard & Morgan, 2009):

- "*Outsourcing is the contractual use and profitable utilization of resources, assets and competencies from a third party;*
- *Outsourcing provides guaranteed performance standards of quality, stability, cost-benefit criteria and their measurement;*
- *Outsourcing aims to provide defined services that were previously performed in-house;*
- *Outsourcing may be connected to a personal transfer;*
- *An outsourcing project is connected to a process transformation*".

The term information technology (IT) outsourcing in encompasses all services, based on those which are information technology supported as well as on the implementation and operation of IT systems. IT Outsourcing services usually include a piece of hardware (mainframe, server, personal computer, network, and other devices), a software component (operating systems, standard application software, and custom application development) and a service component in the narrow sense (consulting, design, implementation and operation of IT solutions for the customer). IT Outsourcing can either outsource the IT infrastructure or include the outsourcing of all IT tasks and resources.

The purpose of this research is to analyze the case of outsourcing where the IT infrastructure, the employees, responsibilities and tasks will be outsourced and transferred from customer to a service provider. One way to further differentiate IT Outsourcing services is the division into Business Process Outsourcing (BPO), applications management and infrastructure outsourcing services (Burr, 2014, p. 135). From another perspective, Kurzlechner (2014) stresses that the services offered are too complex. This, in turn means that potential customers cannot be persuaded to take the step to an outsourcing approach (Kurzlechner, 2014, p.4).

Large companies, e.g. with more than 500 employees, have their own significant share of value added in the provision of services for several large customers with a comparable organization size; stakeholders and target groups have to be given special consideration. In outsourcing projects, the savings and efficiencies are often overestimated. However, significantly underestimated is too often considered the complexity of a sourcing project, from the perspective of its many direct and indirect factors of influence (Brodnik, 2014).

Large-scale projects are often called mega-projects. Brookes analyzed these specific type of projects emphasizing that these projects are characterized by extreme complexity (Brookes, 2015). In a real and complex world, there is always chaos. By making artificial separations (simplification of reality) and by reducing complexity one can achieve only a state of apparent planning and superficial security (Vollmer, 2014, p. 112). In **Annex 2**, a generic procedure model in outsourcing projects is displayed graphically as a synthesis of the presented aspects.

2.1.3. Industry 4.0 framework

The keyword *Industry 4.0* means a development that changes the traditional industries fundamentally (Manhart, 2015). The competitive situation, i.e. German companies and economy, is characterized by a growing momentum. Dealing with increasing product and process complexity associated with volatile markets and the ever-shortening product, market, technology and innovation cycles are permanent challenge for German companies. These include both the development of competitive products and services as well as the management of more efficient and versatile logistics and production systems. High commodity prices and the already emerging effects of demographic changes intensify the competitive situation of German companies. In connection with the outlined difficult competitive industry, the 4.0 strategy *will be* regarded as a key driver for the maintenance and expansion of Germany's competitiveness. Under *Industry 4.0* we understand an intelligent integration of products and processes in the industrial value chain. This "*intelligence enables the generation of added value through more efficient or new processes by achieving better sales opportunities for higher-value products, services or combinations thereof*" (Kempf, 2014).

Kersten et al. analyzed the possibilities of Industry 4.0 use as an element of risk management, by a combination of people, objects and systems dynamic, real-time optimized and self-organizing; enterprise-wide value networks arise. These effects have been studied based on the supply chain management process (Kersten et al., 2014).

The SAS Institute GmbH instructed the "*Forsa Gesellschaft für Sozialforschung und statistische Analysen mbH*", to conduct a study in 200 companies. The involved enterprises evaluate the "*Industry 4.0 draughts*" in the close future as very important according to the 84%responses of the involved enterprises and at bigger enterprises even of 89% (Altmann, 2013, p.9). In addition, for German politics this is an important fact. Furthermore, Sigmar emphasizes five dimensions (industrial policy, employment political, data security, middle class companies' policy, and the regulatory dimension), which are relevant and essential for the implementation of Industry 4.0 (Sigmar, 2015).

Worldwide there are even more future projects compared to Industry 4.0, such as *Industrial Internet Consortium (IIC)*, which are preparing for the digitization age (Merkel, 2015). However, it is also quite controversially discussed in the business world: Does the economic world really need a dedicated concept as Industry 4.0, or will a continuous development and optimization of industry be enough, without the need for a separate concept: Industry 4.0 (Gersemann, 2015)? In addition, the progress of Industry 4.0 is seen increasingly critical by the public and perceived as too slow leading to the conclusion that other continents will potentially overtake Europe (technologically) in the future (Giersberg, 2016).

An interactive map shows test environments and competence centers in Germany, where Industry 4.0 applications can be tested (BMWI, 2016). In recent years, there has been a tough competition, whether German or American industry is leading the digitalization era. The responsible parties have now decided to go the way to the Intelligent Factory from now on together. Representatives from the German "*Platform Industry 4.0*" and the American "*Industrial Internet Consortium*" (HC) express their intention to cooperate closely in the future (Giersberg, 2016).

2.1.4. Delimitation of this research

The focus of this research is the design of Complexity Management for usage in a large-scale business environment. The proposed holistic model is designed for an exemplary large-scale project in the case of IT Outsourcing. The Complexity model is highly interdisciplinary. As part of this thesis, exclusively complexity relevant aspects are examined and included in the model and modelling processes.

Methods and instruments, which are not complexity-specific, are not examined in detail and used. In the corresponding sections in this thesis, a reference is given to the distinction in this case. In **Annex 1**, the focus of the research is presented graphically; in this graph, the disciplines, which are relevant and have a complexity-specific character, can be seen.

2.2. Relevant complexity management research areas

2.2.1. The complexity role in projects related to Industry 4.0

Industrial companies are currently facing the challenges of increasing individualization of products and services, the necessity of resource efficiency and shortening time-to-market. These challenges need an IT penetration (to support all processes) and networking develop products, manufacturing resources and processes. Concepts are often grouped under the term Industry 4.0 (Lachenmaier et al., 2015). According to (Voigt& Kiel, 2015), the key success factors, which were the study results developed in 2015, carried out with the support of 56 experts, are innovation, flexibility and complexity management and data security.

The Fraunhofer Institute collaborates with various universities and industrial companies to develop Industry 4.0 initiative (through different projects). In 2013, the Institute published a study done with 661 manufacturing companies, supplemented by 21 renowned experts in the industry, leading scientists and association and trade union representatives. Because of the survey, three future-relevant topics were identified as particularly important and urgent: (1) dealing with complexity; (2) innovation capacity; (3) flexibility.

Furthermore, precise statements, regarding complexity, are underlined in the following: "The competitive advantage will be the mastery of complexity and complex technologies along with the necessary know-how in the future. We can standardize services. The problem is that we are trying to standardize process chains and processes. This does not meet the future demands and challenges, because the processes always evolve" (Spath et al., 2013).

Thomas Bauernhansl also, published in the "mav Innovationsforum" the thesis, which recognized that "diversity of the technologies used and the lack of dominant designs today, together with a further increased individualization and personalization of products and services, will result in a *complexity explosion*. Growing complexity is always accompanied by a multiple of decentralization and autonomy of divisions in a large company. Only sufficiently complex corporate structures can arise with which the high level can be successfully "managed" to external complexity". Bauernhansl sustained that the assessment of the Industry 4.0 potentials in large company can be done via so-called "*use cases*". He considered these as *application scenarios* that use Industry 4.0 technologies (by considering application of the benefits transparent). He suggested that preliminary there have to be analyzed the internal environment of the large company in order to identify which use cases are useful for the application and for which the Industry 4.0

technologies are possible to be used. A graphic detail in **Annex 3** illustrates these relationships (Bauernhansel, 2014, 2).

Industry 4.0 strategy wants to bring the German industry in a position to be ready for the future production. Industrial production has to be able to deliver strong customization products under the conditions of high flexible large-scale production, high degree of customers and business partners' integration in business and value-added processes and the coupling of production and quality services.

New business models and significant potentials for optimization in the context of the production and logistics strong needs that have to be developed. This, in turn, adds new services to important areas of application, such as mobility, health, climate and energy (BMBF 1, 2014).

The process levels of the organization are consistently linked to each other and can be tuned with one another repeatedly based on the most recent process data. Horizontal integration, i.e. the networking among several companies, is the starting point of the flexible design of joint value creation processes. Many companies are increasingly confronted with a complex value chain, the steps of which can no longer be described as a chain, but form a web of relationships in which individual companies focus on specific skills. The volatility of the markets continues to grow while the predictability of development, as an important prerequisite for production planning, is declining. Some companies have found their way into the intelligent networked production by initially buying networked production processes as services of third parties (BMBF 2, 2014).

Some institutions and companies currently concretize the development of the value chain in order to control the growing instability. The Deutsche Ingenieure e.V. association published a status report in April 2014 and there have been recognized that product life cycle is increasingly oriented towards individual customer requirements. The life cycle starts with the product idea to order processing and ends with the completion of the order. Through the combination of people, objects and systems dynamic, real-time optimized and self-organizing, enterprise-wide value networks arise in order to support a specific product life cycle (VDI/VDE-Gesellschaft, 2014).

For the implementation of the Industrial 4.0 Vision, the research of (Erol et al., 2016) recommend to develop an Industry 4.0 roadmap with the following dimensions:

- *Market Perspective*: customer segments and the structure of the customer needs;
- *Product perspective*: benefits and added value for the customer;
- *Process perspective*: Resources and Technology;
- *Network Perspective*: partners to fulfil customer benefits. (Erol et al., 2016).

2.2.2. Pre-conclusions

In Table 2.1 is presented the synthesis of the complexity role in projects related to Industry 4.0.

Tab. 2.1. Stages of development of complexity in the project Industry 4.0 (own table)

Scientific Concepts		
Complexity in the project Industry 4.0	- *Produktionsarbeit der Zukunft – Industrie 4.0* (translated: Production work of the future-Industry 4.0): Implementation and comprehensive analysis of a study by the Fraunhofer Institute with the following lead questions: - Future requirements for production companies; - Developing solutions for successful production work by using new technologies; - Which mega trends will affect the future production work? The objective of the study was to create a working basis to actively shape the fourth industrial revolution and thus to support companies on their way to Industry 4.0, to compete successfully in the future in the global market.	(Spath et al., 2013)
	- *Komplexität bewirtschaften* (translated: manage complexity): Complexity relevant discussion within the framework of the project Industry 4.0 with the structure: 1. New requirements for the product lifecycle; 2. Towards the *Fourth Industrial Revolution;* 3. Potential for successful implementation; 4. Model for the implementation of Industry 4.0.	(Bauernhansl, 2014 (1))
	- *Komplexität bewirtschaften: Die Einführung von Industrie 4.0 in Produktionssysteme* (translated: The implementation of Industry 4.0 in production systems): Presentation of an analysis, a study carried out in 2013, and the resulting requirements to the industry, focus on production systems at *mav Innovationsforum 2014* in April 2014 in Böblingen.	(Bauernhansl, 2014 (2))
Complexity in the project Industry 4.0	- *Zukunftsprojekt Industrie 4.0* (translated: Futureproject Industry 4.0): Presentation of the future project Industry 4.0, the *Deutsches Bundesministerium für Bildung und Forschung* (translated: German Federal Ministry for Education and Research), which has the goal to put the German industry in a position to be ready for the future of production.	(BMBF 1, 2014)
	- *Zukunftsbild Industrie 4.0* (translated: Picture of the future Industry 4.0): "pictures of the future" are understood as an instrument of strategy development, with the help of complex issues for the future, presented in illustrative descriptions. These incorporate a variety of different aspects to a consistent overall picture and show, starting from different professional perspectives, how a possible future could look like. They help to structure the discussion on key issues and to focus and at the same time on relevant details included in the overall context, to evaluate possible technical, economic or social developments. The explanations of the present "Future picture" based primarily on interviews with experts Research Union Economy Science and the BMBF Papers 512 (Research for production, services and labor) and 514 (IT systems).	(BMBF 2, 2014)
	- *Industrie 4.0 - volkswirtschaftliches Potential für Deutschland* (translated: Industry 4.0 - national economic potential for Germany): Implementation and preparation of the results of potential assessment in the form of a study for the use of Industry 4.0 to the year 2015	(Kempf, president of BITKOM in cooperation with

Scientific Concepts		
		Fraunhofer-Institut, 2014)
	- *Industrie 4.0 Statusreport – Wertschöpfungsketten* (translated: Industry 4.0 Status Report - value chains): A value chain describes the value-added processes throughout the life cycle of an asset. The concept Industry 4.0 landscape includes four characteristic internal value chains: - Product and Product Line Engineering; - Process and plant development; - Product Production; - After Sales Services - Technical facility.	(VDI/VDE-Gesellschaft, 2014)
Complexity in the project Industry 4.0	- *Auf dem Weg zur Industrie 4.0 – ein dreistufiges Vorgehensmodell* (translated: On the way to Industry 4.0- a three step approach): Developing an Industry 4.0 roadmap with the dimensions: Market Perspective, Product perspective, Process Perspective and Network Perspective.	(Erol et al., 2016)

The top-level objective of the strategy Industry 4.0 and complexity management, to prepare the industrial manufacturing for future challenges is similar to the top level. Also, similar is the methodological determination of the mega-trends of the business world. In the study done by the Fraunhofer Institute, it has been pointed out that mastering the complexity is a mission critical action of the future. Due to the actuality of the project Industry 4.0, no concrete methods and instruments exist in science and practice. The detailed specifications (processes, organization, technology, dynamics of the environment and other factors), the complexity drivers by several researchers, are almost the same; similar is the fundamental separation between the internal and external perspective (associated with company's environment issues).

The model and approach by Bauernhansl with *use cases*, proposed in order to perform the analysis of complexity is used and further developments were discussed later in the thesis.

It is noteworthy that publications on Industry 4.0 are all very timely. Also, it should be noted that to date, only objectives and frameworks exist. Concretely derived concepts and recommendations are lacking. Within the research context of this thesis, Industry 4.0strategy implementation approach will be further developed in the framework of the complexity related topics.

The perspectives of the Industry 4.0 roadmap of (Erol et al., 2016) correspond to potential applications for the use in a Balanced Scorecard model. These ideas of (Erol et al., 2016) will be integrated in the further development of this research.

2.2.3. Concepts for managing complexity in business situations

2.2.3.1. Holistic complexity management

In the following section, scientific concepts will be analyzed and presented, focused on the holistic approach of complexity in business situations. They are displayed in chronological order.

Claus Gerberich research (cited by (Maier, 2004)) shows that the principal aim in complexity management is creating a balance between internal and external complexity. Gerberich emphasized that not only the reduction should be in the foreground; otherwise, there is a risk that the company is concentrated on its core competencies. In addition, he mentions the following recommendations for action (Maier, 2004):

- Complexity management is a critical success factor. Not the minimum is desirable, but the optimum;
- The complexity causes have to be recognized. These are often in management, product, organization, and value chains;
- Product and process structuring is the central element of complexity management;
- Complexity management requires real commitment by management;
- Complexity management is an ongoing task and has to be performed from both an inwardly and an outwardly perspective.

The industrial ecology is still a young research filed of interest, with an emphasis on science, engineering and planning sciences. It searches for viable solutions to manage business processes in ecosystems and deal overall, with the increasing complexity and uncertainty. A guiding principle of this research discipline is that there are no laws of nature in dealing with complexity. *The human mind is plastic and the human thinking does not take place according to a fixed set of rules*. *Thoughts can be "shaped" to deal with complexity. The human mind is led by motives, which has a significant influence on the approach in dealing with complexity in the planning, information gathering and derived actions.*

In order to cope with problems in a complex environment, the five processes presented in Figure 2.1 are recommended; they should always be performed sequentially (Dörner, 2008).

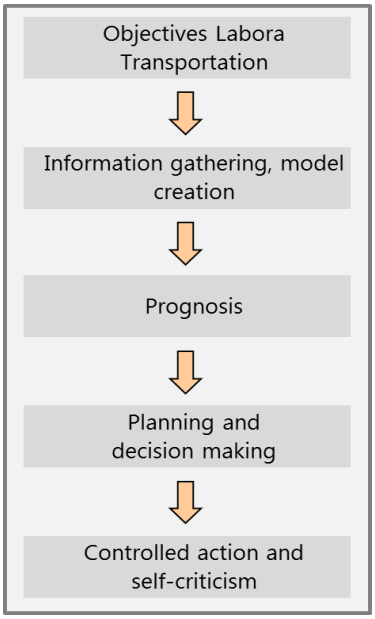

Fig. 2.1. Process Map Stations of action (Dörner, 2008)

The phase *Objectives Labora Transportation* includes the formulation of upper and lower targets, but also the conducting of a situation analysis. A look into the past is important, i.e., deriving future trends from past conditions and developed resulting situations.

In the phase *Information gathering, model creation* a surroundings analysis (technological, legal, economic, social and environmental dimensions) needs to be performed; it is to consider the near and far environment. It is also important to consider the fact that any business situation is influenced by both visible and invisible factors. In the formation of the model, the expected effects of the environment must be considered and defined. The analyst must be aware that the results are dominated by a limited perception and rationality.

In the next phase, *Planning and decision making*, the future steps have to be planned. A De-conditionality is to be performed which is an appropriate method in this step. Specifically, this does not mean to carry out detailed planning to reach the overall target, but rather gradually, to proceed in the direction of the target. The background is that the framework conditions affecting the project are unstable and can thus have a significant impact on the activities required in the project.

In the last phase *Controlled action and self-criticism*, the previous steps must be reflected. The results should be discussed in a group. At the end, a decision for the next steps must be taken (with involvement of converting organizational units). If a correction of partial results is required, the steps listed shall be repeated.

In summary, the following recommendations for action are given (Dörner, 2008):

- Most of the events are not only dependent on one factor;
- The conditions are changing. The conditions are constantly changing; this must always be considered in carrying out the tasks;
- General rules should be distrusted;
- Detailed planning is not always useful if the complexity of factors can affect the project;
- When carrying out any measure, the actions should be followed by the question: "*Why do you do that?"*

Denk & Pfneissl (2009) classify complexity drivers into the following three categories:

1. General complexity driven status and performance criteria:

- Lack of transparency;
- Unclear structures / interfaces;
- Inertia change / implementation weaknesses;
- Barriers to communication;
- Tendency to dumb simplification;

2. Drivers of structural internal complexity:

- Structure of market services;
- Product and product range structure;
- Customer structure;
- Brand policy;
- Structure of production and logistics structure;
- Order sizes / classes and lot sizes structure;
- Alliance and joint venture structures;
- Contract sales structures;
- Structure of the resources;
- Supplier structure and contractual structures in sourcing;

- Supply chain;
- Make or buy structures;
- Structures of the organization;
- Structure organizational structure, modularity and granularity;
- Structural fit / misfit of organization, responsibility and accounting;
- Process structure;
- Number of divisions, business units, profit centers, cost units etc.;
- Number of sub-societies and served regions;
- Network effects of the business portfolio;

3. Drivers of complexity in the control systems:

- Complexity, based on unclear objectives, scope and design of the steering instruments;
- Contradictory function of planning and forecasting;
- Unclear business goals or prospects for development as a basis of the control instruments;
- Undifferentiated structuring and accuracy requirements, for example in long-term planning;
- Planning of existing resources versus thinking in development and effectiveness goals;
- Complexity of business management instruments (in conjunction with structural changes);
- Business instruments are complicated by nature, due to a consideration of numerous requirements (by law, ...). A major challenge is it to deal with structural changes in large (often international) organizations;
- Integration level managerial instruments in the existing organization;
- Complexity of regulatory processes (planning, forecasting);
- Planning - and forecasting processes require the coordination of a variety of participants in companies;
- The complexity in the planning increases with increasing maturity of the information booths, through consultation and feedback loops increases;
- Technical complexity in the control instruments;
- Developed control instruments produce a high degree of technology-related complexity due to numerous interfaces;
- Often arises in complexity management tools due to technical constraints simplification.

Denk & Pfneissl (2009) summarize what qualitative aspects must be considered in a complexity control model:

1. Internal and external complexity have relationships. In case of changes attention must be paid to the interactions;
2. The content of the design complexity should always be done on the basis of a net-benefit assessment;
3. In case of changes of complexities, changes can arise elsewhere. These consequences must be an integral part of a proper orientation in complexity-related decision making;
4. In practice, there is the tendency that complexity is evaluated only based on hard factors (processes, resources etc.). The complexity of consequences that arise from *management practices* may be far more dramatic. These aspects can be very hardly measurable today.

Engel and Scheel (2009) recommend a four-column procedure model for dealing with complexity, as described in the article: *Der Spagat – Unternehmen zwischen Differenzierung und Kostenfalle* (translated: The balancing act - between business differentiation and cost trap). These four columns are:

- *Strategy Anchoring*: Anchoring of complexity management in the company's strategy and culture;
- *Transparency*: Complexity transparency costs on product and customer level;
- *Value chain*: Targeted regulation of complexity along the entire value chain;
- *Sustainability*: Tools and systems to ensure continuous monitoring and control.

Christian Neubaur recommends a holistic enterprise wide approach to the complexity of management in the report: *20 Jahre Komplexitätsmanagement* (translated: 20 years of complexity management). Neubaur described "*three guiding principles*" for implementation (Neubaur, 2009):

- Comprehensive analysis of the initial situation;
- Holistic demonstration of various interactions;
- Constructive management of complexity.

The aim is that various influencing factors are taken into account when making decisions; holistic decisions are made by considering interactions, as well as successfully align the company to the complexity of the environment (Neubaur, 2009). In addition, Štuikys & Damaševičius have developed a *logic to measure complexity* based on analyzing the different relationships between system's elements. At first, it is differentiated between the node (feature) and second, between the following relationships: mandatory feature relationship (and-relationship), optional feature relationship, alternative feature relationship (case-relationship), groupings of relationships (cardinality) and relationships among nodes and constraint relationships (Štuikys & Damaševičius, 2009); these results are not presented in the list of researches, because of a lower impact on this research.

In 2010, Brown et al. (from the BCG Company) recommend the following eight strategies for mastering complexity:

- **Make complexity transparent:**

Analyze and expose areas where complexity arises in an organization and what the related costs and benefits are. Companies can implement this simple system for measuring the degree of complexity in order to streamline the complexity and minimize costs within the organization. This may be realized through a company-wide *complexity index*. For this example, the respective departments, number of portfolio products, brands, legal entities, manufacturing plants and suppliers must be taken into consideration as complexity factors. The company is then able to improve this *basic complexity index* by concrete and targeted measures and thereby control the complexity existing in the company.

- **Apply the 80/20 rule:**

In many companies, the 80/20 rule is established and it means that 20% of customers or products account for 80% of sales. This rule can also be applied to the complexity. In the second step, the same calculation for the remaining 20% of revenue shall be carried out. The aim is to identify the customers and products, where a mismatch to the generated turnover exists in order to initiate targeted improvement measures.

- **Optimize the whole, not separate silos:**

Silo mentality hinders all efforts to reduce operational complexity systematically. Without a cross-functional, end-to-end view of the entire enterprise, decision-makers tend to concentrate on their own functions or departments. The silo thinking is a source of process complexity. In order to optimize processes and

minimize costs, companies should analyze all critical, cross-functional processes, as well as those that serve internal purposes only. Measuring factors such as time, cost, error, volume and the number of people and points of contact should be considered. This analysis includes the identification of costs and potential costs in processes, step by step.

- **Segregate complexity into separate systems:**

Due to the separation of complex products and processes and how to deal with them as outliers, it is possible for the company to realize the company's standard processes efficiently and in a cost-optimized manner. For example, if a complex product must be built according to customer requirements, it is possible to separate this line of products and the production processes from each other. A part of the production process is made by mass production; other sub-processes, such as finishing work and customization are produced individually.

- **Bundling features together to "standardize" complexity:**

By bundling groups of arbitrary functions in standard packages, industrial companies are able to produce standard elements efficiently while providing added value for customers individualized.

- **Defining plant and asset roles:**

To minimize the complexity of the production and to achieve more output from the production, network characteristics with the needs of specific products and customers shall be classified. Products with similar characteristics are to be consolidated to achieve greater cost savings, flexibility and efficiency. In the next step, the classification of the preparation of the product lines must be performed in two categories:

- High-volume elements - These requirements are classified into as *high-volume production* with a limited number of products with only a few changes.
- Multi product or flexible assets - For a broader portfolio of small series products or products with volatile or unpredictable demand, production facilities are involved with quick-change ways of reaching versatility and flexibility.

By defining specific asset roll-like *high-volume asset* or *low-volume assets* and creating strict guidelines for the allocation of products to assets, the company has the possibility to reduce the costs per unit.

- **Identifying organizational blockages—and delayer:**

Complex organizational structures include layers and interfaces, which have no clear responsibility. There is a risk that difficult decision and obscure responsibility takes place leading to 'orphan' costs and complexities. This complexity, often outside the company, extends to joint ventures, investments, suppliers, subcontractors and other partners. This increases the number of people in the business processes. A high number of interfaces can paralyze the organization in practice in their actions. Moreover, the addressing of organizational complexity management requires a large-screen view. Networks must be analyzed, information flows between organizational silos and blockages have to be identified and relevant processes with no clear owner shall be subjected to a particular observation. The dependencies between functions and interfaces are often not visible and important elements can fall through the cracks. Therefore, it is important to clarify responsibilities, especially for tasks and processes in the organizational units.

- **Challenging assumptions and model new scenarios:**

The impact on the cost of complexity is rarely clearly identifiable. By modelling different optimization scenarios, a company can strategically gauge where relevant improvement can be achieved. Often, the findings are not unique. A modelling of the impact of various scenarios for reducing the complexity can show

how capacity utilization for the overall performance of the organization behaves (Brown et al., 2010).

An important achievement for the complexity approach belongs to Addor, which developed a recommendation methodology called *Seven Steps in the intuitive handling of complexity,* in 2011. In step one, *Get the situation*, the core of the problem is described and often graphically represented. Step two involves the *Intuitive by characterizing the problem into archetypes*. This is an analytical method of psychology to analyze the structure of the collective unconscious. In systems theory, the structure of behavior patterns is described. Step three involves the use of archetypes, step four *formulating the problem as a dilemma cloud*, as well as the formation of hypotheses, which are then discussed afterwards. Step five *questions the hypotheses* put forward. Step six is the so-called *Intuition Check* with different approaches, such as encapsulation and thematic vagrancy. Step seven is the *examination of the methodological approach* of step one to six and a fresh start, if required, to assess the complex situation (Addor, 2011).

In 2012, Frank-Michael Dittes lists various natural phenomena, which pass over a system behavior of a complex state in a chaotic state. As an example, he used a sand pile, where an additional grain of sand is sufficient so that an avalanche is triggered. This sensitive dependence of a system behavior, for example, of the initial and conditions is referred to as "*deterministic chaos*". The word "*chaos*" is derived from the Greek language and includes several aspects: complete irregularity, incalculability, unpredictability of the system and the instability of the system state. Deterministic systems are unstable and easily interruptible: Minute alterations lead to large changes in the results. Dittes (2012) imposes the following reasons for the steady growth of complexity:

- The functions of systems are constantly being improved;
- Systems are differentiated and flexible so that they can better correspond to a more differentiated reality;
- Systems can be expanded with more and more features to appeal to a wider range of customers;
- Various systems are intertwined with each other to provide the overall benefit of a combined system.

Dittes recommends (like other previous cite researchers, too) capturing complexities through networks and making them tangible. The networks have two types of components (Dittes, 2012):

1. *Node*: these are the place where the connections are linked with each other.
2. *Edge*: these are the connections between the nodes themselves. These edges can possess certain properties.

Johnson (2012) describes the main components of complexity management as follow:

- "The system is a collection of many interacting objects or agents;
- This objects behavior is influenced by storage or feedback loops;
- The objects can adapt their strategies according to their tale;
- The system behavior is usually open;
- The system is to be kept functional;
- The system displays emergent phenomena that are generally unpredictable, and can take extreme forms;
- The emergent phenomena typically occur in the absence of any kind of "*invisible hand*" or "*central management*";
- The system displays a complicated mix of ordered and disordered system behavior".

Stephan Krumm is the business partner in the consulting company *Schuh & Company Complexity Management*. The company is specialized in strategic and operational management complexity. Based on 20 years of experience in the field, Krumm recommends a five-point programme to control complexity by taking into account the following organizational issues (Krumm, 2012, p. 3-4):1. Product; 2. Process; 3. Production; 4. Innovation; 5. Personnel.

Jacobs (2013) developed a generic and holistic complexity model (*Complexity: Toward an empirical measure)* by defining the *Generalized Complexity Index* (GCI), with three dimensions: *Multiplicity, Diversity* and *Interconnectedness*. The base of the complexity evaluation model was originally the product management; however, it can also be applied in a generic context, such as organizational review. For each of the dimensions, a mathematical formula was defined as described in the following (Jacobs, 2013):

- *Multiplicity* is defined as follows:
  Multiplicity=# of variants=V; *(2.1)*
- For *Diversity*:
  Diversity=1-(unique elements/total elements) =1 – U/T; *(2.2)*
- For *Interconnectedness*:
  Interconnectedness=connections/max connections=A/M. *(2.3)*

This approach will not be more concretized and used in this research, because it only partially fits with the scope, for example, because of the lack of uncertainties consideration and because of it is most suitable to product management.

In 2013, Donald Lessard, Vivek Sakhrani and Roger Miller published an article "*House of Project Complexity - Understanding Complexity in Large Infrastructure Projects*", in which they have developed a model to analyze and present complexity in a graphical way, called "*The House of project complexity*". The core of the model are the following two dimensions: (1) institutional features and (2) technical features. (Lessard et al., 2013). This model is briefly presented in **Annex 4.**

In 2013, Dieter Specht and Gunnar Berntsen have developed a model in dealing with complexities. Focus of their research and modelling is the "*definiteness degree of information"*. Starting point is the idea that business decisions are nowadays usually meet in an environment that is characterized by indirect effects, relationship networks and delays. Nevertheless, the identification and mapping system contexts in decision-making is often limited as cause-effect relationships and generally leads to erroneous handling of complex systems because the actual networking processes of system elements are ignored. The long-time sufficient uncross linked approach reaches its limits at a time of highly complex systems and networks with their respective structures and processes. The decisive factors in the detection of a complex system are:

- The level of aggregation;
- The selection of the essential elements of the system;
- Identification of characteristic relationships between the system elements.

Therefore, not only the collection of *quantitative information* but also, *qualitative information* is necessary to evaluate the system performance adequately.

The decision problems are characterized by the importance, complexity and the structured nature of the problem, the duration of action and the reversibility problem solving as well as the degree of uncertainty of environmental factors and the dynamics of the environment. The decision field of the decision-maker

comprises selectable alternatives or strategies in a given time that state the business environment and the consequences of each alternative course of action in a given state. Many of the planning and decision-making situations are performed in an environment in which the objectives, constraints and consequences of possible actions are not known in detail. In these cases, the planning and decision-making processes underlying information are imperfect. For the classification of imperfect information, used information can be distinguished by their definiteness as follows: security grade of determination, insecurity and un-sharpness. Three types of un-sharpness can be distinguished (see Figure 2.2):

- *Linguistic impreciseness*: These are substantive indefiniteness of words and sentences of the human language;
- *Informational un-sharpness*: This type of un-sharpness results from the difficulty to compress a large amount of information about a clear overall judgment. Although they are precisely defined terms, however, a large number of properties is necessary in addition to this comprehensive description;
- *Relational un-sharpness*: This type of un-sharpness includes statements that the mutual dependencies of the included objects do not have dichotomous character. This means that the relationships between the objects are not sharp, by way of example statements like "A" is greater than "B".

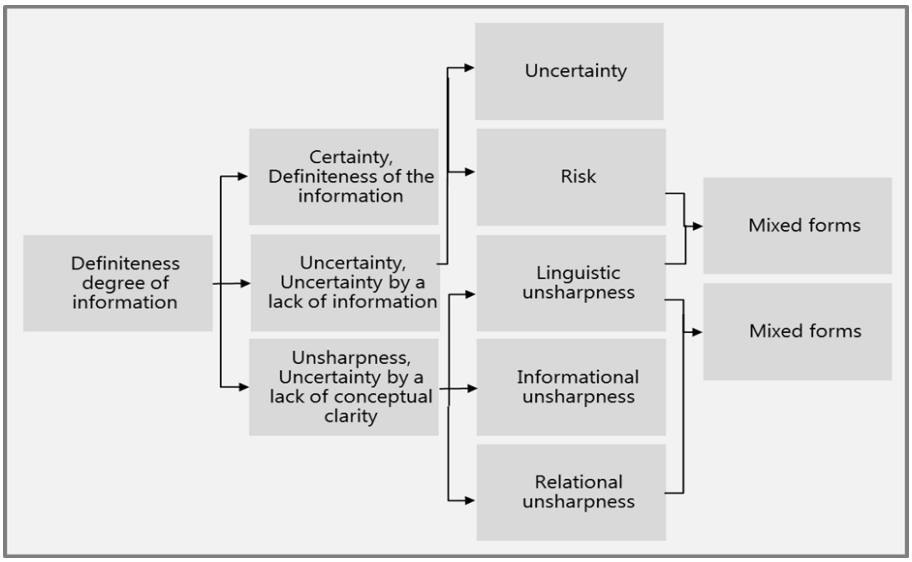

Fig. 2.2. Certainty degree of information (Specht and Berntsen, 2013)

In 2013, Wildemann has developed 23 functional modules that are considered relevant for complexity management in a company. These are specified in more detail in Figure 2.3, with respect to a service company and will be used in the present research, too. The complexity drivers in the business environment are manifold; these can be classified into a narrow sense (*detailed view*) and a broader sense (*holistic view*). Based on the detailed view, Wildemann has also developed three relevant basic strategies:

- **Avoiding complexity -** Through preventive measure the generation of complexity itself is to be avoided. Examples are modularization and standardization of products, organizational structures and processes. A

complexity avoidance may not be very pronounced to permanently survive in the market;

- **Mastering complexity -** The aim of this strategy is to handle unavoidable complexities. Caused by external system requirements, internal complexity applies it to dominate as efficiently as possible. The control can for example be done by organizational conditions, flexible interface designs or flexible and scalable IT systems;
- **Reducing complexity -** A reduction can be done through targeted measures in an existing system, for example by reducing the variety of products or the diversity of the system elements and their connections or processes" (Rennung et al., 2014, based on (Schoeneberg, 2014, p. 16) and (Wildemann, 2013)).

In **Annex 5**, the 23 modules are described in detail.

In 2014, Keune group of researchers shows how to manage complexity with a long-term perspective with a systemic focus on a process model in Transition Management. The transition management, by using incremental steps, focuses on changing the system and is geared towards sustainable development. This process model is shown schematically in Figure 2.4 (Keune et al., 2014, p. 149).

Niermann explained that situations in management are often unclear objectives that can be ambiguous, diverse and contradictory. The ideal of the perfect control is an illusion. This ambiguity, lack of transparency and inconsistency is the justification for the necessity of the role of the manager in the company (Niermann, 2014).

Strategies	Design	Time effect in ...
Reduce complexity	Reduce the existing complexity	Today
Manage complexity	Efficient handling of unavoidable complexity	Tomorrow
Avoid complexity	Preventing the development of new complexity	Future

Fig. 2.3. A universal complexity management (Wildemann, 2013, p.76)

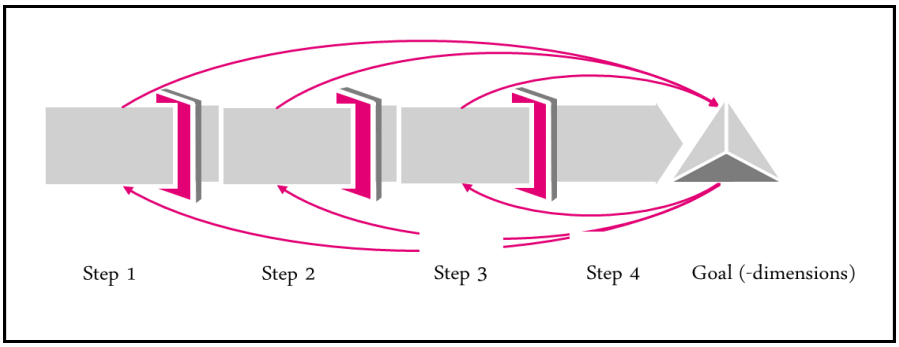

Fig. 2.4. Transitions Management (own graphic, derived from (Keune et al., 2014, p. 149))

Schoeneberg recommends practical possible tools and methods of managing complexity. Holistic and interdisciplinary approaches are in the foreground. Based on

the current state of research, he transferred the management of complexity in various business situations, e.g. in the automotive industry or product management. He classifies the complexity drivers as exogenous and endogenous, further for a detailed and holistic approach. Based on his previous researches, he structures the complexity drivers, as shown in Figure 2.5. In addition, Schöneberg characterized the complexity drivers using internal and external perspectives, related cluster issues and specific criteria (Table 2.2) (Schöneberg et al., 2014).

In "*Strategies for coping with complexity*" Wolfgang Vieweg presented the analysis which is based on past research objects, and on the following six main strategies (Vieweg, 2015, p.29):

- High sensitivity: pay attention to weak signals, establish a broad radar, high attention and mindfulness;

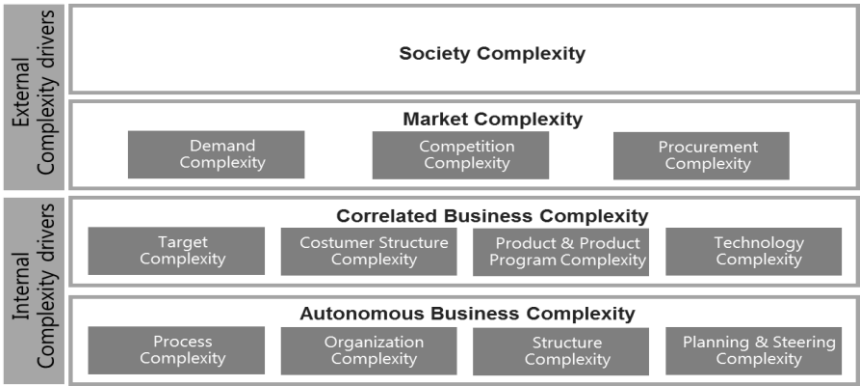

Fig. 2.5. Complexity drivers (Schoeneberg, 2014)

Tab. 2.2. Complexity drivers (Schoeneberg, 2014)

Complexity drivers		
View	***Cluster***	***Criteria***
External complexity drivers	Society complexity	– changing values; – environmental awareness; – economic and environmental factors; – political framework;
	Demand complexity	– diversity of customer requirements; – individuality of the demand; – market dynamics; – global requirements;
	Competition complexity	– number of strength of competitors; – changing markets; – competitive dynamics; – globalization;
	Procurement complexity	– number of suppliers; – procurement strategy and concept; – fluctuations in demand; – uncertainty of the delivery or quality;

Complexity drivers		
View	***Cluster***	***Criteria***
Internal complexity drivers	Target complexity	– number of tracked targets in parallel – dynamics of the target adjustment – maturity of goal achievement
	Costumer structure complexity	– number of customers and customer groups – heterogeneity of customers and customer groups – level of participation
	Product and product program complexity	– structure of products – product and version number – dynamics of the product changes
	Technology complexity	– technological change – availability (innovative) technologies – technology lifecycle
	Process complexity	– number of interfaces and design – degree of crosslinking of the processes – degree of standardization
	Organization complexity	– number of hierarchy levels – degree of centralization – number of organizational units
	Structure complexity	– number of distribution levels – number of stock, staff, equipment, ... – communication systems – vertical integration
	Planning and steering complexity	– communication systems – frequency and level of detail of the management and control area

- Interpretation of information, think and play through possible consequences, create and study the connections, promote variety of thought (simulation);
- Management is a permanent process of progressing and the road map is drawn just during the walking;
- Flexibility, perspectives change, think in the view of the involved parties and contacts;
- High responsiveness by high problem solution ability and increased inside complexity (resources, potentials and options);
- Higher security to be able to master uncertainties better (stability and mistake tolerance).

Vieweg proposed method is originally based on the VUCA concept, which was developed in 1995 in the military field and which has been developed further. The meaning for the acronym is, as following: Volatility – Uncertainty – Complexity – Ambiguity. The core of the strategy is thinking in options and chances. The management observes emphatically the development of the defined scope (e.g. in projects), preparation is made for pre well-thought-out options in parallel, around then at the right moment, possible measures will be initiated to perceive an expected chance.

In 2015, Nils Pfläging and Silke Hermann developed a new special concept in German: *"Komplexithoden"* (translated: methods of complexity), to which they linked complexity and methods. According to this approach, for coping with complexity, numerous concrete tools are recommended:

- **Methods for performance:**
  - Due to the uncertainty of the current status and future influences, only *relative targets* are set up by management

  - Individual and team performance is measured also *relatively*. This promotes dialogue within the team;
  - *Value-Based Pricing*: This method means to know your customers benefit perception and identify with it. The offers to the customers are aligned to individual needs.
- **Methods for agility:**
  - *Dissolution of workplace*: An intelligent work setting is to be established through geographical, temporal, and oriented to the needs of the value-added flexible design.
  - *Agile project work*: This method supports social density, collaboration and self-control system in the project situation and promotes response capability, dialogue and innovativeness.
  - *Sense-making*: Permanent questioning of assumptions and evaluation of the situation is the focus of this method. Repeated questioning with the different forms of "why" can carry this out.
- **Methods for learning:**
  - *Informal structure work*: Each organization has got an informal structure. A balance of strong and weak links, as well as permeability and stability characterizes a positive network pattern.
  - *Communities of interests/practice*: The organization should create open spaces, where the know-how colleagues, experienced staff and groups organize themselves.
  - *Cultural observation*: Shared values, behavior and rituals could be conditionally observed *from outside* and also be evaluated partially. If someone wants to change the culture, concrete measures in the organization need to be taken.

Within these basic adjustments, concrete proposals for methods were developed (Pfläging & Hermann, 2015). Due to the limited extent in this research, only three methods for each strategy category are listed and analyzed.

Wallner and his colleagues published a package of complexity management, with the focus on *supply chain management* (Wallner et al., 2015). After an extensive analysis of the external and internal complexity drivers, a method for visualization is presented. On this base, some methods for *change and/or reduce complexity* are discussed in detail. These methods are designed for the strategy "*Complexity design*" (Wallner et al., 2015):

- "Product/value analysis;
- The aim is to carry out a value-oriented analysis and product design in order to reduce complexity;
- Equal parts management;
- Components of products are used in various products; this has a direct effect on the manufacturing process;
- Classification and prioritization;
- Products and processes are - based on the value-added content - analyzed and classified. Subsequently, appropriate measures are derived from the result;
- Order penetration point;
- Incoming orders were separated, based on defined criteria. This enables an efficient processing of standardized production units;
- Supply chain design;
- (Re-)design of supply chains in order to increase the efficiency and effectiveness;

The following methods were created for the strategy of "*Complexity control*" (Wallner et al., 2015):

- *Project planning* - The use of milestones is an effective control mechanism in the projects in order to manage the complexity between the various planning and management layers;
- *Changing demand* - In Demand Management, intelligent incentive systems should be established to enable that customer requirements can be structured and incorporated stably, and forecasts are drawn up in order to avoid unpredictable effects in the following processes;
- *IT as an enabler* - Many business processes are activated mainly through the application of information technology (IT). Rapid data access and integration of IT are key elements for the prevention and control of complexity.
- *Logic of communication* - The quality of shared information is very important. These rules have to be created in order to ensure that the transmitter and receiver interpret the information correctly".

A holistic and relevant approach for the present research was developed by Marston Johnston and Rodney L. Stevens and published in their paper, in 2016 entitled: *"A systematic approach to analyzing environmental issues involving complex systems"* (Johnston & Stevens, 2016). The focus of their research was the complexity caused by the environment and the development of a concept of utilizing the illustrative capacity of modelling, in order to understand processes and decision-supporting scenarios. Here small and large-scale situations are considered. In large scale, focusing on the processes within a system and existing trends are explained. In small case systems, the focus is directed to the characterization and the importance of the parameters that describe a system itself. The systems' environment is characterized by the following criteria (Johnston & Stevens, 2016):

- Large-scale and long-term;
- Multicomponent;
- Real world conditions;
- Multiscale and multidisciplinary;
- Multivariate and nonlinear.

The structure of a complex system can be modelled in a sequential procedure as suggested in the following (Johnston & Stevens, 2016):

1. "Describing the relevant system;
2. Identifying actual variables;
3. Checking for systematic relevance;
4. Studying interactions;
5. Determining a role within the defined system;
6. Examining overall interconnectedness and system dynamics;
7. Weighting preferences and impact of variables;
8. Combing variables to forecast individual scenarios;
9. Evaluating the model;
10. Formulating strategy".

Dunja Lang has discussed the intensive dealing with complexity in business situations; however, a concrete application is left open. Focus is the handling of conflicting objectives, bureaucracy-orientation in the organization and manager's behavior when dealing with complexity (Lang, 2016, p. 28-42).

According to Lang (2016), situations in business have showed the most common mistakes in dealing with complexity and identified various recommendations for action; the most common mistakes in dealing with complexity are (Lang, 2016, p. 28-42):

- "Unfavorable division of work;
- The illusion of uniqueness;

- The illusion of objectivity;
- Switch off one's head;
- Formalism and bureaucracy;
- Compulsion to control and culture of mistrust;
- Either-or thinking and unresolved dilemmas;
- Neglect of the "*big picture*";
- Uncross linked thinking;
- Application of the "*if-then logic*";
- Unsuitable know-how".

Based on many years of practical experience and the study results published as "*Common mistakes in Management*", a complexity method "*Change®Evolution*" was developed. The method's six steps in detail are the following (Lang, 2016, p. 174-219):

1. "Capturing the current state to target-state discrepancy holistically from multiple perspectives;
2. Analyzing and re-modelling background and objectives;
3. Understanding relationships and areas of tension;
4. Developing design and steering options;
5. Assessing possible troubleshooting issue;
6. Implementation and anchoring of troubleshooting solutions".

2.2.3.2. Specific approach of complexity management (service-related)

The following section describes specific concepts that are analyzed and presented in chronological order, which have "*service provisioning*" in scope.

Philip Haynes combines aspects of complexity theory and application to the public service management. He analyses the complexities within the "*New Public Management*" approach and the challenges and applications of management techniques in the key areas of the public sector, such as performance management, staff development leadership, strategic management and use of IT. He also examines the relevance of the new theories such as knowledge management, emotional intelligence and risk management in association with complexity management (Haynes, 2003).

Marc-Oliver Blockus (2010) developed a comprehensive framework for assessing complexity in terms of their cost and benefit effects, in the case of service companies. At the lowest level, the different forms of complexity are described as:

1. Characteristics of service complexity;
2. Manifestations of the complexity of the performance, support and customer processes;
3. Manifestations of employee's complexity. This level affects the middle level "*a result complexity*". This level comprises of the following:
    1. Complexity of the performance, support and customer processes;
    2. Task complexity;
    3. Complexity of the external factor;
    4. Technological complexity;
    5. Material complexity;
    6. Location and branch complexity;
    7. Employees complexity;
    8. Customers structural complexity;
    9. Service complexity;
    10. Performance program complexity.

According to (Blockus, 2010), the complexity cost and complexity benefit can be derived. The cost elements are subdivided into the following categories:

- Complexity cost planning;
- Complexity cost of documentation;
- Complexity costs of coordination;
- Complexity costs by deviation;
- Opportunity cost of complexity;
- Complexity cost of willingness to perform;

The benefits of complexity are divided into three categories: synergies; productivity effects and revenues (Blockus, 2010).

The publication *"Flexible Complexity Management and Engineering of Innovative Services"* by Natalia Kryvinska and the collaborators (2014) discussed how the management and engineering of innovative services with global-distinctive customer in the service sector, can be controlled with the continuously increasing complexity. One possible strategy is to support this strategy through modern technological-oriented service architectures and solutions. The goal is to support the creation and delivery of services in complex processes and relationships through information systems, e.g. web portal. One example is value networks that consist of distributed value chains. These networks can, by using complex web portals, connect a large number of participants and roles (Kryvinska et al., 2014).

2.2.3.3. Special (nonservice-oriented) research areas of complexity management

In the following sections, approaches of the complexity of management, which support specific (but nonservice-oriented) research areas, are analyzed and presented.

Maike Scherrer-Rathje together with research colleagues from the University of Aachen (Germany) and other colleagues from the Hungarian Academy of Science in Budapest published their research results on the *Generic Model of Complexity (GeMoC)*. The scope of the research is to identify arising problems in collaborative networks. Furthermore, these problems will be linked with different system characteristics (e.g. network structure, trust, degree of commitment, coordination, change, and more).

The GeMoC model approach is based on the following complexity drivers (from Balázs Csanád Csáji and Laszlo Monostori), which were presented at the 17thIFAC World congress in Seoul, in 2008 (explanations from (Scherrer-Rathje, 2009)):

- Uncertainty (e.g. limited information);
- Dynamics (e.g. sudden or constant change);
- Multiplicity (e.g. a large number of participating elements and influence factors);
- Variety (e.g. many types of elements);
- Interactions (e.g. communication load);
- Interdependencies (e.g. feedback loops).

The GeMoC model links the 11 identified following complexity-related problems and the twenty-four system characteristics as following (Scherrer-Rathje, 2009):

1. **Interdependencies of the participating organizations**:
   There are often asymmetrical relationships between companies and power relations, which lead to an unbalanced partnership.

2. **Strategic incompatibilities:**
   The strategies of both partners must be compatible in principle. Differentiate too much, no efficient cooperation is possible.
3. **Lack of confidence:**
   The organizations in the network should always trust each other. If this is not the case, extensive control measures are established, with no added value for the parties.
4. **Culture incompatibility:**
   In the cooperation of participating organizations, a mutual cultural understanding should exist. This ensures that no obscurities disrupt business relationship.
5. **Heterogeneous customer requirements:**
   An adequate customer behavior regarding customer expectation to the service provider, as well as understanding of its internal processes, ensures a constructive framework for the formulation of requirements.
6. **The establishment of partnerships:**
   The extent of complexity in the collaboration between the partners is characterized essentially how it is possible to find partners with an appropriate business strategy.
7. **Misunderstanding in communication:**
   Company, thus also potential partners, are characterized by the industry, culture and their internal corporate values and language. A respectful and open approach in communication supports a smooth cooperation.
8. **Insufficient and inefficient flow of information:**
   The complexity in the partner network can be positively influenced by a targeted and timely exchange of information.
9. **Inefficient network management:**
   Cooperation should be, with a shared understanding of partners, planned, implemented and monitored. Common challenges are ensuring clear responsibilities and timely decision-making.
10. **Inefficient knowledge management:**
    The acquired knowledge during partnership should be externalized to ensure stability at potential changes, for example retirement of a partner.
11. **Inefficient process architecture:**
    The complexity of collaboration can be substantially reduced if clear delineated processes models are agreed and the interfaces are clearly defined between the organizations.

The GeMoC model can be used to identify root causes for specific problems arising in complex networks. This can be reached by analyzing the relationship between the problem and the system characteristics, as in Figure 2.6 (Scherrer-Rathje, 2009).

Udo Lindemann, Maik Maurer and Thomas Braun analyze the complexities in product design, which are characterized by a steady increase in complexity. The focus of the research is a structural concept; the structures resulting from the complex interdependencies of system elements. They have developed a method that allows the analysis, control and optimization of complex structures and applicability of cross-domain problems. The proposal of the procedure is shown in Figure 2.7 (Lindemann et al., 2009) published in German and in 2010 in English.

The approach is based on the *Design Structure Matrix* (DSM) method, which consists of detecting, modelling, analysis and synthesis of interconnection of elements in highly networked systems. Typical examples of such systems are complex and highly integrated product architectures, organizational structures and processes. DAM allows to put in such systems, elements of a kind with respect to

the fact that they are connected by a comparable relationship among themselves. As modelling base, a square matrix is used that maps the vertical and transverse axis of the individual elements of the system and each individual cell can be used to map the relationship between two elements. In this case, such a DSM is modelled as "*line has influence on the column*" or "*column affects the line*".

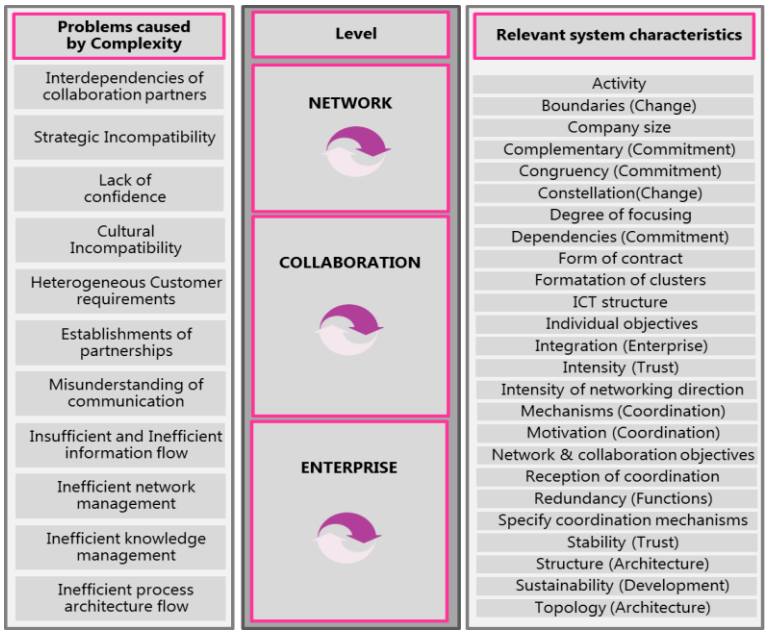

Fig. 2.6. Generic model for complexity (Scherrer-Rathje, 2009)

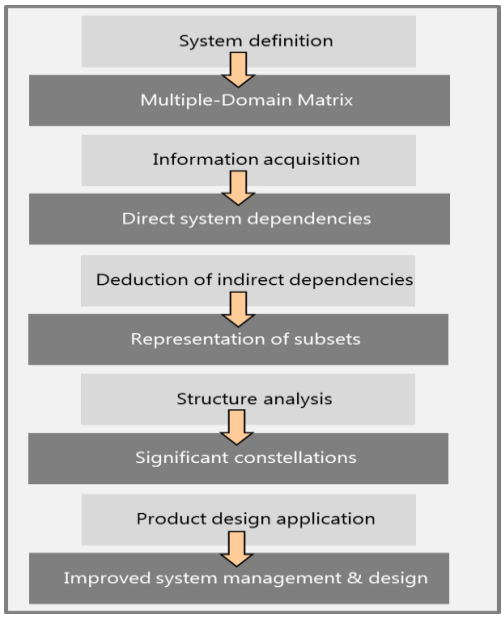

Fig. 2.7. Procedure of complexity management (Lindemann et al., 2010)

Based on the recent research state, Harrys Daniilidis, David Hellenbrand, Wolfang Bauer and Udo Lindemann, presented the concept of *Using Structural Complexity Management for Design Process Driven Modularization* at the International Conference on Industrial Engineering and Engineering Management (IEEM), in Singapore in 2011 (under IEEE). Starting from a high internal complexity and diversity in most companies, they developed a systematic approach and methodology to modularize a product architecture of the design process view by using the general procedure of structural complexity management. The overall objective is to reduce complexity, cost and product development time in the company and to streamline product architectures through modular design. The approach is based on the *Structural Complexity Management (SCM)* method (Figure 2.8).

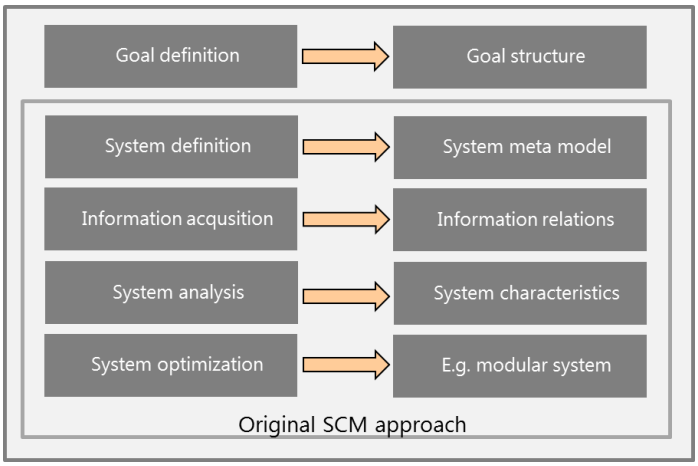

Fig. 2.8. Structural Complexity Management (Daniilidis et al., 2011)

The design process result is presented by the Whitney index (WI), which sets the dependencies of system elements in relationship with their number (Daniilidis et al., 2011).

Melanie Kramp (2011) has developed a *model of the integrative process management*, in which were considered the complexities strategies in relation with following concepts: *managing complexity, complexity prevention* and *reduction of complexity*, in connection with the specific process management phases (Table 2.3). Furthermore, the *process management* instruments mapping is created.

A process-based approach to identify complexities was developed by Marcello La Rosa (2011) and his team of researchers, based on the *Business Process Management* (BPM). The proposal incorporates the detection of a broad range of functions required by a collection of patterns. The eight patterns are shown in Table 2.4.

Tab. 2.3. Process management phases of an integrative approach (own table, derived from (Kramp, 2011))

Phases	Description
0	Develop overarching target system for the process landscape
1	Identify processes
2	Define processes
3	Operate and control processes
4	Monitoring Processes

Tab. 2.4. Eight patterns procedure (own table, derived from (Rosa et al., 2011))

Pattern number	Description
1	Layout Guidance, to reduce clutter, especially in large process models
2	Layout Split, to transform the existing processes and apply the layout guidelines BPM
3	Group Highlights, to characterize the elements to different groups
4	Graphical Highlights, to highlight certain features and relationships
5	Pictorial Annotation, to strengthen model-specific concepts
6	Textual Annotation, to supplement and add domain-specific information
7	Explicit Presentation, to visualize and distinguish the various ingredients of a process model
8	Naming Guidance, to bring clarity and convey domain-specific information

Rosa et al. provide a systematic analysis of the properties, which are suitable for the management of complex process models in which these properties affect the concrete syntax, but there does not exist a corresponding abstract model. The analysis result provides a form of a collection of patterns and an evaluation of the state-of-art languages. In this pattern-based analysis in process modelling, identified relative strengths and weaknesses in the languages and tools are considered (Rosa et al., 2011).

In 2012, considering the research results in 2011, Daniilidis published the article: "*Systematic goal definition for complexity management projects*" which is a stepwise systematic approach to manage complexity tasks with scope in the product development process. The stepwise approach includes the following phases: define goal, plan goal, structure goal and define measures. The core of the approach lies in the "*Goal definition*" phase where it is possible to define a number of concrete objectives (derived from each strategy). An example of objectives list could include (Daniilidis et al., 2012):

- Optimization of the internal complexity and variety;
- Optimization of the product architecture regarding the actual organizational structure;
- Optimization of the product architecture regarding the actual manufacturing process;
- Highlight the interrelations between development process and product architecture;
- Highlight the communication network within the development process;
- Analyze and highlight of changes' impact on product architecture;
- Thereby, a distinction is made between "*complexity control*" and "*complexity reduction*".

Christoph Danne (professor at the University of Paderborn, Germany) shows the relationship between products varieties and the complexity increasing phenomena. He focuses on inventory management, using the case of the automobile manufacturers, but companies from other industries, too. The result is summarized as follows (Danne, 2012):

1. Large range of variants are the strongest complexity drivers;
2. Complexity costs are critical and difficult to assess;
3. Complexity Management is seen as an "*Optimum diversity*" and the following strategies could be developed:
    - Avoid complexity;
    - Reduce complexity;
    - Master complexity.

Markus Schäfermeyer and his colleagues (2012) from the Goethe University Frankfurt (Germany) examined the increasing complexity of companies' business processes. According to their studies, one possible strategy for dealing with the

complexity is processes standardization. They analyzed the interactions between standardization effort, business process complexity and business process standardization. They analyzed the hypotheses that the increasing of business process complexity is associated with increasing standardization effort as well as declining business process standardization and that increasing standardization effort is related to increasing business process standardization. For this purpose, a conceptual model was developed and evaluated. The model supports the understanding of the business processes complexity effects on their standardization and the standardization effort to understand and analyze business processes. To test the model hypotheses, a survey of 255 experts was developed in the field of business process management. The results show that business process complexity has a strong positive impact on standardization efforts. In addition, it was clear that increasing standardization effort could not be considered a tool to achieve the standardization of complex business process (Schäfermeyer et al, 2012).

In 2013, Regina Grussenmeyer and Thorsten Blecker focus their research on "*Complexity and Robustness Influence on Production Performance - A Theoretical Framework*" in the field of product design and manufacturing by taking into consideration factors as operating, resources, labor and materials. The following variables are defined and integrated into the proposed valuation model (Grussenmeyer & Blecker, 2013, p. 57-58):

- **Complexity -** complexity of the variability, connectivity and functionality of the various elements of a production system, as well as their dynamic change over the life cycle (critical aspect). The product, the production plan and the vertical integration affect the degree of complexity;
- **Stability** means the reliability of production systems in this context. Here, the characteristic of a stable production process, the planned activities will be considered under certain conditions;
- **Flexibility** is the ability of a production system to respond timely to changing conditions (e.g., in products, processes or capacity utilization) or instability (interruptions machine);
- **Robustness** is the ability of a system where outer and inner interference to maintain its functionality;
- **Performance** - The orientation of the considerations with regard to robustness and complexity should lead to an improvement in the supply chain performance, which can be measured in several ways. In production, the performance is analyzed in four reference values: efficiency, effectiveness, productivity and profitability.

Furthermore, in 2013, Thomas Hutzschenreuter and Julian Horstkotte examined the impact of corporate expansion in terms of complexity. Here, the following variables are used:

- TMT (Top Management Team) growth rate;
- Common TMT-specific experience;
- Added product scope;
- Added cultural distance;
- Expansion steps;
- Cultural diversity;
- Product diversity;
- Minority;
- Acquisition;
- Total ownership;
- Firm size;
- Profitability;

- Capital structure;
- Slack;
- Industry mix.

These variables are evaluated according to different use cases and consolidated at different complexity values (Hutzschenreuter & Horstkotte, 2013).

Peter Kruse (2013) researches are focused on organizational development in conjunction with strategic management. Kruse turns out that the management between *stable* and *unstable* states of a system must be different and he recommended for the unstable systems management the following two strategies for action: (1) trial and error and (2) self-organization (Kruse, 2013).

Seyda (2013) presented the results of the study on the complexity drivers in supply chain management (in the context of the 41st International Conference on Computers & Industrial Engineering). She analyses the complexity drivers from a temporal perspective (current and potentially) and from the point of whether the complexity is avoidable or unavoidable (Figure 2.9).

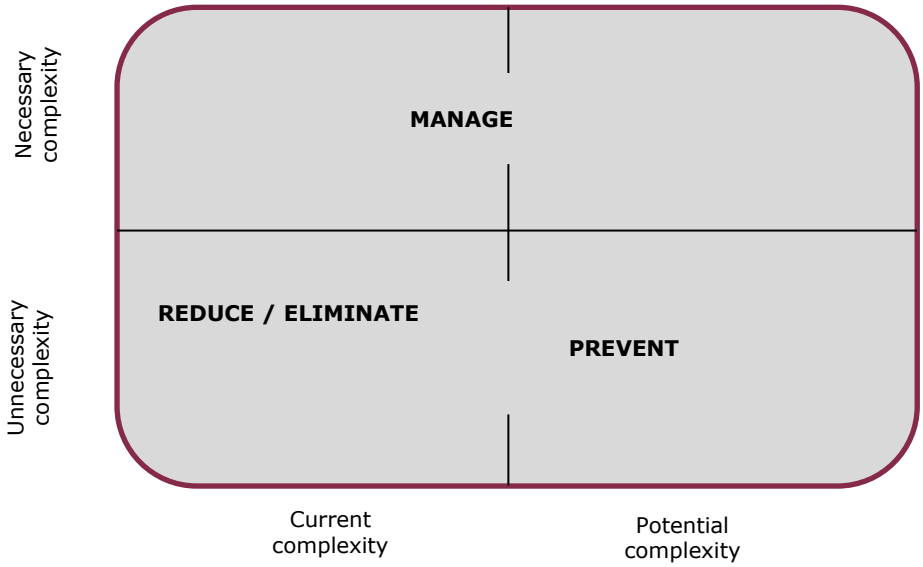

Fig. 2.9. Matrix of approaches to dealing with complexity (Seyda, 2013)

Seyda refers to leading researchers in the complexity area, as the studies of Wildemann, and she used the concept of leading consulting companies. According to (Seyda, 2013) complexity drives in the supply chain are grouped, by taking into consideration their origin, into the following groups: internal; supply / demand interface; external. Complexity inherent in the supply chain is observed in different forms and origins. *Static complexity*, that is related to the connectivity and structure of the subsystems involved in the supply chain (e.g. companies, business functions and processes); *dynamic complexity*, that results from the operational behavior of the system and its environment; and *decision-making complexity* that involves both static and dynamic aspects of complexity (as depicted in Table 2.5).

Tab. 2.5. Some drivers of supply chain complexity (Seyda, 2013)

ACCORDING TO ORIGIN			
Type	***Internal***	***Supply/demand interface***	***External***
Static	– Number/variety of products – Number /variety of processes	– Type of product – Number/variety of suppliers – Number/variety of customers – Process interactions – Conflicting policies	– Changing needs of customers – Changing resource – requirements – New technologies
Dynamic	– Lack of control over processes – Process uncertainties – Employee related uncertainties – Unhealthy forecasts / plans	– Lack of process synchronization – Demand amplification – Parallel interactions	– Changes in the geopolitical environment – Shorter product lifecycles – Trends in the market – Market uncertainties – Developments in the future
Decision making	– Organizational structure – Decision making process – IT systems	– Differing and conflicting – Decisions and actions – Non synchronized decision making – Information gaps – Incompatible IT systems	– Changes in the environment – Factors that are out of span of control – Uncertainty of the unknown and uncontrollable factors

More recent, Bongsug Chae used the three dimensions for analyzing complexities (according to his publication "*A complexity theory approach to IT-enabled services (IESs) and service innovation business analytics as an illustration of IES*") (Chae, 2014): internal mechanism; environment; co-evolution.

A specific approach, (used in military defense) for an innovative procurement process, was developed by Michael Essig and Andreas Glas (2014). This uses the PBL (Performance-Based Logistics) model, also known as performance-based life-cycle product support or performance-based contracting, which is a strategy for cost- effective weapon system support. Their study is based on five theses for the usability of PBL for the German defense procurement:

1. The procurement of complex service bundles will increase;
2. Efficiency over the life cycle requires the integration of procurement and utilization phase;
3. The increasing importance of incentives as a coordination mechanism for industry;
4. PBL will be procurement alternative to be checked in the future;
5. PBL in numerous projects requires overarching Governance structures.

The core of (Essig & Glas, 2014) approach is given by the contracting for the acquisition, the product support management processes that have to determine the performance increasing of the delivery outcomes, in the case of a system or a product. Thesis one to three and five are incorporated in the further course of this research; reason for this is that the insert is different, but essential features for the

use cases fit (e.g., high-voluminous projects, buying complex services, long-term projects, operation management etc.) (Essig & Glas, 2014).

Raimund Klinkner is the Chairman of the Board of the "*Bundesvereinigung Logistik (BVL)*"; BVL Board Annual Report 2014 includes the results of a survey developed with the members' involvement (10,000 members from the top echelons of industry, commerce, services, and science). The report is titled "*Complexity, cost, cooperation*". The analysis of the results shows that "*Industry has learned to deal with complexity*". Complexity management and process optimization are among its main tasks. About 70% of the respondents have recognized that in companies in industry, trade and logistics services have been introduced specific projects for management of complexity. "*Complexity management becomes the drive and pulse generator for process optimization and innovation. Complexity characterizes the logistics sector - efficient management of complexity is therefore a competitive advantage*". In addition, almost 77% of respondents describe structures and processes as complex to very complex. "*It is the diversity of customer requirements and product diversity, leading to more complexity above all in the economic sphere*" (Klinker BVL, 2014 p. 8).

Tania Lieckweg and Katrin Glatzel have developed a model to analyze consulting firms, complexity-related problem areas and questions based on different *sense-dimensions* (as seen in Figure 2.10). Each of the dimensions can be characterized from the perspective of the current issues and challenges (with which an organization is facing); the map-based on questions result that is provided by consultants could provide an insight into the events of the company and guide the consulting work, too (Lieckweg & Glatzel, 2014).

Sun and Rose (2014) continue the systems approach for managing complexity in the case of the industrial supply chain. The leading questions of their research are:

- How is a complex supply chain to be evaluated?
- How can we assess the complexities induced by changes of a system?
- How to develop the implementation methods and tools for complexity measurement?
- How to verify the first three questions with industrials cases and thus reduce the non-value added complexity?

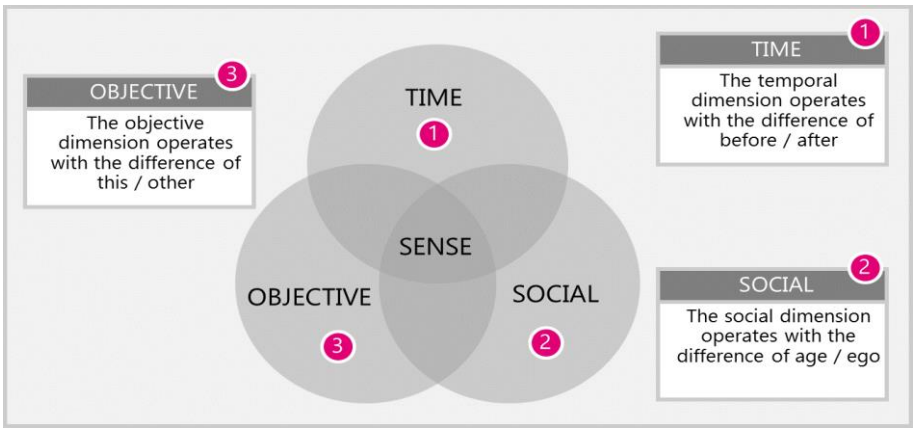

Fig. 2.10. Model of complexity-related problem areas (Lieckweg & Glatzel, 2014, p.18)

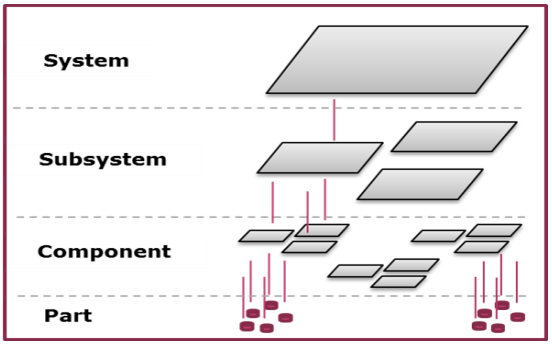

Fig. 2.11. System decomposition into three layers (own figure, derived from Sun& Rose, 2015)

To create a model for complex supply chain, a three-layer architecture was proposed (Figure 2.11). For each level, the attributes of basic elements and their interfaces have to be defined. The basic element for the subsystem layer is the subsystem, similarly for the layer of component and part. In the created model, the interfaces are described as the relationships among all the elements. (Sun & Rose, 2015) employ a conceptual model including the following four elements: process, role, object and its states (PROS), in order to describe a complex system.

2.2.3.4. Complexity in outsourcing projects

In 2007, at the "*2nd Aschaffenburg Management Day*" at the University of Aschaffenburg, Eberhard Schott presented the characteristics of complex situations (in the presentation entitled: "*Komplexität als zentraler Faktor für Erfolg und Kosten des Outsourcings*", translated as Complexity as a key factor for success and cost of outsourcing). Schott discussed this problem, using the example of outsourcing projects (Schott, 2007a). These projects are characterized by: unmanageability, opacity, networked, intrinsically dynamic, severe predictability of the consequences, politely (see Figure 2.12).Schott emphasizes three possibilities to deal with the complexity: (1) Avoid complexity; (2) Reduce the complexity; (3) The ability to manage complexity.

Furthermore, Eberhard Schott published the article *Komplexitätsfalle Outsourcing* (translated: Complexity trap Outsourcing) where he notes that the level of complexity mainly depends on the nature and extent of the outsourced functions. In addition, internal resistances, especially for projects with staff transition, impede the course of the project (Schott, 2007b).

Because of many debates, Schott notes that complexity in outsourcing can be limited as follows:

- Reduce the scope of the project;
- Building confidence and do not move rules or processes in the foreground;
- Set clear steps within the organization that are precisely defined and fixed by contract;
- Involving external know-how;
- Only set realistic goals;
- As a prerequisite for the outsourcing process, clear, identifiable structures and processes are set up.

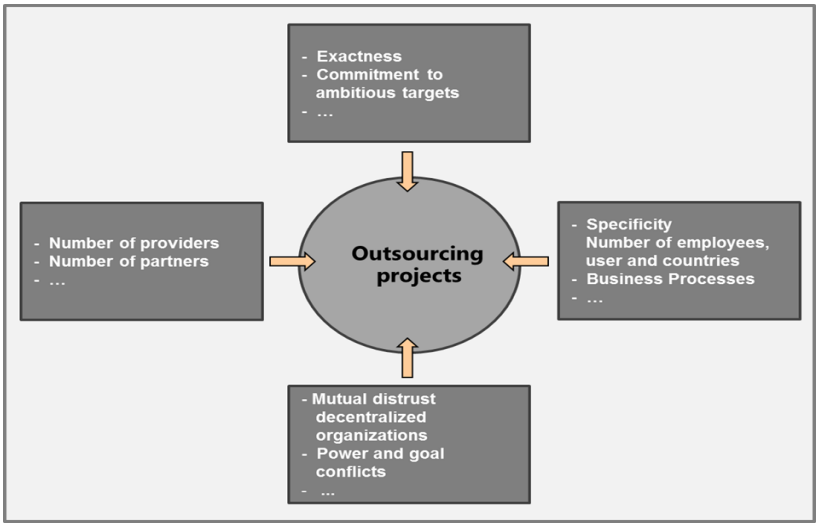

Fig. 2.12. Complexity factors in Outsourcing (Schott, 2007b)

Eberhard Schott and Katrin Severidt have analyzed the dimensions of the negotiation process from the perspective of the service provider. Both researchers have worked out on the various incentives and motivations behind their actions of the parties and provide concrete negotiation strategies to avoid projects complexity. A relevant key message was that the contract cannot cover all the options and therefore a way must be found to cover a corresponding flexibility of future-oriented uncertainties. Another statement was that the contractual arrangements will often be given too much importance and this is a bad start for the future of supply and services relationship (Schott& Severidt 2007).

Later, Schott presented ten propositions, in which he reaffirmed: outsourcing is complex. The impacts of complexity are not reflected enough (Schott, 2010).

In 2014, the Project Management Institute (PMI) has published a book about how to navigate with complexity. PMI pointed out that complexity in programmes and projects will always be existent. However, globalization, new technologies, and fragmented supply chains have significantly increased and compounded the complexity situations that practitioners are confronted with. Faced with objectives that are more challenging and a higher percentage of their budgets at risk due to complexity, business leaders realize the critical need for successful delivery of these unique programmes and projects. As a result, there have been a variety of studies and publications on complexity, but few of them are focus on providing practical approaches (Project Management Institute (PMI) 1, 2014).Navigating Complexity: The *„Practice Guide*" provides methods for effectively manage complexity in programmes and projects, in the following six sections:

- Organizational Considerations;
- Encountering Complexity;
- PMI Foundational Standards and Useful Practices;
- Navigating Complexity: The Assessment Questionnaire;
- Complexity Scenarios and Possible Actions;
- Developing the Action Plan.

PMI has formed three main categories of complexity for the control of programmes and projects (Project Management Institute (PMI) 2, 2014):

- Human behavior;
- System behavior;
- Ambiguity (Project Management Institute (PMI) 2, 2014).

In the last years, in the field of Project management the need has arisen for an intelligent and fundamental strategy to address the challenge of dealing with complexity (Dalcher, 2015).

According to (Essa et al., 2016) there have been identified key issues for a successful outsourcing project: dealing with uncertainty and importance of mutual trust relationship. Besides the importance of trust, dealing with the uncertainties in outsourcing projects has been recognized as a very important aspect. (Essa et al., 2016) describes these aspects (only) on a very high level. In addition, it has been worked out that all the parties involved in outsourcing projects are trying to maximize their benefits during the project development.

The first package of measures recommended has been the consideration of uncertainties in the pricing models. Second, it has been recommended that the parties' behavior have to be evaluated permanently through a third company (Essa et al., 2016).

Although *outsourcing process* was intensively studied in recent years, together with its impact on organizational aspects that is still not very well understood (Bals & Turkulainen, 2016, p. 1).

2.2.4. Pre-conclusions

In order to better analyze the associated concepts for managing complexity in business situation, Table 2.6 shows the synthesis of the main ideas provided by the state of the art in the field (chapter 2.2.3).

Tab. 2.6. Stages of development of business-relevant complexity research (own table)

	Scientific concepts	
Holistic complexity management	*Komplexität und Dynamik als Herausforderung für das Management* (translated: Complexity and dynamics as a challenge for the management): This book by Frank Maier is comprised of various approaches (product, organization, process, dynamics, and more) of complexity management from an organizational perspective.	(Maier, 2004)
	Industrial Ecology: Erfolgreiche Wege zu nachhaltigen industriellen Systemen (translated: Successful ways to sustainable industrial systems): Development of an approach with five processes, based on the industrial ecology, to deal with the increasing complexity and uncertainty.	(Dörner, 2008)
	Komplexitätsmanagement (translated: complexity management): Extensive consideration and approaches of enterprise complexity with practical relevance. The first part of the book is theory-oriented; in the 2nd part of the book, several practical application cases are analyzed.	(Denk & Pfneissl, 2009)
	Der Spagat – Unternehmen zwischen Differenzierung und Kostenfalle (translated: The balancing act - between business differentiation and cost trap): Development of a 4 column procedure model for dealing with complexity	(Engel & Scheel, 2009)

Scientific concepts		
	20 Jahre Komplexitätsmanagement (translated: Twenty years of complexity management): Development of guiding principles of complexity management.	(Neubaur, 2009)
	Mastering Complexity - capture the hidden opportunity: Boston Consulting Group (BCG) recommend eight strategies for mastering complexity with organizational focus.	(Brown et al., 2010)
	7 Schritte im intuitiven Umgang mit Komplexität (translated: *Seven steps in the intuitive handling of complexity)*: Seven steps to manage complexity, based on different disciplines, like learning organization, dynamics and the system archetypes.	(Addor, 2011)
Holistic complexity management	*Komplexität: Warum die Bahn nie pünktlich ist* (translated: Complexity: Why the train is never on time): Analysis of reasons why such complexities arise and why they always strive to grow. Consideration of the boundary between complexities at the edge of chaos.	(Dittes, 2012)
	Simply Complexity: A Clear Guide to Complexity Theory - A Clear Guide to Complexity Theory: Neil Johnson describes and analyses based on a variety of scientific disciplines (e.g. finance, social relationships, global terrorism and others) and practical examples an overall explanatory complexity management.	(Johnson, 2012)
	Chefsache Komplexitätsmanagement (translated: Complexity management - matter for the boss): recommendation of a five-point plan to manage the complexity, based on twenty years of business experience.	Krumm, 2012)
	Complexity: Toward an empirical measure: Development of a generic complexity model: Generalized Complexity Index (GCI), with three dimensions: Multiplicity, Diversity and Interconnectedness	(Jacobs, 2013)
	The full house of Project complexity: Development of a House of Project complexity, which comprises three principal components: the foundation of the house that captures the technical and institutional elements of the project opportunity, a set of technical and institutional architectural choices that are put in place as a project concept and the set of performance outcomes.	(Lessard et al., 2013)
	Anforderungen des Technologiemanagements an die Modellierung von Entscheidungssituationen (translated: Requirements of technology management in the modelling of decision situations). Dieter Specht and Gunnar Berntsen developed a derivation of a model for dealing with complexities, which is based on safety, uncertainty and indefiniteness. They specify requirements for a model and apply these for managing technology in a holistic view. Specific models for the management of complexity in business are not pronounced.	(Specht &Berntsen, 2013)
	Komplexitätsmanagement in Vertrieb, Beschaffung, Produkt, Entwicklung und Produktion: Leitfaden zur Einführung eines durchgängigen Komplexitätsmanagements (translated: Complexity management in sales, procurement, product, development and production: A Guide to the introduction of an integrated management complexity): Providing a very extensive practice-oriented book that analyses strategic complexity management for the entire company (on functional level: Sales, Purchasing, Production, ...) and modelled recommendations are shown.	(Wildemann, 2013)

Scientific concepts		
Holistic complexity management	- *Ecosystem Services Governance:* - *Managing Complexity?* Process model for managing complexity with long-term perspective in a transition phase.	(Keune et al., 2014)
	Was ist Management? (Translated: What is management?): discussion on how to deal with complexities in the exercise of strategic management tasks.	(Niermann, 2014)
	Komplexitätsmanagement in Unternehmen: Herausforderungen im Umgang mit Dynamik, Unsicherheit und Komplexität meistern (translated: Complexity management in companies: Challenges in dealing with dynamics, uncertainty and complexity masters). The research team led by Prof. Schöneberg combines science-based approaches together for complexity management. This strategic corporate management is considered in dynamically changing environmental conditions. Furthermore, the specific operational implementation of complexity management measures is presented and discussed.	(Schoeneberg et al., 2014)
	LFP (light footprint strategy): This method is originally based on the VUCA concept: V, Volatility; U, Uncertainty; C, Complexity; A, Ambiguity. Basic idea is the thinking in options and chances.	(Vieweg, 2015)
	Komplexithoden (translated: Methods of complexity): Development of various specific instruments, with the dimensions: Methods for performance; Methods for agility; Methods for learning.	(Pfläging &Hermann, 2015)
	Operational Excellence and Supply Chains - Optimization Methods, Data-driven Approaches and Security: Development of different proposals with the target: changing / reducing complexity. The methods are categorized into "*complexity design*" and "*complexity control*".	(Wallner et al., 2015)
Holistic complexity management	*A systematic approach to analyzing environmental issues involving complex systems (a web-based course):* The focus of the research object is the complexity caused by the environment and the development of a concept of utilizing the illustrative capacity of modelling to understand processes and decision-supporting scenarios.	(Johnston& Stevens, 2016)
	Gefangen im Komplexitätsdilemma: Wie Sie mit Zielkonflikten, Bürokratie und Verhaltensparadoxien wirkungsvoll umgehen und Organisationen agil, flexibel und stark machen (translated: Trapped in complexity dilemma: How to effectively deal with paradoxes goal conflicts, bureaucracy and behavior and make organizations agile, flexible and strong): Identification and preparation of the most common mistakes in dealing with complexity in business situations and recommending a procedure in six steps.	(Lang, 2016)
Specific approach of complexity management	*Managing Complexity in the Public Services:* Philip Haynes combines aspects of complexity theory and applies them to the public service management. He analyses the complexities with different management techniques, such as performance management, staff development leadership, strategic management and use of IT, and new theories such as knowledge management, emotional intelligence and risk management.	(Haynes, 2003)

Scientific concepts		
	Komplexität in Dienstleistungsunternehmen: Komplexitätsformen, Kosten- und Nutzenwirkungen, empirische Befunde und Managementimplikationen (translated: Complexity in service companies: Complexity forms, costs and benefits, empirical findings and management implications): Marc-Oliver Blockus developed an approach for the evaluation of complexity in terms of their cost and benefit effects identifying the key levers of complexity management in service companies. For this recognition and a first empirical application, the author derives recommendations for analyzing the complexity and the planning, implementation and control of design complexity.	(Blockus, 2010)
Specific approach of complexity management (service-related)	*Flexible Complexity Management and Engineering of Innovative Services* by Natalia Kryvinska et al. describes the discussion of how the management and engineering of innovative services with global-distinctive customers in the service sector could be managed by application of state of art information systems.	(Kryvinska et al., 2014)
Special (nonservice-oriented) research areas of complexity management	*A generic model to handle complexity in collaborative networks:* Development of a Generic Model of Complexity (GeMoC) based on six main characteristics of complex systems.	(Scherrer-Rathje, et al., 2009)
	Structural Complexity Management -An Approach for the Field of Product Design: The focus of this research is a structural approach to complexity management. This means system structures to address the challenge of complexity in all areas of product development and considered. Structures resulting from the complex interdependencies of system elements. The designed proposal is applied based on two practical use cases.	(Lindemann et al., 2009) (Lindemann et al.,2010)
	Using Structural Complexity Management for Design Process Driven Modularization: Development of a systematic approach and methodology to modularize product architecture of the design process view by using the general procedure of structural complexity management.	(Daniilidis et al., 2011)
	Zukunftsperspektiven für das Prozessmanagement: Der Umgang mit Komplexität (translated: Future perspectives for process management: Dealing with complexity): Key barriers to achieve entrepreneurial potential is the limited ability of the installed systems for dealing with complexity. The focus is the development of a reference model with important components of a sustainable - summarizing process management - oriented complexity. The contents are based on concrete requirements and recommendations for the design, integration and organizational practice.	(Kramp, 2011)
	The concept *Managing Process Model Complexity via Concrete Syntax Modifications:* Managing Process Model Complexity by using the BPM technology standard model. They identified eight patterns to operate on the concrete syntax of a process model and classified them according to a hierarchy.	(Rosa et al., 2011)

Scientific concepts		
Special (nonservice-oriented) research areas of complexity management	Systematic goal definition for complexity management projects: stepwise systematic approach to manage complexity tasks in product development	(Daniilidis et al., 2012)
	Auswirkungen von Komplexität in Produktionssystemen, insbesonders auf das Bestandsmanagement (translated: Impact of complexity in production systems, esp. on inventory management): Analysis of variants of products to the complexity.	(Danne, 2012)
	Der Einfluss der Komplexität auf die Standardisierung von Geschäftsprozessen. Eine empirische Untersuchung (translated: The influence of complexity to the standardization of business processes. An empirical study): Analyzing interactions between standardization effort, business process complexity and business process standardization and a model to evaluate the mutual interactions.	(Schäfermeyer et al., 2012)
	Complexity and Robustness Influence on Production Performance – A Theoretical Framework: Analysis and evaluation in the product design and the manufacturing of products with the factors: operating, resources, labor and materials. And the following variables: Complexity; Stability; Flexibility; Robustness; Performance.	(Grussenmeyer & Blecker, 2013)
	Managerial services and complexity in a firm's expansion process: An empirical study of the impact on the growth of the firm: Evaluation of complexity with different use cases in a firm's expansion process.	(Hutzschenreuter& Horstkotte, 2013)
	Erfolgreiches Management von instabilen Systemen - Veränderung durch Vernetzung (translated: Successful management of unstable systems - Change through networking): Discussion and recommendations of various concepts of system management with a focus on: organizational development to master the complexities in companies. Here it is resorted to comparisons of different social systems.	(Kruse, 2013)
	Review of complexity drivers of supply chain: Development of a classification of complexity drives in the supply chain management process.	(Seyda, 2013)
Special (nonservice-oriented) research areas of complexity management	*A complexity theory approach to IT-enabled services (IESS) and service innovation business analytics as an illustration of IES*: Investigating the interrelationships between complexity theory, the role of IT and innovation.	(Chae, 2014)
	Performance Based Logistics – Innovatives Beschaffungsmanagement für die Streitkräfte (translated: Innovative procurement management for the armed forces): Using the PBL (Performance-Based Logistics) concept for use in high-volume projects in the armed forces for the realization of complex services.	(Essig & Glas, 2014)
	Jahresbericht 2014 (translated: Annual report 2014): Presentation of the annual report of the TOP Board of the German "*Bundesvereinigung Logistik (BVL)*", with the title: complexity, cost, cooperation, in which the result of a study is presented.	(Klinkner-BVL, 2014)

Scientific concepts		
	Beratung im Dritten Modus: Die Kunst, Komplexität zu nutzen (translated: Consultancy in the Third Mode: The art of using complexity): Based on the strategic management consulting, extensive analyses and recommendations will be made to use complexity management in the strategic instruments (change management, human resources, organization theory and leadership).	(Lieckweg & Glatzel. 2014)
	Supply Chain Complexity in the Semiconductor Industry: Assessment from System View and the Impact of Changes: Building up a general model for complex systems and then generate the supply chain instance model.	(Sun & Rose, 2015)
Special cases of application of complexity management Complexity in outsourcing projects	*Komplexität als zentraler Faktor für Erfolg und Kosten des Outsourcing* (translated: Complexity as a key factor for success and cost of outsourcing): Initial analysis of the complexity of outsourcing and recommendation of different strategies.	(Schott, 2007,1)
	Komplexitätsfalle Outsourcing (translated: Complexity trap Outsourcing) first model to explain the "*complexity trap*" in the case of outsourcing.	(Schott, 2007,2)
	Verhandlungen für Outsourcing-Verträge - Konfliktfelder und Lösungsansätze (translated: Negotiations for outsourcing contracts - conflict and solutions): Analysis of the dimensions of the negotiation process of the provider. Furthermore, the incentives of the entities involved are measured and concrete negotiating strategies for avoiding complexity are presented.	(Schott & Severidt, 2007)
Special cases of application of complexity management. Complexity in outsourcing projects	*Ten Thesis on Outsourcing*: Schott presented ten propositions to reflect complexity in Outsourcing projects.	(Schott, 2010)
	Navigating Complexity: A Practice Guide: Providing a practical-oriented framework and guidelines for dealing with complexity in programmes and projects, based on a number of studies and publications.	(Project Management Institute-PMI, 2014)
	Improving Outsourcing negotiations: Identification of key issues for successful outsourcing: dealing with uncertainty and importance of mutual trust relationships.	(Essa et al, 2016)

Many of the concepts are aimed at the assessment and the mastery of individual complex situations rather than on long-term complex situations in an overall context, e.g. *Seven Steps in the intuitive handling of complexity*. The concept *Managing Process Model Complexity via Concrete Syntax Modifications* focuses on the representation of the processes and the contained complexities. Eberhard Schott analyzed complexity in outsourcing situations for the first time in 2007 and he recommends three strategies and derived theses to deal with the complexity. Schott analyses the causes of complexity trap in the case of outsourcing project and derives complexity factors. Furthermore, practical guidelines on how complexity can be limited are given. These recommendations are partially inconsistent with other researchers in this research field. For example, it is known

that the complexity of the company itself is a trigger for an outsourcing project. However, Schott recommends the creation of clear structures in the run-up to the project. Schott is thus one of the few researchers, to bring the complexity of management with outsourcing projects systematically together. A scientific universal model for use in large-scale projects is not provided.

Brown et al. (2010) developed eight strategies, which are gradually performed one after the other. The view and the examples shown relate to the industrial production of products. With the aid of production-related classification, complexity should be manageable. Simulation modelling support that the company will be able to prepare for future challenges. The *Generic model for complexity* from Maike Scherrer-Rathje can be regarded as the standard model in the management of complexity from a perspective of collaboration. A derivation of management strategies, scenario building and recommendations for practice are not included in the model. The empirical study named "*The influence of complexity to the standardization of business processes"* from Markus Schäfermeyer and colleagues at the Goethe University Frankfurt analyses the standardization strategy in dealing with complexity in business processes. The focusing of the study and the development of a model assesses the relationship of this complexity strategy. An extension of the perspective on external corporate networks would be an interesting perspective to include the internal and external view of a company. Dietrich Dörner focuses on the management under uncertain environments and proposes a procedure model for dealing with complexity. In addition, he provides general recommendations for action at the highest strategic level. Dörner is using a global view and focuses on human action behavior in management. Dieter Specht and Gunnar Berntsen developed a derivation of a model for dealing with complexities, which is based on safety, uncertainty and indefiniteness. They specify requirements for a model and apply these to manage technology in a holistic view (also to apply for outsourcing situations). Specific models for the management of complexity in business are not pronounced. Dittes analyses the reasons of complexity and recommends (like other researchers also) complexities through networks to capture and to make transparent. His focus is on the border of complexities to chaos. In 2014, PMI published "Practical guide", therewith creating a new standard approach for the first time in science (besides the research from Schott especially for Outsourcing), where complexity management and projects / programmes are linked with each other. The practical analyses and concepts of Wildemann are very extensive and all encompassing: they relate to functional blocks in the company. Despite the fact that a specific reference to provision of services is lacking, Wildemann's approach will be of relevance in the context of this research.

The science of complexity management significantly existed only in the last 10 years. Moreover, it should be noted that (due to the interdisciplinary) a wide variety of research approaches exist. It can be observed that a variety of concepts in the past 3 years include similar structures, for example, the necessary internal and external view of complexities. It must also be noted that a variety of models have got a "*decision making-character*". In the context of long-term (outsourcing) projects, the time perspective must be considered. Exclusively a literature of 2014 uses the terminology: „navigating complexity". In the systematic approach with environmental focus from Johnston, M. Stevens, external factors are adequately sufficiently taken into account. In outsourcing relationships also external factors are of great relevance (see also Rennung, 2015, p. 263) and therefore the content to be taken into account in this research.

The approach provided by Lang (2016) is very extensive and refers to the management of complexities in the business environment. The steps in the recommended procedure are extensively enriched with a variety of different management tools. This is what the strong interdisciplinary nature of complexity management needs. A modification of projects for major customers, such as large-scale outsourcing is not given.

2.2.5. Large-scale service–oriented projects – the research context definition

At the beginning of this chapter, the term "*large-scale*" is defined and delimited. Within the context of the PhD research, the following presumptions on the business environment characteristics and projects were considered:

- Duration of the contractual agreement more than five years;
- Service provision has industrial character (mass production);
- Large-volume-paying activities (more than 10 million € per year);
- Projects and programmes with a duration of more than two years;
- Projects are associated with extensive organizational and process changes from the beginning of the supply relationship;
- The participating organizations have more than 500 employees, respectively, and are distributed internationally and structurally;
- Classic examples of such projects were considered the outsourcing and Merger & Acquisition projects;

In addition, two important observations have to be considered on:

- *Services*: It is not important what kind of services are provided accurately and delivered. Furthermore, an attempt is made to consider both perspectives (even from the perspective of the provider and on the other hand from the perspective the service recipient);
- *Steering and control of projects*: Approaches on project management are considered as the recommended by PMI.

In **Annex 2**, a specific use case of an IT Outsourcing project is described. This is used for the research in this thesis. In addition, in recent research contributions to risks in outsourcing, extensive causes and effects are analyzed; the issue of complexity is often not included (Sorokina, 2016). Even (Bohács et al., 2016, p. 1) describes that projects are usually controlled by means of defined milestones.

In 2005, Stefan Behrens and Christopher Schmitz developed a *framework for the implementation of IT Outsourcing governance*, with the following key questions:

- Wherein lies the need to control complexities?
- What governance mechanisms can be established to operate the control and coordination of complexity?
- How should the governance mechanisms be configured?

The complexity is influenced not only by the objectives but also by the type of services, by the organizational structures of business partners, their cultures and the overall scope and circumference of the project (Behrens & Schmitz, 2005) (Figure 2.13).

The research team of Frank Keuper, Marc Schonmann and Klaus Zimmermann argues that the strategy to reduce complexity represents an "old focus" in outsourcing projects and recommends a flexible strategy to meet customer requirements and increasing differentiation (Keuper et al., 2010).

At the Annual SRII Global Conference 2012, Sujoy Basu, Sharad Singhal, Jun Li, Bryan Stephenson and Wen Yao published the paper: "*Governance Framework*

for IT Transformation Projects in Outsourcing" which describes at the beginning, that the outsourcing process can be divided into three phases (Basu et al., 2012):

1. Design phase of the contract;
2. The "*on-boarding phase*" are in today's internal Services (CMO) transferred to the service provider and the new service-customer (FMO) begins the relationship;
3. Operational phase FMO.

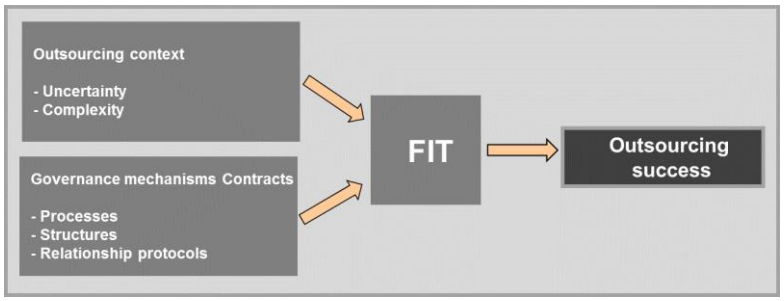

Fig. 2.13. Framework for IT Outsourcing Governance (Behrens & Schmitz, 2005)

This entire process can be derived in two main activities:

- Transition: The future provider takes over the responsibility of the service provision; the existing structures are retained.
- Transformation: Transfer of services in the future service structures (FMO).

The publication takes up the challenges in the phases and gives recommendations from the perspective of a service provider; in this case the current scientific status and of best practice approaches from practice is used. The customer integration process is subdivided into three dimensions (Basu et al., 2012): (1) Technological dimension; (2) Organization dimension; (3) Process dimension.

As part of the "*on-boarding process*", the following critical success factors are identified and characterized (Basu et al., 2012):

- **Visibility of roles, responsibilities and process:** The governance model must provide clarity about the persons involved, roles and processes. Without this transparency, the effort and time aspects in the change process cannot be managed;
- **Master data management:** Valid and complete master data serve to support the processes. The corresponding sources are to be identified and converted into a consolidated framework. Likewise, a process of permanent deployment of master data is set up;
- **Collaboration and communication:** The governance model must provide a suitable communication structure to ensure that all project participants can efficiently access to necessary information. However, the participants and the stakeholders also must be provided with target-group oriented specific information (e.g. project status, technical information about the performance etc.);
- **Platform architecture:** The various layers of the IT service delivery should support governance framework. These different layers are:
    - User presentation layer;
    - Data processing layer;
    - Process layer;
    - Data and support tools layer;

Based on these layers, a reporting is placed so that a statement on the status of integration capability is ensured to any date.

- **Cost-Benefit Analysis:** Across all layers, the governance framework should monitor these costs and benefits and make decisions about the architecture design appropriate and the integration efficient.

Furthermore, in their paper "*An integrated approach to the management of IT Outsourcing projects*", Nils Urbach and Tobias Würz developed a strategic approach to the management of IT Outsourcing projects. The framework includes the following elements (Urbach & Wurz, 2012):

- Requirements Management;
- Contract Management;
- Communication Management;
- Risk Management;
- Performance Management;
- Service Improvement.

Hagen Rickmann, Stefan Diefenbach and Kai T. Brüning (2013) published with further authors' extensive literature on the topic of outsourcing influenced by current and future megatrends (Rickmann et al., 2013). The authors Carsten Glohr, Jörn Brast and Sarah Lee deepen this Next Generation Outsourcing (NGO), which is characterized by the following:

1. Termination of an existing contractual relationship between (potential) customer and service provider;
2. Selection process of the customer;
3. Transfer of services, or processes;
4. Optimized power handling.

The following strategies to minimize risks of outsourcing are recommended:

1. Contractually fixed exit clauses:
    - Regulations on asset-transition;
    - Arrangements for staff transition;
    - Provisions for documenting and know-how transfer;
    - A system for data security and intellectual property;
    - Cost of (Re)Transition;
    - Timing and transitional periods for (Re) Transition;
2. Development of fallback scenarios (Glohr et al., 2013, pp. 119-144).

Junichi Kato and Richard Schoenberg (2014) presented the paper "*The impact of post-merger integration on the customer-supplier relationship*" in 2014. This study seeks to illuminate, using case study methodology, the customer-supplier relationship, which is affected during a post-merger integration process in the business-to-business context. Part of the results are "*variables influencing B2B (business to business) customer-supplier relationship used in Q-sort procedure*" to evaluate the impact on customer loyalty. Two categories were built:

- Supplier's marketing, sales and operational activities influencing relationship;
- External and conditional factors.

In **Annex 6**, these *variables* are listed specifically and in detail. The consideration of this paper was chosen because this is due to the reflection of the external customer, an additional dimension to the complexity of the M&A process (Kato& Schoenberg, 2014).

Furthermore, in 2014, Rocha developed core components and the structure (orientation, risk management, portfolio management, organization, stakeholder management, performance evaluation and business transformation) that can support the implementation of a governance project, in order to control and manage

it, based on the Enterprise Project Governance (EPG) model (Rocha, 2014) (as described in Table 2.7). Enterprise Project Management (EPM) is a management field of organizational development that support companies to manage comprehensive changes. It is a method, which contains communication aspects and a type of project working to support company's organization and, directly linked with the vision of leadership, mission, strategy, goals and objectives.

Tab. 2.7. Core components for project governance (Rocha, 2014, p. 43-44)

Components	Scope
Strategic Alignment	The responsibility of the EPG is to ensure that the projects are in line with corporate strategies and objectives and that the project is implemented effectively and productively.
Risk Management	Risk management is a systematic process of identifying and assessing business risks and taking action to protect a company. Companies need risk management to carry out a review of possible risks and to avoid incurring losses (due to avoidable errors).
Portfolio Management	The portfolio provides a big-picture view. As projects and programmes are engines of value creation, portfolio offers the connection between strategy and execution with clarity about the dangers involved. It facilitates the appropriate sort, adds and removes projects from the entire scope.
Organization	An effective EPG assumes that the leading people to be organized and their contributions are modelled. An appropriate organizational structure, roles and responsibilities are required for all participants.
Stakeholder Engagement	In every company different parties and interest groups exist, therefore there are also different expected results from the project stakeholders. There is a communal social need that the company's activities are transparent in mega-projects to make organizational and project decisions comprehensible. For this reason, the analysis of the impact of projects on the social community through a stakeholder engagement plan must be designed. The activities consider external and internal stakeholders.
Performance Evaluation	To achieve an effective project portfolio for EPG, the overall performance of the project is to periodically measure and monitor. This serves as a basis to ensure that the business objectives are consistent with the changing environment during the project.
Business Transformation	Effective business transformation requires a continuous process established to enable the company to implement business strategies to achieve its vision. This requirement is entered into at any time, because vision and strategy must constantly adapt depending on the development of economic influences. Business agility, or the ability to achieve business transformation it is a measure of management and business success and as such essential in the monitoring of the EPG. A creation of swap capability allows the customer to continue to optimize performance in response to changing service requirements and new strategic drivers

In 2014, Thomas Söbbing published a very comprehensive book "*IT Outsourcing Manual*"(1200 pages)with various aspects of outsourcing projects. However, aspects of complexity management are not covered in this book (Sobbing, 2014).

Based on the "*Partial Least Squares Structural Equation Modelling (PLSSEM)*", Mohamad Ghozali Hassan, Abdul Aziz Othman and Mohd Azril Ismail used the approach to explore the factors of environmental dynamism impact on the

strategic outsourcing success. The proposed framework is composed of three dimensions of environmental dynamics, which contain (Hassan et al, 2015a):

- The different possible levels of competition in a market that a company faces;
- Distinct technological changes and
- Unsystematic fluctuating level of customer demand products.

The three dimensions of environmental dynamics represent the frequency of the change in demand, technological change and the level of competition. The aim of the research was to investigate the influence of the three dimensions of environmental dynamics (customer requirements, levels of competition and technological changes) the outsourcing success (Hassan et al, 2015a).

Subsequently, Hassan and his research team published the paper *Project Management Strategies in Outsourcing Best Practice,* in 2015, in which different input-parameters were evaluated by outsourcing experts. Implications were valued in the following variables (Hassan et al, 2015b): (a) Dependence and supplier-manufacturer relationship; (b) Communication behavior and supplier-manufacturer relationship; (c) Supplier-manufacturer relationship relates to outsourcing success; (d) Environmental dynamism factor with supplier-manufacturer relationship and outsourcing success.

Based on this analysis, the following project management strategies were derived (Hassan et al., 2015b):

- Communication Management;
- Performance Management;
- Knowledge Transfer Management;
- Relationship Management;
- Crisis Management;
- Risk Management;
- Cost Management.

In Table 2.8, these strategic recommendations are presented and characterized.

Tab. 2.8. Recommended strategies in outsourcing
(Rennung, 2015, derived from (Hassan, et al., 2015b))

Strategy	Description
Communication Management	A bi-directional focused communication at all stages of the project supports a joint project success and avoids misunderstandings among the participating stakeholders.
Performance Management	An establishment of a permanent review of the project quality and adherence to the compliance allows evaluating the performance of the project.
Knowledge Transfer Management	A continual knowledge transfer enables an increase of the total project quality and ensures the agreed timeline.
Relationship Management	A distinctive respect management supports the project success. This can occur through continuous transparency and regular communication.
Crisis Management	A crisis management must be built up from beginning, in case of the entry of a crisis; the partners are prepared to continue the business.
Risk Management	A risk management supports that potential risks can be identified and minimized and possible "*back up*" plans are provided.
Cost Management	All partners should reach their respective cost aims, so it is necessary that the costs are analyzed constantly.

In 2015, Lu and the research team stress that the consideration of complexities should be an integral part of project management (Lu et al, 2015).

Because of their study, a model was developed with the perspectives: tasks and organization, as well as the underlying workload (TO model). The "influencing factors of project complexity are broken down in four levels and mapped with the following attributes:

- Solution complexity;
- Requirement complexity;
- Task uncertainty;
- Sequential interdependence;
- Reworking relationship;
- Communication relationship;
- Parallel relationship;
- Position role;
- Allocation of organizational position skills;
- Technical errors;
- Team experience;
- Position experience;
- Degree of centralization;
- Degree of formalization;
- Degree of matrixing" (Lu et al, 2015).

In **Annex 7** of this thesis, the structure of the TO model is presented. The TO measurement method addresses the hidden workload behind the dimensions, which enables to evaluate project complexity and its impact on project schedule, cost, quality, and other performance indicators indirectly. It is mentioned in the conclusion of the research that the external factors are not considered in the model (Lu et al., 2015).

Gerhard Ortner (2015) connects the scientific approach of project management with the issue of outsourcing. Here, the PMI concept is used with the following phases as guiding principle: Project Initiation; Planning; Executing; Monitoring; Closing.

No processes can be considered isolated, but rather are closely linked and are conditional on each other. As barriers the following topics are identified (Ortner, 2015):

1. **Management:** Strategic and long-term management dimension must be aware of;
2. **Project:** In order to exercise the necessary control and responsibility of the project, the project manager must have appropriate experience;
3. **Future service partners:** A valid assessment of the future partner is essential and acts to minimize risk;
4. **Other stakeholders:** All stakeholders of the project should be involved sufficiently, so as to take into account all their objectives and interests;
5. **The general conditions:** To ensure that a real assessment of the conditions is carried out in terms of stability.

Paul D. Witman und Christopher Njunge (2016) published a paper with the goal to describe a case study in service outsourcing, which provides a series of scenarios, including process inputs, outputs, and known business rules. They provide some important technical and business definitions (with their respective elements), which will help to understand the use case. The elements are each described in a few sentences in shorthand (some of them with a short description). The "*Business Elements*" are shown in the following:

- Long-term perspective;
- Servicing are functions of processing the production or the services, interacting with customers;

- A business process is a set of related tasks that accomplish a particular business function (e.g., creating a bill, accepting payment);
- Power of attorney is a document that allows one or more individuals something;
- Information is an organized collection of facts (data) about people, places, things, concepts;
- Business rules are the rules which govern human and automated operations of an organization, including such things as authentication requirements, eligibility rules;
- Decision-making is the process of determining the next steps to take, given a collection of available information and applicable business rules. It may be entirely manual, partly automated, or fully automated;
- Information ethics is to deal with the ethical principles related to the management and use of information, particularly as it relates to the impact of that information on people.

The "*Technical Concepts*" are listed in the following (Witman & Njunge, 2016, p. 5-6):

- Outsourcing is the transfer of the execution of specific business processes to a separate organization, outsourcing often enables the partner to share information;
- Data migration and conversion is the process of moving data between different stakeholder IT systems;
- Black-box is a term that refers to being unable to directly see and understand the internals of a system or process;
- Information quality is a key success factor of an information system. The scope is to describe various characteristics of information, including accuracy, accessibility, timeliness, format, and other factors.

A similar logic is used in the later stages of this research for the use case description.

2.2.6. Practice-oriented research and scientific articles

In the following, there are presented, analyzed and evaluated approaches, which have developed the foreground of practical experience from outsourcing projects.

In 2014, Christiane Strasse and Uta Blankenfeld described in the Financial Germany article "*Ten Tips for proper outsourcing*", important critical success steps to design an outsource project (Table 2.9).

The company Simplicity GmbH published in 2005, an Internet article entitled: "*Outsourcing Study: Outsourcing-Studie: Versteckte Kosten und hohe Komplexität*" (translated: Outsourcing Study: Hidden costs and high complexity), in which the results of a study done by Deloitte company (*Calling a Change in the outsourcing model)* was interpreted. The study was conducted in 2004 through personal interviews with executives; the respondents were from 25 major international companies in the fields of manufacturing, transportation, consumer products, utilities, financial services, technology / media / telecommunications, healthcare and the public sector. The study's results show that 70% of respondents have had very negative experiences with outsourcing projects. According to Deloitte, the original outsourcing engagement is mainly due to the following reasons: cost savings, more comfortable handling, flexibility and lack of in-house expertise. However, many companies have found out that outsourcing does not simplify their processes. On the contrary, partially higher complexity, additional costs, frictional losses in the value chain and a superior claim to the management

become apparent thereby. The complexity of this multidisciplinary topic has been underestimated (Simplicity GmbH, 2005).

Tab. 2.9. Ten important critical success steps to design an outsource project (own table, derived from (Strasse & Blankenfeld, 2004))

No	Name	Short description
1	Target Definition	To match the targets, the right outsourcing model must be chosen in set-up.
2	Task	The detail tasks of the future service have to be defined and described.
3	Alternatives	Different options in the temporal dimension, technical expression and outsourcing model characteristics must be evaluated.
4	Selection	Based on various offers, the right provider should be selected; the experience and expertise of the potential providers are taken into account.
5	Contract	The services are to be fixed with warranty, liability, deadlines and confidentiality provisions in the contract.
6	Project management	A joint project management between the parties with rules on communication, coordination and escalation instances must be set up.
7	Briefing	The project's success depends largely on a mutual exchange of information to get a common understanding.
8	Respect	The customer-service provider should not be over-controlled and treat them with respect.
9	Acceptance	A review of reached objectives should finalize the project.
10	Service	Contractual arrangements for the life operation should be defined and commonly agreed upon.

With their publication of "*Outsourcing complex business processes*", Matthias Holweg and Frits K. Pil (2012) created a new sub-discipline in complexity management. An *enterprise partnership* provides an alternative to the traditional model. *Enterprise partnership* can be especially useful for companies in order to carry out the extensive outsourcing processes and services. In this publication, the development of a partnership between a client and the service is analyzed. This partnership provides a useful option for outsourcing projects with high process complexity. The *enterprise partnership* approach is based on a corporate partnership, bidden a joint venture or a share-based relationship, which are provided by the services. Thus, common interests are encouraged and the establishment of an opportunistic behavior is significantly reduced. A legislative framework provides the necessary ground for enterprise partnership. This construct is designed for a long-term horizon (Holweg & Pil, 2012).

Andreas H. König (2012) developed, in "*IT-Outsourcing anno 2012?*", six strategic pieces of advice for a successful outsourcing project, based on the fundamental conflict of interest between customers and service providers. The customer wants scalable low cost, flexibility and high quality; the service provider would like computable guaranteed revenues, stability and high profitability. The six advices are summarized in Table 2.10.

Eberhard Schott and Jörg Striebeck (2012) describe the specific characteristics of IT services in outsourcing. These services are characterized by: transfer function; resources transmission; high specificity and binding; market relatedness.

Tab. 2.10. Six strategic advices for a successful outsourcing project (own table, derived from (König, 2012))

No	Short description
1	Regarding cost consideration, all factors are taken into account.
2	Processes, configuration management and project management must be structured before the outsourcing project starts.
3	The business case must take all costs, including incidental expenses, into account. The business case must alone be valid without special effects.
4	Several partners as specialists on an equal footing are the key to success.
5	Clear contractual arrangements, with flexibility for changes and exit
6	Expectations Management at end users and clear commitment of all stakeholders

Furthermore, in the publication, the outsourcing paradox is explained. The future demand side of the partnership (customer) is in the beginning of the business relationship the seller of the relevant services. As part of further outsourcing processes different interests of the parties are created. In order to run the outsourcing for both sides successfully, these interests must be considered mutually exclusive (Schott& Striebeck, 2012).

Kai Schwarz interviewed Rudolf Kergassner (service company: IPsoft). The managed services provider IPsoft continues to see a strong demand for outsourcing solutions to companies. The most common reasons for outsourcing projects failure are centralized in Table 2.11.

In 2014, Branimir Brodnik summarizes the seven greatest errors often made in outsourcing projects as presented in Table 2.12.

Tab. 2.11. Most common reasons for failed outsourcing projects (own table, derived from (Schwarz, 2013))

No	Short description
1	Comprehensive Outsourcing Scope caused too much complexity
2	Definition of the current state before starting the project and target definition
3	Weaknesses in contract design
4	Insufficient provider selection
5	Joint Implementation of the parties involved
6	Too short a time expectation

Tab. 2.12. Seven greatest errors in outsourcing projects (own table, derived from (Brodnik, 2014))

No	Short description
1	Excessive ambitions
2	Unrealistic expectations
3	Lack of "*cultural fit*" with our partners
4	Inadequate implementation experience
5	Dizzy management commitment
6	Sanctions-oriented provider control
7	Non-matching particular interests of the parties

Rudolf Kergassner (2014) argues that many outsourcing projects fail. Many projects do not even reach the FMO and therefore remain in an intermediate state (CMO+). The reasons of this fact are listed in Table 2.13.

Tab. 2.13. Reasons why outsourcing projects do not reach the FMO operations (own table, derived from (Kergassner, 2014))

No	Short description
1	Too large extent of the outsourcing project
2	Not an exact determination of the actual state
3	Weaknesses in contract design
4	No analysis of the operating model of the provider
5	Insufficient involvement of management
6	Underestimation of the time complexity
7	Too high expectations of profitability

In 2014, Jeremy Smith, Director of the company MATURITY GmbH, published the results of the study entitled "*Future of Outsourcing*", at which 250 IT and business managers of medium to large companies participated. The study result show that over 40% of respondents rated their experience with outsourcing as *generally satisfied* and almost 30% of respondents with the value *satisfied*. Something more than 10% answered "very satisfied" and each of 0-10% answered *less satisfied* or *not satisfied* or recognized that: *We do not use an IT service provider*. Overall, the result was that about 70% were either *satisfied* or *mostly satisfied*. Complexity relevant aspects have not been included in the study and they have not been listed as a future field of action (Smith, 2014).

In the same year, Martin Wocher reported that several outsourcing industry specialists recognize a re-growing trend to large-volume outsourcing deals. In order to support Industry 4.0 topics, companies have orientated their related organizations accordingly; future topics are for example intelligent networks (Wocher, 2014).

2.2.7. Pre-conclusions

As a preliminary synthesis on outsourcing projects topics, Table 2.14 presents the scientific concepts related to the reference research done.

Tab. 2.14. Stages of development in outsourcing projects (own table)

Scientific concepts		
Large scale projects – case Outsourcing	*Ein Bezugsrahmen für die Implementierung von IT-Outsourcing-Governance* (translated: A reference framework for the implementation of IT Outsourcing governance): Development of a framework for the implementation of IT Outsourcing governance.	(Behrens& Schmitz, 2005)
	Innovatives IT-Management: Management von IT und IT-gestütztes Management (translated: Innovative IT management: Management of IT and IT-based management): Discussion in various topics in Outsourcing projects and managing IT aspects from different perspectives and authors of (practical-oriented) experts of IT management.	(Keuper et al., 2010)
	Governance Framework for IT Transformation Projects in Outsourcing: An integrated framework for on-boarding governance can be used from the organization, technology and process perspectives in outsourcing integration projects.	(Basu et al., 2012)

Scientific concepts		
	Ein integrierter Ansatz zur Steuerung von IT-Outsourcing-Vorhaben (translated: An integrated approach to the management of IT Outsourcing projects.	(Urbach& Würz, 2012)
	IT-Outsourcing: Neue Herausforderungen im Zeitalter von Cloud Computing (translated: IT Outsourcing: New Challenges in the Age of Cloud Computing): Analysis and strategy of a holistic outsourcing based on new and current megatrends. Based on the contributions of various authors from the perspective of providers, consulting and research, the changes and trends of IT Outsourcing environment are presented mainly by the influence of cloud computing.	(Rickmann et al., 2013)
Large scale projects – case Outsourcing	*The impact of post-merger integration on the customer-supplier relationship:* Development of 37 variables that affect a B2B relationship between supplier and customer. The criteria are described in a short form, but applied no closer in detail or in a model.	(Kato& Schoenberg, 2014)
	Beyond Project Decisions. Deciding on how to Decide: Presentation of a summary of the core components with the target for project governance in projects.	(Rocha, 2014)
	Handbuch IT Outsourcing (translated*: "IT* Outsourcing Manual"): A very comprehensive guide: *"IT Outsourcing Manual"* with more than 1200 pages of content on various aspects of outsourcing projects.	(Söbbing, 2014)
	The Impact of Environment Dynamism on Strategic Outsourcing Success: Carrying out a research to investigate the influence of the three dimensions of environmental dynamics (customer requirements, levels of competition and technological changes), the outsourcing success, based on the model: Partial Least Squares Structural Equation Modelling (PLSSEM).	(Hassan et al., 2015a)
	Project Management Strategies in Outsourcing Best Practice: Based on a study, Hassan et al. developed seven strategies for successful outsourcing projects: - Communication Management - Performance Management - Knowledge Transfer Management - Relationship Management - Crisis Management - Risk Management - Cost Management	(Hassan et al., 2015b)
	Measurement model of project complexity for large-scale projects from task and organization perspective: Consideration of project complexity model by means of the TO measurement method, which address the hidden workload of the dimension's organization and tasks.	(Lu et al., 2015)
	Projektmanagement-Outsourcing (translated: Project management- outsourcing): Scientific approach model in outsourcing projects based on the PMI standards.	(Ortner, 2015)
Large scale projects – case Outsourcing	*Black Box Thinking: Analysis of a Service Outsourcing Case in Insurance*: Description of a case study in Service Outsourcing, which provides scenarios, including process inputs, outputs and business rules. Important technical and business definitions are presented to structure a use case of Outsourcing.	(Witman & Njunge, 2016)

Scientific concepts		
Practice-oriented research and scientific articles	*Description of "Ten Tips for proper outsourcing"* as a critical success factor in the design phase of an outsource project, in the article: *"Zehn Tipps für richtiges Outsourcing"*	(Strasse & Blankenfeld, 2004)
	Outsourcing Study: Outsourcing-Studie: Versteckte Kosten und hohe Komplexität (translated: Outsourcing Study: Hidden costs and high complexity): study with outsourcing experts about reasons of failure of outsourcing projects	(Simplicity GmbH, 2005)
	Outsourcing Complex Business Processes Analysis of a real existing partnership to bring out the distinction between BPO and enterprise partnership.	(Holweg & Pil, 2012).
	IT-Outsourcing anno 2012? Development of six strategic pieces of advice for a successful outsourcing project.	(König, 2012)
	IT-Outsourcing in Deutschland (translated: IT Outsourcing in Germany): Analysis and definition of IT outsourcing services from other services, as well as elaborations of specific characteristics.	(Schott & Striebeck, 2012)
	Sechs typische Pannen bei Outsourcing-Projekten (translated: Six typical mishaps in outsourcing projects):Presentation of the main reasons for the failure of outsourcing projects, based on an interview with Rudolf Kergassner	(Schwarz, 2013)
	7 Gründe, an denen Outsourcing-Projekte scheitern (translated: 7 reasons to which outsourcing projects fail): Summary of the seven main mistakes that are made in outsourcing.	(Brodnik, 2014)
	Multi-Kulti im IT-Outsourcing sorgt für Erfolg (translated: Multi culture in IT Outsourcing enables success): Summary of the main reasons why outsourcing projects cannot be transferred to the target operating.	(Kergassner, 2014)
	IT-Outsourcing 2020: Analysis and interpretation of a study in 2014 in which 250 IT and business experts were consulted on the future development of Outsourcing projects.	(Smith, 2014)
	IT-Outsourcing nimmt Fahrt auf (translated: IT Outsourcing is picking up speed): Newspaper report on the development of IT Outsourcing projects and industrial focus in the IT industry.	(Wocher, 2014)

The framework for the implementation of IT Outsourcing governance from (Behrens and Schmitz, 2005), brings the outsourcing context and Governance model together. The outsourcing success depends on reaching the FIT degree of these two elements. This design approach is considered later in this research, too.

(Kato & Schoenberg, 2012) uses a fundamentally different structure (in their paper: *The impact of post-merger integration on the customer-supplier relationship*). However, the individual content (processes, organization, technology, cooperate ...) is almost identical to the complexity drivers by researches already shown.

(Basu et al., 2012) uses the typical structure of an integration in large-scale outsourcing projects in the paper *Governance Framework for IT Transformation Projects in Outsourcing*. This structure and the application of the different service management layer are used later in this research, also.

Ortner combines project management standards with outsourcing projects for the first time in 2015. The procedure itself is strongly oriented to the PMI

standards. Likewise, for the first time, (Hassan et al., 2015a and 2015b) brings multidimensional externally influenced complexity and outsourcing success.

Various consulting firms, mostly together with a scientific institute, analyze most of the practice starting with typical errors in outsourcing projects and provide appropriate recommendations. The above coverage ratio of the challenges as content is quite high. In the cases of practice-oriented research, the distinction between reasons for failure, strategies, measures and recommendations is often untidy. It is also, worth noting that often the attempt is made to break down the outsourcing success on a few success criteria (e.g. 6 Strategies for ..., or 7 Reasons for ….). Their contents of the results are comparable; complexity is usually identified as one of the causes. Concrete recommendations for dealing with complexity is lacking in the elaborations.

Project management needs an intelligent and basic strategy to address the challenge of dealing with complexity (Dalcher, 2015).

2.3. Conclusions

In the past ten years, various studies on outsourcing projects were carried out. A large number of scientific articles use the word complexity, but (only) complicated connections are discussed in the statements; this can be seen in product-related discussions in particular. The results are very different. Some studies show a high level of dissatisfaction regarding the lived experience of outsourcing projects; other studies confirm a high overall satisfaction in meeting the desired goals. The importance of complexity is also interpreted very differently. In some results of studies and recommendations, complexity is not even listed in other sources; it is rated as a substantial cause of the failure of projects and titled as TOP operating field. In summary, it can be stated that complexity management should play an important role in future outsourcing projects.

Most concepts of the research area of Industry 4.0 and business-related Complexity Management have the production as the focus of attention. Service is often considered only an accompanying service to producer goods. Concepts to Industry 4.0 include hitherto little implementation focus. Also very recent elaborations placing the emphasis on pointing out the need for the industry and the associated challenges.

Comparable is the consideration of the state in the research field of Complexity Management. In 2010, Blockus have extensively published complexity relevant research in a service management environment for the first time. In addition, starting in 2010, some researchers, such as Schoenberg, Wildemann, developed extensive criteria for complexity management. The expressions of these criteria are extensive and meet the requirement for a conventional customer / provider relationship. Intensive research for the "*Business use case: Outsourcing"* was so far only done by Schott between 2007 and 2010. However, only a few researchers, such as Dieter Specht and Gunnar Berntsen, emphasize the important role of uncertainties. Likewise, the issues that many models have a *judicial determination* shall be addressed. In long-term projects, controlling of complexities in a longer period is required and necessary. A variety of research in complexity management therefore comes to the result that the scenario building is an appropriate way to represent simulations for future complexities. Almost all of the concepts denote the relations of stakeholder involved as a network. The present results of the analysis of the research status are taken into account in the following

chapters of this research and moreover, the existing research gaps will be closed. All existing complexity models are not completely suitable for being used as a complexity management in major outsourcing projects; each of the models have got relevant gaps, for example, the model of Lu: "*Measurement model of project complexity for large-scale projects from task and organization perspective"* is very extensive, but excludes external factors at the same time. Equally remarkable is that concrete implementation concepts, with suitable methods and tools, are missing. However, also this scientific gap will be closed during this research.

OP1.1 objective achievement
After the definition of the research core (conceptual framework) and context (delimitations), a comprehensive literature research was presented and analyzed chronologically. The result constitutes the current state-of-the-art in the research field of *Complexity Management*, clustered in neighborhood research areas.

3. PREPARATION OF A BUSINESS COMPLEXITY MANAGEMENT MODEL IN A LARGE-SCALE BUSINESS ENVIRONMENT

3.1. Further related disciplines in the context of complexity management

The following section provides further scientific disciplines to be investigated (as knowledge and wisdom resources), which are relevant for a consideration of complexity management in large-volume business situations. This is represented by the debates and discussions in this research. Partially, only individual aspects will be presented, particular those, which are relevant, in terms of, research results and findings. Cross-disciplinary research could be of particular relevance (Veldman & Alblas, 2012). The different disciplines convergent on complexity management are structured by considering their relevant issues and aspects and they are not illustrated sorted by time.

3.2. Analysis of further disciplines in order to complete the state of research of complexity management

3.2.1. Service Provisioning Management

Service Blueprint (SB) is a method for describing service processes.

The first stage of development is different between two activity levels and is separated by the visibility line (*line of visibility*). Thus, the process steps (in which the customer is involved in the services provision), are visible separated from the activities of the service provisioning (supplier's perspective). Further separation of client activity to interact with the provider offers customer interaction line (*line of interaction*).

The customer interaction line illustrates the communication between the customer and the supplier. There the customer activities are thus visualized separately from the service provider activities. The internal interaction level (*line of internal interaction*) puts the activities of the provider in the background, the so-called: back-office activities. Different departments provide supporting activities. The customer does not directly perceive these.

Secondly, the *line of implementation* separates the support activities from the management activities. While the support activities include a special service creation process, the management activities are preparatory activities and are valid for multiple services. Classical management activities are controlling and personnel planning.

The third stage of development offers the possibility of the determination of the performance creation process from the performance potential by an additional planning line (*line of order penetration*).

Tab. 3.1. Complexity dimensions for measurement method for services (own table, derived from (Rieck, 2011))

No	Short description of complexity dimensions
1	Composition with criteria: possibility of acquiring individual partial services, number of partial services
2	Stakeholders, with the criterion: level of participation of stakeholders
3	Term effect, with the following criteria: duration of the performance, duration of the service
4	External factor, with the criteria: impact of the external factor on the result, degree of individualization, level of integration
5	Information asymmetry, with the criteria, uncertainties on the part of the supplier, uncertainty on the part of customers, degree of mismatch of customer goals between supplier and customer
6	Customer loyalty, with criteria: degree of identification with the supplier, potential demand frequency with the same provider

Above this line are the activities afferent to the planning of the service creation process. Below, however, preparatory activities are presented, which are responsible for providing the performance potential of the service. If individual levels of service blueprints are not relevant for a service, this layer may be omitted in the presentation. The notation is not further discussed here (Thomas& Nüttgens, 2010, p. 43-44).

André Rieck (2011) developed a measurement method for services, based on the complexity dimensions described in Table 3.1.

The individual dimensions and characteristics are weighted and consolidated to a "*total complexity*" with the results of ratings (using questionnaires) (Rieck, 2011, p. 21-34).

Sabine Haller points out that service are characterized by the two characteristics *immateriality* and the *integration of an external factor*. Furthermore, various approaches and forms of service delivery are discussed, for example, by integration or degree of interaction, significant research results are based on the research of Meffert (Haller, 2015, p. 7).

This consideration is essential for outsourcing because no classical service provider / customer relationship exists. In general, in a transition phase, the existing service provisioning is unchanged delivered from the service provider in the first phase. Only subsequently, the current services, as part of the transformation phase, will be transformed into a target state (*FMO Services*). Due to numerous boundary conditions, for example, links between the processes and the stakeholders, a "*pure*" FMO Service operating is often never achieved.

The integration of the external factor is a major challenge and often constitutes a problem because the service provider cannot control the service provision on its own (Haller, 2015, p. 252). The Balanced Scorecard presents a special method for target selection and formulation, which includes key figures of four quadrants: financial perspective, the customer perspective, the process perspective and the employee / performance perspective. For each of these four areas, key objectives and their measurements are set up (Haller, 2015, p. 77-78).

3.2.2. Customer Integration and Customer Relationship Management

Gernot Dern (2011) intensively studied a holistic complexity-oriented integration management in a company. It is emphasized that the organization needs to be able to deal with the existing complexity. The challenge for an organization is being reactive (Dern, 2011, p. 210-219).

Due to the numerous interfaces and customer proximity, also the concept of "*customer integration"* is analyzed in this research. Depending on degree of inclusiveness, internalization and externalization of the service, several customer rolls can be distinguished (Table 3.2).

Tab. 3.2. Possible rolls of the customer in business situations (own table, derived from (Fliess, 2009, p.210-212))

No	Name	Short description
1	Co-Designer	The customer is involved in the design phases of services or products.
2	Co-Producer	The customer provides the necessary external factors of production; this role relates mainly to the production-based perspective of the service process.
3	Co-Interactor	The customer communicates and interacts with the customer contact personnel of the Service provider.
4	Substitute for Leadership	The customer handles the management and / or management responsibilities (motivation and evaluation of performance) of the inserted contact employees.

Jannis Angelis emphasized that further research should integrate multiple stakeholders and interested parties, which occur in the customer role as Co-Creator. The boundaries and the effect of Co-Creation, influenced by the various stakeholders and customers, should be made visible in a model (Angelis, 2012).

Liem Ngo Viet and Aron O'Cass note in their study that customer participation can have an extremely positive impact on the company's own service quality and innovation. A more detailed review, with regard to the order complexity, has not been studied (Ngo and O'Cass, 2013).

Stein et al. extensively studied the management need to have important and comprehensive information, available for a B2B partners (situation). Especially in business-to-business marketing, the enhanced cooperation of the company with its customers is often crucial for maintaining a healthy company (Stein et al., 2013). Stein et al. provide a supportive method for effective classification of *Customer Relationship Management (CRM)* information. The result is a professional use of valuable historical information for building competitive strategies and the appropriate programmes and associated strategies to involve customers according to the value-delivery network. A challenging complexity arises in the design of customer-specific data exchange (Stein et al., 2013).

In the research and practice, complexity is often considered with a different objective and in a different perspective. A company has a potential benefit to reduce internal complexity by supplier and customer integration and a clear demarcation itself, therefore focus on their core tasks (He et al., 2014, p. 262).

The concept of customer integration is constantly developing in the services sector, through new technologies; these are, for example, automated checkout at the hotel, self-check-in at the airport, online banking or self-scanning POS in retail. Current research projects examine the relationship between this development and the customer perception on quality (Meyer, 2014).

3.2.3. Systems Engineering

The *Systems Engineering (SE)* is a structured approach to reduce complexity. SE is part of a systems theory that means: *thinking in systems*.

The stated objective is to break down complex issues into individual aspects, to network and to develop detailed solutions, without losing sight of the whole. SE supports the approach to manage complexity or to achieve transparency for complex problems. This in turn, makes possible to identify sub-problems and their interactions with each other, including their interaction with the system environment. Only such a base allows a targeted search for solutions to complex problems. Methods and tasks of SE are presented in Table 3.3.

Depending on the complexity and project phase of the system to be developed, the main tasks and content are different. A system analysis can be carried out on four levels (Andler, 2015, p. 335):

- Enterprise level;
- Product / service level;
- Business process level;
- Technology / infrastructure level.

Tab. 3.3. Methods and tasks of Systems Engineering for complex problems (own table, derived from (Fliess, 2009, p.210-212))

No	Short description of methods and tasks
1	Definition and planning of systems engineering tasks and evaluation of the progress reporting to project management
2	Requirements analysis, requirements definition and requirements management is the basis of system development
3	System Design Optimization (modelling, simulation and evaluation), the development of the system
4	System documentation (functional specifications, drawings, manuals, and others …)
5	Configuration Management / Change Management, in developing there are often changes that must be entered comprehensively in all documents to manufacturing drawings
6	System integration (interface specification or product development) in order to ensure a perfect integration into the next larger system
7	System verification and validation to ensure that the requirements have been met
8	Risk management through periodic target / actual comparisons for critical parameters (mass, electric power, SW / program duration / size ....)
9	Product and quality assurance (e.g., fault trees, failure analysis, FMEA)
10	Sustainable development: each IT-system should be developed in a sustainable way

3.2.4. Network Management

Network thinking and network management is an independent special discipline; parallel developed in this period, is the discipline of service network management.

The method is based on netmapping, i.e. networked thinking and systemic thinking. Peter Gomez and Gilbert Probst (Honegger, 2013, p. 59) essentially base this approach on the scientific work.

The most recent publication is the book "*Venetztes Denken und Handeln in der Praxis – mit Netmapping und Erfolgslogik schrittweise von der Vision zur Aktion"* (translated: Integrating thought and action in practice - with netmapping and successful logic - gradually from vision to action) of 2013 by Honegger, who also

conducted research at the University of St. Gallen, for many years. The scientific approach is illustrated in Figure 3.1.

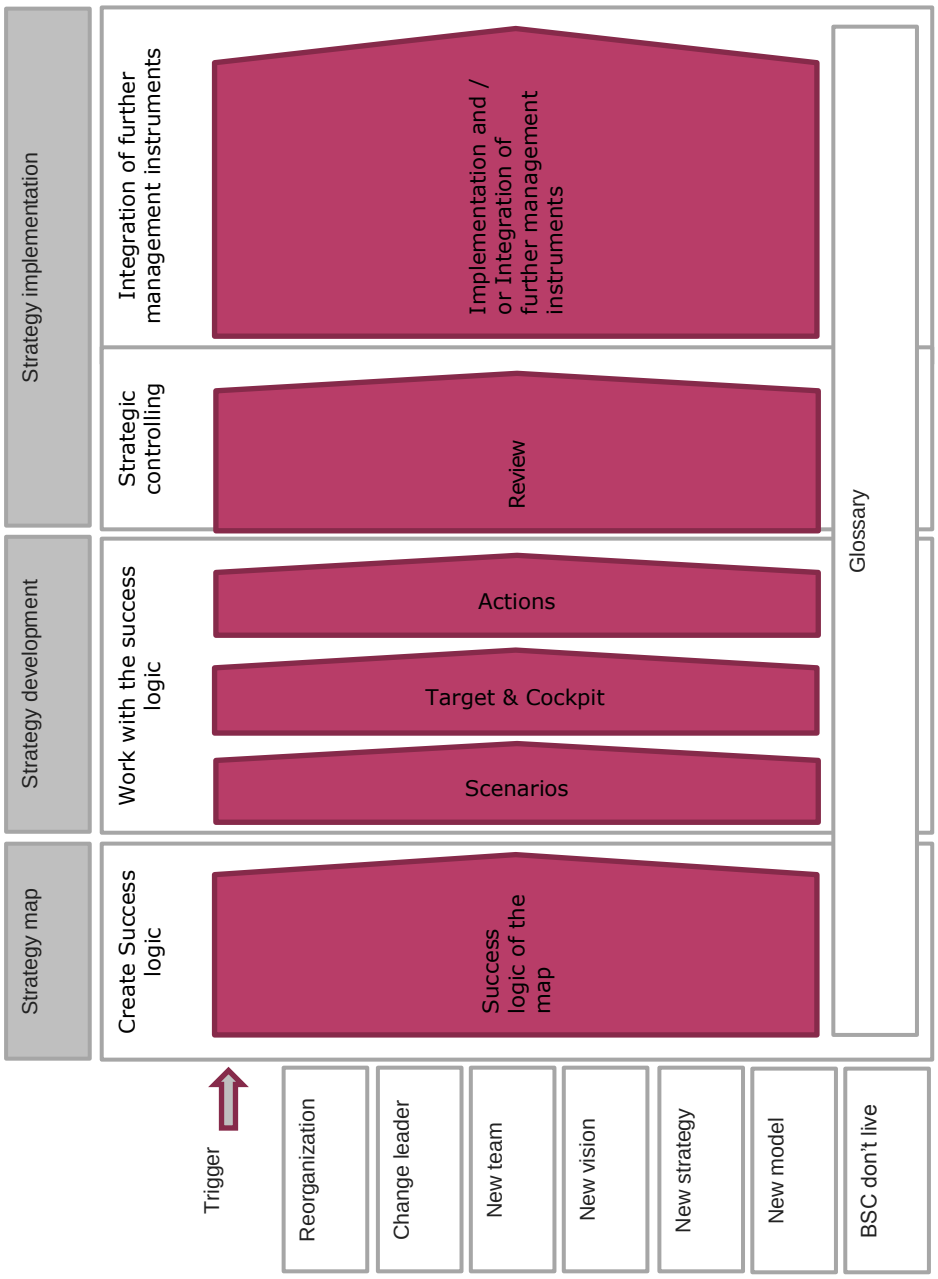

Fig. 3.1. Modules of the strategy method Netmapping (Honegger, n.d.)

In the core of the "*Netmapping approach*" is the logic of success (in German: Erfolgslogik). The procedure is presented in a short form, as follows:

1. Create a successful logic as map;
2. Working with the logic of success (scenarios, goals &cockpit and actions);
3. Review;
4. Introduction and / or integration of other management tools.

3.2.5. (Strategic) Management

In general, there is the view that with increasing size and complexity of the company and with an increasingly diversified and dynamic environment there is the need to increase future-oriented corporate management. In this context, especially the strategic management is mentioned. The strategic approaches have to support the management through the increasingly discontinuous economic developments consciously by acting in a proactive manner and taking into consideration the external environmental relations. The strategic management is to be established as a "*mind-set"* from an overall conceptual view. With the target to develop innovative potential for success, strategic management should locate continuously new businesses and thus implicitly achieve the success assurance and long-term survivability of the company. Here, strategic management should rely not only in the extrapolation of backward-looking data, but also on anticipating future events in order to overcome the increasingly complex environmental developments (Menzenbach, 2012, p. 46).

As part of an outsourcing project, the customer (who has the services outsourced) and service provider (who will deliver these services to the client) have got the same long-term and strategic interests.

A rational analysis to decide and act effectively in an increasingly complex and networked environment is often no longer possible. The variety of information and facts inhibits, and means that even urgent decisions repeatedly are in delay. Intuition can reduce the complexity of problems by identifying the underlying pattern. It is important, therefore, that possibilities, which lie outside of the mind, will be admitted (Hans, 2013, p. 103).

Complexity with a variety of inputs in business situations is only partly detected for this reason, it is recommended to develop visions. This should be done in four steps: (1) Actual analysis of the company's situation; (2) Vision Development; (3) Measures Catalogue; (4) Commitment Agreements.

The entire process can be illustrated with the "*Start-path-goal*" picture. Based on these visions, concrete strategies can be derived. These strategies can be fulfilled by measures; a suitable management measurement method is a Balanced Scorecard (Hans, 2013, p. 96).

Peter F.-J. Niermann describes that situations in management are regularly unclear; objectives can be ambiguous, diverse or contradictory. Accordingly, problems, conflicts, contradictions, dilemmas and paradoxes are core task and justify the need for the management in the company. The ideal of the perfect control in management is an illusion. A management exists and justifies itself, because of this ambiguity, lack of transparency and inconsistency. Companies and organizations do not function as a "*trivial machine"*. A Management must learn with sense, knowledge and experience to be able to deal with complexity and change.

A management, which only focuses on business indicators, underestimates the nature of complex systems. Complex systems are the basis of the global market economy. They are not fiction and also, no concept of art, which are described by the today's unforeseen or incalculable economic interrelationships and interdependencies. Complex systems are the mirror image of a dynamic, turbulent world of dependencies: beyond rational understanding, managers are faced with the

task dealing with complexity. "*Dealing*" means in this case: controlling, eliminating, avoiding, hiding, or simply reducing permit (Niermann, 2014, p. 15-17).

A management system serves the top management to adopt structural provisions, which positively influence the behavior of an organization that it is viable and it stays in the future (Rassfeld, Jochem, 2016, p. 96).

Gilbert Probst and Christian Wiedemann have developed a "strategy guide" which breaks down into the following main phases:

1. Identifying the strategic starting position;
2. Understanding the complexity of the strategy situation;
3. Developing the strategy;
4. Implementing the strategy;
5. Checking and examining the strategy.

After clarifying the strategic starting position, it is necessary to understand the complexity of the strategy situation. This is important because strategic decisions and actions must always be evaluated with consideration to this complexity. First, the main factors of the success of an organization and their interdependencies are identified. The result can be presented in the form of a network. Next, the temporal dependencies and the impact strengths are complemented.

In the next step it is checked what the direct benefit of the strategy of the factors is and what can be regarded as an early warning system for risks and dangers. Based on these factors, appropriate measures can be planned in time. The so refined network then accompanies the further strategy process. Step 2: "*Understanding the complexity of the strategy situation*" is divided into the following intermediate steps:

1. Business complexity:

The strategic situation is identified, the vision has been developed and the current Strategic Success Positions (SEP) are determined. Now the business complexity of the organization should detect and develop a strategy that takes account of this complexity. For this purpose, the strategically relevant, internal and external factors have to be determined and their dynamic interactions appreciated. The procedure is based on the standard approach of "*systems thinking"* by Gomez and Probst. Here, the *cause-effect* by means of arrows is displayed graphically and is brought into a relationship (Probst, Wiedemann, 2013):

2. Business dynamics:

Basis for the next step is the result that the cause-effect is shown in a network. The network will now be specified with respect to the temporal dependencies between the factors, and with regard to their impact strengths.

3. Steering interrelationships:

After the business complexity has been fully recognized, it is important in the next step to determine the *steering level* of the complexity-factors for the network; steering levels can, for example, be defined as follows: state, countries, cities, districts, streets. From the perspective of the selected planning level for the strategy process, factors can be distinguished in the network as steerable and not steered. Furthermore, certain factors can be identified and used as indicators of early warnings:

- **Not steerable factors:** They are part of the environment for the strategy process. The chosen steering levels cannot directly influence them. Using scenarios and contingency planning, an organization can prepare their necessary changes to respond in a sufficiently flexible manner in the event of occurrence.
- **Steerable factors:** They are the starting points for strategic action.

- **Early warning indicators:** They allow early to receive first weak signals about future events. Therefore, an organization is able to deal proactively with the associated risks and opportunities.

As part of the strategic management, Günter Müller-Stewen and Christoph Lechner developed methods to deal with changes in companies. Outsourcing projects are intensive organizational changes. The General Management Navigator (GMN) is comprised of four plus one working fields shown in the Figure 3.2.

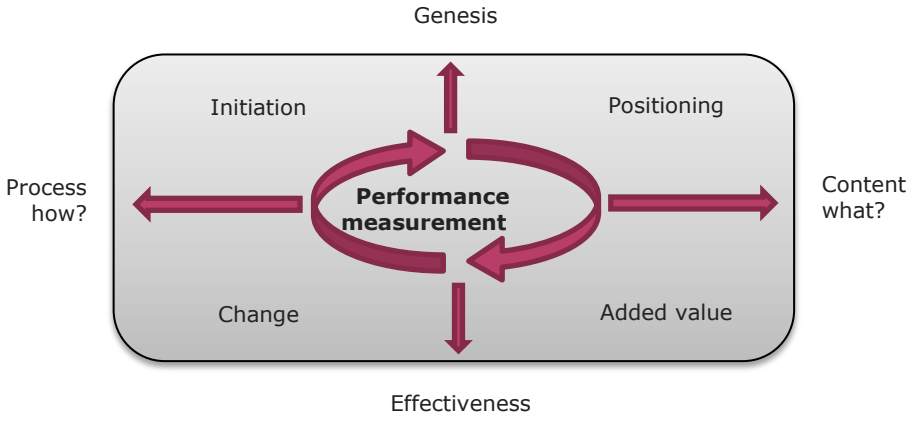

Fig. 3.2. Veränderung im GMN (translated: Change in GMN), (Müller-Stewens & Lechner, 2016, p. 431)

They are named after ***Initiation***, ***Positioning***, ***Value creation, Change*** and ***Performance measurement***. The field of strategic management is recognized not only statically, but the fields are arranged so that they - starting from the initiation - enable a procedural consideration. The *reflection* takes an important position and gives suggestions what happens in a company to more accurately observing and looking for patterns of explanation for it. The five fields are briefly described in the following:

1. **Initiation: Start initiatives for influencing the company -** Starting point of consideration are strategic initiatives that arise in a company. Each *pulse* is understood as a strategic initiative in the company, which significantly affects its development. Examples include: the entry into a new business, a specific value model or collaboration with another company. This is to be understood not only in terms of initiation by top management strategy planning, but also conditioned conscious and launched movement whose action and development evolved over a period of time.
2. **Positioning: Determining the relationship to stakeholders -** Strategic initiatives aimed at positioning the external relationship of a company. This outside world includes all groups that may have an influence on the company's activities, or in turn are influenced by this. Between them and the businesses, recursive exchanges take place, which relate not only to the transfer of money and goods, but are also influenced by political and cultural interaction processes. Overall, the goal of positioning is determining the relationship between a company and its stakeholders in each environment area.

3. **Value creation: Design of the inner relations -** The position of a company is closely linked with its "inner life", that is, its capabilities and value-added processes. Because depending on the abilities of each company, this usually has a direct impact on its responsibilities towards the environment. Strategic initiatives that affect the value of a company are therefore directed to the development and / or improvement of organizational skills. This can then be specifically extended on elements such as the value added model, organizational structure, management systems or the training of human resources.
4. **Change: Bringing the initiatives to life -** The fourth field engaged in is whether and how operational efficiency can be achieved and the company is able to change. In detail, it is about the impact of strategic initiatives in the organizational base process. It should be taken into account as well that companies are not only technical systems for the production of goods and services, but also social systems in which behavioral phenomena play a special role. Strategic initiatives can flourish here, are gaining momentum or are undermined and hindered in their effectiveness.
5. **Performance Measurement: progress monitoring and feedback -** The fifth field of GMN deals with performance measurement. This term principally refers to all types of approaches that monitor the development of strategic initiatives of the genesis to become effective to and measure. It is not only about the focus given to the financial measurement, but also about establishing comprehensive, multi-perspective and early detection approaches (Müller-Stewens & Lechner, 2016, chapter five). The "*Balanced Scorecard Model*" by Robert S. Kaplan and David P. Norton uses four dimensions (Balanced Scorecard Institute, n.d.): learning and growth perspective; business process perspective; customer perspective and financial perspective.

The GMN model replaces the four dimensions of BSC and uses the four fields of the GMN approach separately for the design phase of an audit of the concept and the implementation phase. This forms a GMN scorecard. The "*sixth degree of maturity*" supports the evaluation of maturity, this includes the following categories: non-existent, rudimentarily defined, basics, "*state of art*", going your own way, leading edge (Müller-Stewens & Lechner, 2016, chapter 6).

The application of the BSC is concretized in the following (Czyperek, n.d.):

- Balanced Scorecard is a deductive system of the vision and strategic objectives are derived, in consequence, then the performance indicators and measures
- A balance (*balanced*) about different perspectives, monetary and non-monetary indicators, short-term and long-term objectives, leading and lagging indicators (performance drivers - key performance figures)
- For the individual perspectives, each of the four to seven strategic objectives are derived from the corporate strategy or programme strategy.
- Strategic goals are cause-effect chains linked together
- Balanced Scorecard is a continuous learning process.

As part of the future management, also few concrete methods and tools have been developed for dealing with uncertainties. "*Sensitivity analyses*" are useful to identify uncertainties and evaluate uncertain business situations (Fink, Siebe, 2011, p. 348). The project management method "*sensitivity analysis*" enables to check the stability of the results of the utility analysis. In the management technique "*sensitivity analysis*", the results of evaluation of the respondents are averaged and weighted by a multiplication factor. Creating a sensitivity analysis must then reveal if the stability of the value of the individual criteria is still given (Simon, 2016, n.d.).

In connection with the complexity analysis and assessment, often the cause-effect logic is in the foreground in methods. The Ishikawa diagram is a tool for the graphical representation of cause-effect relationships. It is considered a simple tool for a systematic analysis of problems. To determine the causes of problems, it uses a symbolic fishbone giving it the name fishbone diagram.

The possible causes that have a specific effect on the entire problem are structured according to their influence in major and minor problems. A graphical structuring based on their cause fields follows this. Thus, a clear cause associated map for a particular problem is created. This may be understood quickly and enables standardized visualization for further analysis of the causes of problems. One suited approach is the Ishikawa diagram for visualization of the dependencies (Hallbauer & Crezelius, 2015); in **Annex 8**, a blueprint of an "*Ishikawa Diagram*" is presented.

A comparable model is presented by Nicolai Andler with the "*X matrix*"; also these strategic goals are broken down and divided in four dimensions (Andler, 2015, p. 256): Medium-term aims and intentions; Strategic objectives three to five years; Results / indicators; Process objectives.

3.2.6. Innovation Management

Service innovation concepts consider far insufficient customer orientation. It shows that with "*increased service innovation"* the "*sustainable Competitive Advantage*" almost uniformly increases (Verma& Jayasimha, 2014, p. 12). For the outsourcing two strategies can be derived. On one hand, this can be a USP (unique selling point) in the bid phase; on the other hand, it can be used as customer retention tool with existing contractual agreements. *"Furthermore, taking into account the different life cycles of products and services, future research should lead to an integrated complexity management*" (Luczak et al., 2010, p. 60).

3.2.7. Project Management

"*Project management research is characterized by dominance of determinism, decision-theoretic approaches, and weak theories. The growth of research interest in non-deterministic paradigms through the lenses of complexity and uncertainty is recent, and could provide stronger theoretic explanations. However, analysis of select project management literature reveals, that the constructs of complexity and uncertainty are yet to be grounded in terms of definitions and constituent variables*" (Padalkar& Gopinath, 2016).

A complexity management can be an essential building block for a Risk Management. In a study of Abeer Toheed Quadri et al., the effects and expenses when used in projects were examined and confirmed (Abeer Toheed Quadri et al., 2015). Large and complex projects result in a wide, hard to manage coordination effort, with numerous difficulties. An effective project management system, supported by an integrated complexity management, allows to control and monitor these complex projects (Xie et al., 2009).

The project management method "*agile project management*" was enshrined and described in the "*Agile Manifesto*" in 2001. This method of project management is characterized by an empirical, iterative and incremental approach. Content focus of the procedure are the following aspects (Tiemeyer, 2014, p. 87-88): Close contact with customers and stakeholders; The ability to actively respond to a large extent; Short planning intervals and reviews results in the ability to respond very flexibly to changes in requirements. This flexibility allows a high degree to be able to react immediately to changes.

Thorsten Reichert (2015) published the third edition of the book, with the short and simple formulated title: *"Projektmanagement"* (translated: Project management). The focus was to recognize and manage the key success topics and to control potential upcoming risks. Among the many recommended methods and tools, the stakeholder management is highlighted as particularly useful and important. Stakeholders are homogeneous interest groups who are involved directly or indirectly in the project or have an interest in the success or failure of the project. In addition, the connection between the stakeholders is pronounced and should be analyzed (Reichert, 2015, p. 126).

Stakeholders may be following roles among others: project owner, project manager, project team members, external experts, representatives of institutions, project customer. Using a stakeholder analysis, these roles and individuals should be described in detail (Stöger, 2016).

3.2.8. Business Process Management

A *Business Process Modelling* should consider different roles and organizational levels in order to break down the complexity into smaller parts and on different levels (Salay& Mylopoulos, 2010, p. 85). All activities that are necessary to deliver the service define a service process (Leimeister, 2012, p. 191).

In the Business Processes Modelling, the activities developed are using present information. It is also of particular relevance when processes are not completely transparent and understandable that unsafe predictable aspects are taken into account. Among the different methods and tools for Business Processes Modelling there are used: pattern recognition approaches, process discovery methods, declarative approaches and ontologies (Arends & Hendriks, 2014, p. 5).

A detailed process model for describing a business process has the following minimum requirements (Jobst, 2010, p. 75-76): Identification, name (object and performing); Description and content of the business process; Party customer (internal or external); Input (triggering event, transferred funds); Output (results, transferred funds); Conventions (physical resources, information systems, information); Flow chart; Interfaces (for the parent and child process models as well as external processes); Company organizational units; Time and place; Process Owner; Purpose; Restrictions and framework conditions.

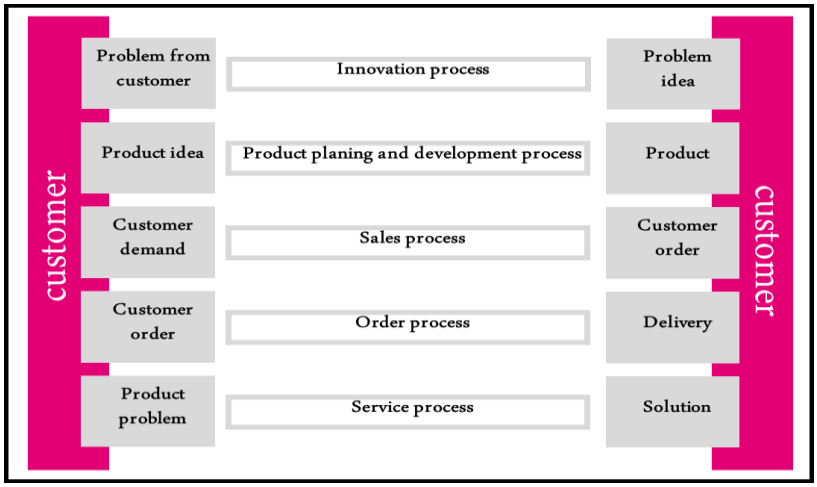

Fig. 3.3. Primary business processes in industrial companies (Schmelzer, 2011)

In 2011, Hermann J. Schmelzer published an article, in which he presented the elements of a holistic process management in an industrial environment (Figure 3.3).

GPM (the holistic model for Business Process Management) is an integrated system of management, organization and controlling, which enables targeted control and optimization of business processes. Schmelzer also, established the success criteria, which are mentioned from the beginning of GPM approach description and in which complexity is considered, also (Schmelzer, 2011).

In addition, Ralf Gaydoul and Christian Daxböck (2011) pointed out that the *end-to-end processes* follow corresponding hierarchy levels or logic (Figure 3.4). Depending on the intended objectives, when applying the end-to-end processes logic in an enterprise with the depth detail information of processes descriptions must be determined (considered). In the manufacturing companies, there are different approaches and delimitations between the *purchase-to-pay* and *order-to-cash* process. Their definition dependents on the industrial sector, the value added level established and the affected products or services (Gaydoul & Daxböck, 2011).

The main objective of the purchase-to-pay process is the timely implementation of the generated order requirements, order processing and execution of order changes, including payment to suppliers (Gaydoul & Daxböck, 2011).

In this research, the *"order-to cash process"* is defined as follows: receipt of customer orders, with dissemination of each individual service provides (as a sub-process), to the generation of a service inventory, which is then billed to the customer by means of a billing process (sub-process).

Business processes have become more and more complex and may span to multiple organizations. Therefore, process modelling has become of ultimate importance. Process models assist in managing complexity by providing insights and by documenting procedures (Van der Aalst, 2012).

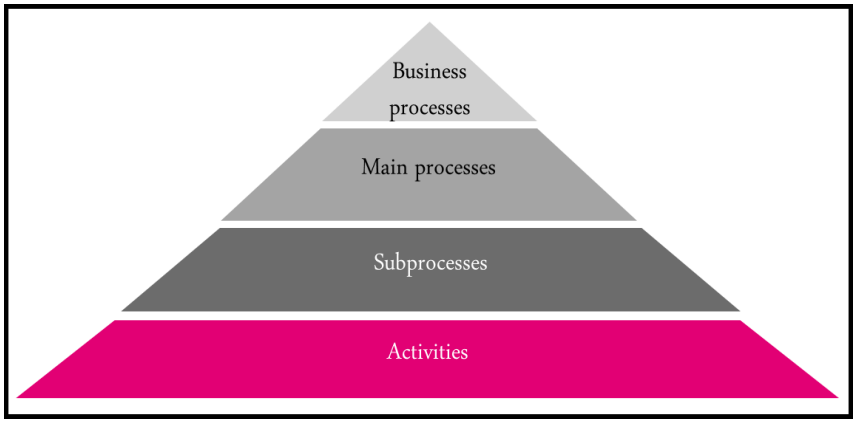

Fig. 3.4. Process hierarchy (Gaydoul & Daxböck, 2011, p. 41)

Peter Fettke (2015), in which he emphasizes that process modelling is a very big challenge, if the consolidation of several process variants over different companies is required, therefore proposes a special approach. Although there are already known and applied various methods of model integration, approaches usually focus on integrating *fewer* process models. By contrast, in the integration of *many* process models, new challenges arise, which are explained by (Fettke, 2015). He introduces the expansion effect, which means, that the size of the integrated

model will be larger than the average size of the initial models. This effect arises from the fact that the output models also contain differences that are included in their whole model and the integration of individual, simple process models will thus enlarge the complexity problems. The number of possible groups of all models origins correspond to the combinatorial problem determining all the partitions of a set. With increasing cardinality of a set, the number of possible partitions increases exponentially (*explosion effect*).

Fettke (2015) proposed method consists of the following five steps: (1) handling models are initially prepared in order to be uniform; (2) between the initial models, the similarity is determined; (3) based on the similarities, a hierarchical agglomerative clustering analysis is performed; (4) this cluster structure is used on the progressive integration of the initial models; (5) using selected indicators, the results are interpreted and a reasonable level of integration is set (Fettke, 2015).

Recurring researches for increasing supply chain agility and flexibility show there are almost no concepts in terms of impact evaluation. For example, in 2015, Dominik Eckstein and his group of research have published a study in which 143 German companies have been investigated in order to find out the supply chain adaptability state (Eckstein et al., 2015).

The current analysis of 2015 annual survey "*Management Tools & Trends*" shows that in recent years, companies have experimented with a number of methods and tools, such as Business Process Reengineering (so far without result) to cope with the excessive complexity (Rigby& Bilodeau, 2015, p. 7).

In 2016, Fredrik Milani refers to the first and second (syntactic) types of drivers as the *Business Process Variants*. In the case of the first class, business drivers can be dictated from the outside, but also due to internal-organizational decisions, for example through mergers. By categorizing the diversity of business process variations in variations driver classes, a reduction of complexity is achieved. This allows working with a few classes of drivers instead of a variety of possible causes. According to the second category of drivers, there is determined whether the corresponding processes should be modelled together or separately. The variants, which should be modelled separately, are those, which have great differences and support another business purpose. The similarity and comparability can be assessed using a scale (with scores from 0 to 1), for the evaluation, in the model context. These structures should be executed in the following six steps, as summarized in Table 3.4.

To measure the impact of consolidation regarding complexity, a *Coefficient of Network Complexity* (CNC) metric is introduced. CNC is the ratio between the number of arcs and the number of identified nodes. This metric should also support the evaluation of process models complexity (Milani, 2016).

Usually, in the introduction of process management, a classic approach is recommended which includes the definition of project objectives, work packages and also, setting-up the project monitoring, as well as the reporting structure. An early warning system and the milestones schedule should be established (Krampf, 2016, p. 115).

Mariusz Szuster and Maciej Szymczak have described an innovative approach applied in the case of supply chain management. They have pointed out that through the integration of external units (through outsourcing), innovation can be a significant support (Szuster & Szymczak, 2016). In this context, the basis of the examination process is the concept "*innovative supply chain*" of Ageron, with three dimensions (Ageron et al., 2013):

1. *Operational processes* -Tasks execution and definition are seen as "*doing of business*" actions;

2. *Managerial processes or the management of supply chain flows* - Management processes are considered strategic and they are developed in association with resources administration and control, in a frequently long-term-perspective. Supplier selection processes, supply chain business unit strategy conception, standardization of supply chain processes and organizational aspects are considered in the context of this dimension;
3. *Information systems and information technologies (IS/IT)* – The target of this dimension is considered to create new organizational configuration and to reduce the geographical and cultural distance between supply chain partners.

Tab. 3.4. Six-step approach for Business Process Variants driver classification (own table, derived from (Milani, 2016))

No	Short description of the steps
1	Model the main process – the purpose of this step is to derive the main process in main steps (sub-processes).
2	Identify variation (business) drivers – in this step, the business drivers of variations are elicited.
3	Assess the relative strength of the variation drivers – in this step, the business drivers are analyzed to evaluate drivers regarding the importance and stringency.
4	Identify the variants of each sub-process – the actual existing variants of each sub-process previously elicited (in step 1) are to be identified and listed.
5	Perform similarity assessment of variants of each sub-process – the existing variants for each sub-process of the main process are assessed, in terms of equality and diversity of objectives, regarding the purpose.
6	Construct the variation map – based on the previous steps, the business drivers are present in the business process, the existing variants and their degree of similarity or difference are evaluated. In the last step, this consolidated information is used to determine if the variants of each sub-process should be modelled overall or separately.

3.2.9. IT science

Complex Event Processing (CEP) is originally a subject of computer science area that deals with the identification, analysis, grouping and processing of interdependent events. CEP is thus a collective term for methods, techniques and tools to process events as they happen, i.e. continuously and promptly. CEP derives higher, valuable knowledge in the form of so-called complex events, which are situations that can be seen only as a combination of several events.

Event are seen in the following meanings:

- Everything that happens or is considered happened;
- An object that represents an event that codes or stores;
- An event within a certain system.

CEP, in particular, is the events treatment that only occur through the interaction of several events. These include, for example, the following optional characteristics (Jobst, 2010, p. 148-161):

- The events may be interdependent and can multiply each other;
- The events occur sequentially as a substitute of or even side by side simultaneously;
- The events depend hierarchically on each other and occur repeatedly in the same concatenation;
- The events are completely independent; a complex event is a composite of several events and the defined state;
- The events may be related; a complex event occurs when a certain relation, for example, a fuzzy relation, is satisfied in a time interval.

- The events occur in part, in concurrent processes; *Complex Event* occurs when a certain majority of events has occurred.

These science disciplines will not be relevant in the further researches described in this thesis.

3.2.10. Contract Management

In the contractual arrangements, it must be ensured that the complexity of the control and measurement are displayed and the right incentives are approved by appropriate structures (Renze-Westendorf, 2010, p. 207).

Agreements on IT services are always incomplete in contracts content. From the law and economic (scientific) point of view, contracts are always imperfect. The reason is that not all contingencies that might affect the fulfilment of contractual provisions can be foreseen and take into account. Distinct service-oriented and/or technology-heavy projects represent a pattern case for the incompleteness of contracts. The risk of incomplete contracts continues, especially if the business relationship is an innovation complex system.

In an outsourcing relationship, it is important for both partners to be aware of the corresponding problems when concluding the contract. Necessary changes (either by changing requirements of the customer or by technological innovations) can be detained by innovative contractual mechanisms or periodic adjustment clauses. Important criteria for success are here also, a regular, open communication and a partnership cooperation between customer and service provider (Grimme& Kreutter, 2013, p. 65-66). In addition, Markus Löffler and Felix Reinshagen confirm that outsourcing contracts are never complete because of numerous unforeseeable boundary conditions (Löffler & Felix Reinshagen, 2013, p. 65-66).

In **Annex 9** is shown a model, example of how complexity management can be agreed in a contract between customers and service providers. This contractual agreement between the parties provides the foundation for the operative implementation of complexity management during the operating conditions (the presented model in **Annex 9** is considered a result of this PhD research, too).

3.3. Pre-conclusions and discussions of further complexity relevant disciplines

Overview interdisciplinary consideration: The most important conclusion of the other scientific disciplines analysis is the finding that other disciplines could support with additional knowledge the research in the field of Complexity Management in business situations. First, the reasons for this is that the *"pure complexity models"* are often very mechanically oriented and they reflect, only to a limited extent, their use in a business situation. Furthermore, the preparation for their applicability is lacking in practice (for example, by lack of concrete implementation concepts, as well as the strategic future-oriented character). In addition, it has been observed that the theme (approach and methodologies) of *complexity* is established more strongly in some disciplines (e.g. in the case of process management and strategic management) and in some other disciplines it is scientifically very little developed (e.g. contract management). Furthermore, it can be pointed out that some criteria for complexity management success across all disciplines are nearly equally assessed, for example, the importance of stakeholders.

In the following, various disciplines assessment in relation with complexity management is explicitly addressed. Important considerations will be made by taking into account the PhD research context and future approach.

Service Provisioning Management: The essential feature of the "*external factor*" in the service provisioning discipline is essential for this PhD research, due to the nature of the closed relationship between the customer and the provider, and the course of an outsourcing project (first phase transition and second phase transformation, and then to provide an FMO service operation). In high-volume international outsourcing projects, these first two phases generally, last for several years. In designing the proposed complexity model, this aspect will be incorporated decisively. The service evaluation model by Rieck significantly considered the "*external factor*", which has a dominant character in outsourcing situations. An evaluation scheme for each dimension and criteria is seen as a necessary evolution in the PhD research. Therefore, certain framework conditions must be observed in the evaluation, for example, a clear and understandable definition of the dimensions and criteria. Furthermore, the adopted assumption model consider that the complexities are all known and can be assessed.

A very convenient form for the outsourcing situations is the logic of analyzing the service delivery at different levels and displays. The background is that in the transition and transformation phase, the existing customer organization is greatly changed and the organization and services will be "c*ut out"*, based on the contractual definition. This is a major challenge for complex and major international customers. As discussed, this method supports the necessary transparency achievement. The lines (e.g. "*line of visibility"* etc.), which are used by Oliver Thomas and Markus Nüttgens must be supplemented.

The use of a "*Balanced Scorecard*" for evaluation of services, which is proposed by Sabine Haller, is suitable in outsourcing projects; even here, the dimensions need to be adjusted to the situation.

Customer Integration and Customer Relationship Management: In particular, the role as "*substitutes for leadership"* in outsourcing situations is of great significance within employee's transition. The background is that key players in the service provider organization are often former executives of the customer organization, who have changed their employment, as part of the new outsourcing contract. These employees are called "*transferees*". Due to the strong technological, organizational and process integration of the outsourcing relationships, it has to be considered in the architectural design of services, that the customer organization will take various roles, such as a services Co-Producer or Co-Designer. This is the link of the "*external factor*" of the service provisioning discipline.

Systems Engineering (SE): The range of differences in the methods and approaches of the GSE are very large. An essential component is the model definition (establishment) during which real complexity has to be reduced. The focus of this PhD research is not on handling and management of complexities and uncertainties in projects. Therefore, only individual tools for the model definition, for partial aspects in this research will be used, which are concretized in other disciplines, such as service provision management.

Network Management: "*Network Thinking"* is both a tool of the strategic management discipline and it forms a separate discipline. In addition, an offshoot of Service Management has existed for years in this field and it is called "*Service Networks*". "*Network Thinking*" in combination with a "*cause and effect analysis"* are increasingly used as potential methods for the analysis and presentation of complexities.

(Strategic) Management: It is very remarkable that Gilbert Probst and Christian Wiedemann have firmly anchored Complexity Management in the "*Strategy Guide"*. As concrete tools, they resort to a parallel research discipline "*Service Networks"*. Their proposed procedure allows the derivation and operationalization from the top strategy. In this context, measures can be initiated on the different management levels. Niermann understands complexity and management as a justification and a reasoning for the need of management itself and emphasizes that it is not possible to detect the dynamic environment of a company or of a project. This is a fundamentally different approach in comparison to other approaches to complexity management, and it is based on the target to control and manage complexity. Strategic management approaches should be supplemented by existing complexity management methods. Gilbert Probst and Christian Wiedemann, which provides such a methodological approach, also highlight this in the "Strategy Guide". The associated measures are derived from the corporate strategy. In addition, influencing and not influencing company's environment dynamic conditions must be considered. In this approach, similar as with other approaches of strategic management, it is of great importance, that the stakeholders are taken into consideration. Specific tools, such as the BSC and sensitivity analyses or the X-matrix by Nicolai Andler, support the strategic management in dealing with uncertainties and complexities.

Innovation Management: Dealing with complexities plays a smaller role in innovation management. The focus is on the benefits for the company and the customer; if a company is able to deal with complexities, this leads to a USP of the service providers.

Project Management: "*Agile approach*" has its origin in software development. In the recent years, this methodology was extended to the holistic view of project management field. An important advantage of this "*step by step"* approach is that it can be entered directly to changing environmental conditions and the overall complexity can be partitioned into a number of individual packages. Furthermore, it should be emphasized that even in this research discipline, the stakeholder management has a significant role.

Process Management: An essential element of the process management discipline is the analysis of the main processes, as a collection of sub-processes or the synthesis of partial processes in core processes. In this discipline, a branch of the process management is linked to the network (see CNC). Some research also concentrates, similarly to those in the field of service provision management, on the integration of an "*external factor*". As listed in the outsourcing situations, this is of great importance, because the third party processes (called: "*third party provider"*) must be integrated and often additional parties are involved in the outsourcing situation. The process model by Peter Fettke is very applicable to be used in outsourcing, from a process management perspective, because it includes the process integration and process consolidation, during a transition and transformation phase of the outsourcing project development. Another reason for considered process management of great importance is the large number of stakeholders that must be seen as service provider in an outsourcing project.

IT science: There are several approaches to manage complexities by IT support. The philosophy is basically how changing input factors are controlled in a manufacturing process and they are seen as changes in software sequence, for example, the CEP model. In the context of the PhD research, these approaches are of little relevance, as the focus is the management of complexities in a business environment.

Contract Management: As a result of the previous debates and analysis (chapter 3.2.10) there have been proved that there is currently no scientific status on how "*complexity*" can be contractually established in a customer-service provider relationship. There are some counsellors in the science and practice-oriented literature (see for example the research of (Söbbing, 2006)) how contracts in generally, have to be designed, but the theme of complexity management is not always included.

In various management disciplines, complexity occupies a dominant character (see also (Dern, 2011)). Due to the highly interdisciplinary nature of complexity management, only the importance is listed or emphasized; concrete implementation concepts are far less pronounced.

3.4. Preliminary studies

In order to discover and characterize relevant issues and aspects for future researches there have been conducted two studies in 2014 and 2015. Both studies are part of the PhD research program and they will be presented in the following.

3.4.1. Study 1 - Correlation of complexity driver with the EPM model

At the International Scientific Conference on Management of Knowledge and Learning (MakeLearn 2015), which is organized by the International School for Social and Business Studies (ISSBS) in cooperation with foreign partner universities chosen in accordance with its annual theme, the article "*Importance and evaluation of complexity-causing and increasing factors as a determining success indicator in outsourcing operations*" was presented and published by myself. The aim of this paper was to provide a model for evaluating complexity-causing and -increasing factors. Based on different recent theories in complexity management, success-determining factors were identified and the complexity-causing and -increasing factors confirmed by industry survey outcomes. The research result presented in the paper was a management model to identify complexity in business situations, like outsourcing; in addition, the survey results, developed with experts, are discussed and evaluated from the point of view of their impact on complexity (Rennung, 2015).

3.4.1.1. Description of the study

The modelling process related to a complex model for outsourcing projects is forced by the central question to what extent the Enterprise Project Governance (EPG) can be used. The definitions of the core components are presented in **Annex 10**. These are analyzed and discussed in the following pre-research.

To investigate the effectiveness of the main components of the EPM on the complexity drivers, 50 European experts were interviewed. All respondents have more than ten years' experience in large-scale outsourcing environments. The definitions of the complexity drivers were detailed in **Annex 11**. The minimum value, and thus the least impact on the complexity drivers, was scored with0, and the maximum answer was scored with ten points. Subsequently, the results were averaged among all participants. In addition, in order to compare the main components, the values were summarized. The study was carried out in the 4thquarter of 2014. In Tables 3.5 and 3.6 the research results are shown. In order to perform a better analysis, the internal and external drivers are presented separately.

3.4.1.2. Results of the study (summarized)

Table 3.5 shows the results of the external drivers, mapped with the core components for project governance. Table 3.6 shows the results of the internal drivers, mapped with the core components for project governance and the sum of all evaluated drivers.

Tab. 3.5. Results of the study – external complexity drivers (Rennung, 2015)

Complexity drivers - Results of the evaluation								
	Cluster	Alignment	Risk management	Portfolio management	Organization	Stakeholder management	Performance evaluation	Business transformation
External complexity drivers	Society complexity	8	4	5	6	7	9	8
	Demand complexity	6	6	4	5	6	8	7
	Competition complexity	8	5	8	6	6	8	7
	Procurement complexity	4	5	6	7	4	8	8
	Average external drivers	6,5	5	5,8	6	5,8	8.3	7,5

Tab. 3.6. Results of the study – internal complexity drivers and summary (Rennung, 2015)

Complexity drivers - Results of the evaluation								
Internal complexity drivers	Cluster	Alignment	Risk management	Portfolio management	Organization	Stakeholder management	Performance evaluation	Business transformation
	Target complexity	7	5	7	5	6	5	6
	Costumer structure complexity	9	5	4	7	7	6	5
	Product and product program complexity	8	5	7	4	5	7	7
	Technology complexity	4	6	7	5	4	6	6
	Process complexity	8	6	4	4	5	5	6
	Organization complexity	9	6	5	9	6	6	7
	Structure complexity	8	5	8	9	7	7	7
	Planning and steering complexity	8	6	7	6	9	7	6
	Average internal drivers	7.6	5.5	6.1	6.1	6.1	6.1	6.2
	Sum of 12 drivers	**87**	**64**	**72**	**73**	**72**	**72**	**80**

3.4.1.3. Interpretation of the study results

The main component with the highest score was "*alignment*"; a common strategy of the involved companies in the project was evaluated as *very important*. Even "*business transformation*" was rated as very significant to achieve positive or negative effects on the defined complexity drivers. Furthermore, it was remarkable that "*risk management*" was assessed *low* in all considerations. The interpretation is that risk management was indeed viewed as important by participants; however, the direct effect on the complexity drivers was evaluated rather *low*. The sum of the other core components was rated at the same level, in all cases (value 72-73). The external drivers were evaluated on a *higher level*. The importance and possibilities to manage complexities through the components of the EPG model in the section external drivers were assessed with a higher score (value of 7.5) than in the section internal drivers (value of 6.2). The component "*performance evaluation*" has the highest value in the survey's results. This means that an ongoing consideration of the environment, in parallel with the course of the project, was considered a very effective and suitable method to evaluate complexities.

3.4.1.4. Conclusions of the preliminary Study 1

From the overall of 84 criteria that were assessed (according to the details given in **Annex 11**), only ten criteria were rated less than six points. This high correlation (in the form of high values) shows that the two approaches have a high compatibility and the EPG is a useful complementary approach to be used for managing complexity in outsourcing projects. The combination of the two approaches, which are on the current state of scientific knowledge, provides a very useful method ready to evaluate complexities in outsourcing projects. This could be a suitable foundation to set-up the necessary measures to characterize the complexity drivers. The possibility to manage complexity in large projects can be a unique selling point for outsourcing providers designed in order to prevent the danger of a complex trap for all involved partners in the project.

3.4.2. Study 2 - Strategic methods to manage large outsourcing projects

At the MakeLearn 2016 International Scientific Conference on Management of Knowledge and Learning, a paper (with research results "*An evaluation of strategic methods of complexity management to manage large outsourcing projects successfully*") was presented and published by myself, with the scope of evaluation specific methods of complexity management used in long-term and large-volume outsourcing situations. These methods were created to handle uncertainties and unknowns. These strategic methods were evaluated and compared with regard to their different effects. Based on a literature review, the main complexity management methods were analyzed and compared with the strategic recommendations in outsourcing situations (Rennung, 2016).

3.4.2.1. Description of the study

During the last years, many strategies for outsourcing projects have been developed and published. In (Hassan et al., 2015b) different parameters were evaluated by outsourcing experts. The result of the study is summarized in seven strategies; whose definitions were presented in Table 2.8; these strategies are used in the proposed complexity model. Methods for complexity management were further developed in 2015 and 2016. These were analyzed and they have been integrated as a further dimension to the proposed complexity model. In this study,

the possibility of the methods to support the strategies of outsourcing projects were analyzed and evaluated. Figure 3.5 shows the assessment module figuratively.

In the context of the study, a use case of outsourcing projects was described. The characteristics and content of this use case is similar to the use case which was defined for these studies and it will be presented in Chapter 5. The study was carried out from November to December 2015, with 50 participants, who have had a professional experience of approximately 15 years in the Service Delivery Management in a large-scale business environment and are European citizens. The evaluation is defined by the following assessment logic:

- *Zero points*: The method cannot support the outsourcing strategy;
- *Ten points*: The method can support the outsourcing strategy to a high degree.

Statistical evaluation was designed by calculating all individual values to average values. The results were averaged based on all participant's responses. In order to compare the effects of different strategies, the values are summarized in the last row of the results Table 3.7. To evaluate the different methods separately, the calculated values were also presented in the last right column of the table.

3.4.2.2. Results of the study (summarized)

In Table 3.7, the results of the study are presented in synthesis.

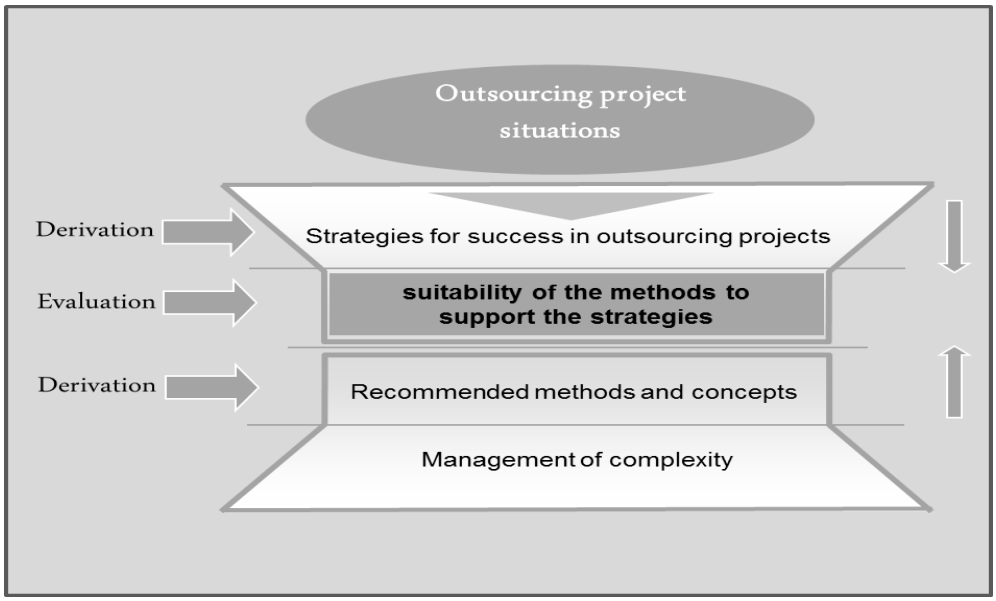

Fig. 3.5. Model to evaluate the methods and concepts of complexity management for outsourcing projects (Rennung, 2016)

Tab. 3.7. Results of the study (Rennung, 2016)

	Outsourcing strategies							
Methods and concepts of complexity	Communication Management	Performance Management	Knowledge Transfer Management	Relationship Management	Crisis Management	Risk Management	Cost Management	**Average of the method**
LFP (Light Footprint Strategy)	3.2	3.4	3.3	3.1	3.0	6.5	7.6	4.3
"Komplexit-hoden"	9.3	9.2	9.5	9.0	9.0	9.4	9.2	9.2
Methods for the strategy "Complexity design"	4.0	4.3	4.5	4.5	4.3	4.9	7.4	4.8
Methods for the strategy "Complexity control"	9.6	9.4	8.9	8.8	9.0	8.8	9.4	9.1
Average of the strategies	6.5	6.5	6.6	6.4	6.3	7.4	8.4	**6.9**

3.4.2.3. Interpretation of the study results

The "*LFP method*" supports the outsourcing strategies to a very limited extent, with an average value of 4.3 (only "*Risk Management*" and "*Cost Management*" have values more than 6). The LFP process model makes possible the cost prevention, which are caused by a classical project planning with fixed milestones, in an uncertain environment (value 7.6). The "*Risk Management*" is supported by the characteristics of the "*step by step*" procedure model. The "*Komplexithoden*" are valued consistently very high, with an average value of 9.2. These methods have a very extensive focus. The "*Methods for the Strategy Complexity design*" are rated low, with an average value of 4.8. Only "*Cost Management*" is highly rated with the value 7.4 because the individual elements of the method highly support the strategy, for example "*Product / Value Analysis*". The "*Methods for the Strategy Complexity control*" were rated also very high with the average value of 9.1. Some methods are very focused on the outsourcing strategies, for example *Communication Management*. The further methods, for example demand and project management, are key topics in outsourcing projects.

3.4.2.4. Conclusions of the preliminary Study 2

As an overview, the current methods of complexity management were evaluated with an average value of 6.9 out of 10 points. It has been emphasized that two methods were evaluated on a high effect and two other methods on a very minor effect level. The differences within of each complexity method are (with three exceptions) less than the value of one. It was concluded that the strategic objectives "*Cost Management"* and "*Risk Management"* are most supported by the complexity methods.

3.4.3. Conclusion of the preliminary studies

The research of complexity management has furthermore evolved between 2014 and 2016. The main finding is that some methods are very suitable for all involved parties, to be established on a strategic level in real-life outsourcing project. The studies' results can be used in the set-up process of an outsourcing

project to avoid a complexity trap for the involved parties and make the whole undertaking manageable. The designed models and combination of several research fields gives an answer to the results of Bauernhansl's studies from 2014. According to these studies, 82% of the directors and executives of leading German industrial companies (participants in the survey) have articulated that the relevance of complexity will increase in the future, while 56% of the respondents indicated that they do not have any method to deal with these increasing complexity occurrences (Bauernhansl et al., 2014).

A further evaluation of the complexity model can be developed, in which the individual criteria are further specified. The future research should continue to develop the high-rated complexity methods for large-scale and long-term projects. Likewise, the methods should be completed by concrete implementation measures. In addition, an integration concept of these complexity methods in outsourcing projects must be scientifically drawn up and prepared for a quick practical implementation in the different layer of contract, process, organization and IT support.

3.5. Requirement management for a business complexity management model in large-volume environment (Outsourcing businesses)

3.5.1. Functional requirements

Table 3.8 summarized the functional requirements for the design of the proposed holistic complexity management model in the service industry, based on the theoretical framework and the pre-studies presented.

Tab. 3.8. Functional requirements for a business complexity management model (own table)

No	Name	Short description of the requirements
1	Different factor perspectives	The model has to sustain different and multi-dimensional external and internal perspectives, so that the different interests of stakeholders can be considered.
2	Complexity management process	The different phases of complexity management: planning, implementation and ongoing review, together with the measures to manage have to be promoted.
3	Time perspective	The complexity model has to support business situations and projects with a long-term perspective (at least three to five years).
4	Open system	Adapted to the specific situation, complexity drivers serve as inputs used to value the complexity. The model must be configurable and it must have an "open character" to capture the dynamics of the known and unknown inputs.
5	Cause - effect relationships	The model should allow the correlations identification and to evaluate the effects.
6	Holistic character	The consideration of the complexity management must support a holistic character for a company, business situation or project.
7	Interdisciplinary	The complexity model must provide functionality to fulfil the crosscutting nature and the interdisciplinary.
8	Derivation of strategic management	A derivable from the strategic management has to be ensured on the functional level.

No	Name	Short description of the requirements
9	Management of uncertainty	The complexity model must deal with known and unforeseeable uncertainties.
10	Support of different kind of layers	The model has to encourage the contractual, organizational, processual, and ITrelated layer.
11	Ensure independence	The model must be designed in such way that it can be established (easy adapt to) regardless of the agreed services between the involved parties.
12	Different level	The complexity of management must be applicable at different levels (strategic, operational).
13	Lack of transparency of inputs	The model must support the fact that not all the features of reality are known. In the lack of transparency, complexity and number of the company's internal and external developments, the existence of other features may be of major importance.
14	External domination	Due to the outsourcing contract relationship there is a dominance of external inputs (directly or indirectly of the client).

3.5.2. Non-functional requirements

Table 3.9 shows the non-functional requirements which are of significant relevance to implement and operate a holistic complexity management model in large outsourcing projects in the service industry:

Tab. 3.9. Non-functional requirements for a business complexity management model (own table)

No	Name	Short description of the requirements
1	Application of adapted complexity criteria	Criteria for evaluation are those established criteria, to identify, evaluate and manage complexity in outsourcing projects.
2	Support the specific standard phases of outsourcing projects	The complexity model must support the relevant phases in outsourcing projects: contract start, transition, transformation, and FMO operations.
3	Applicability and use	The model must be applicable for Service Managers (dealing with the customer and for customer service management).
4	Practicality	Companies must be able to integrate the management of complexity in their operational processes, which means that input variables in the organization can be identified. The output is used to control if the complexity management require measures implementation that can be initiated.
5	Methods and tools	The model has to provide methods and tools to be applied in practice.
6	Contractual agreement	The complexity of the model must be designed so that it can be added as an annex to the framework agreement between customer and service provider.

At the end of the PhD research, a review will take place, whether and to what extent the requirements are met by this research.

3.6. Conclusions

At this point of the research, all the prerequisites for an overall explanatory design process for a business complexity management model for large-scale business environment were present. The current state of research was analyzed, and presented; further complementary research disciplines were analyzed and evaluated with regard to their potential impact and knowledge contribution to achieve the PhD research objective.

The results of preliminary studies have confirmed the existing research gap and have shown the content-related coverage and the specific characteristics between "*large-scale business environment*" and "*outsourcing projects to operations*". All results have been consolidated and summarized in the requirements inventory for the developing process of a business complexity management model. Moreover, a separation between functional and non-functional requirements is useful to develop and apply appropriate management tools.

Objective OP1.2 achievement
Based on the results of Chapter 2, where the current state of research in complexity management was presented, the further research disciplines were analyzed to fulfil the knowledge and wisdom necessary for the future researches. The results of Chapter 3 were summarized as complexity relevant aspects of other research fields or disciplines and the requirements inventory in order to support the knowledge acquisition, transfer and exploitation for designing a business complexity management model dedicated to large-scale business environment.

4. THEORETICAL RESEARCHES FOR DESIGNING THE BUSINESS COMPLEXITY MANAGEMENT MODEL IN LARGE-SCALE ENVIRONMENT

In this chapter, a model for business complexity management used in large-scale environment, e.g. outsourcing project, will be developed and presented systematically.

4.1. Definition of the "House of Large Business Complexity Management"

In the following paragraph, the proposed holistic "*Large Business Complexity Management*" model is described. In the subsequent text, all units are applied to a typical "*Big Deal Outsourcing Project*" in Chapter 5.

Figure 4.1 presents the proposed model that was represented in the so called "*House of Large Business Complexity Management*". This representation is the result of the critical overview, the analysis and synthesis of the relevant references in the field of complexity management that were presented in Chapters 2 and 3.

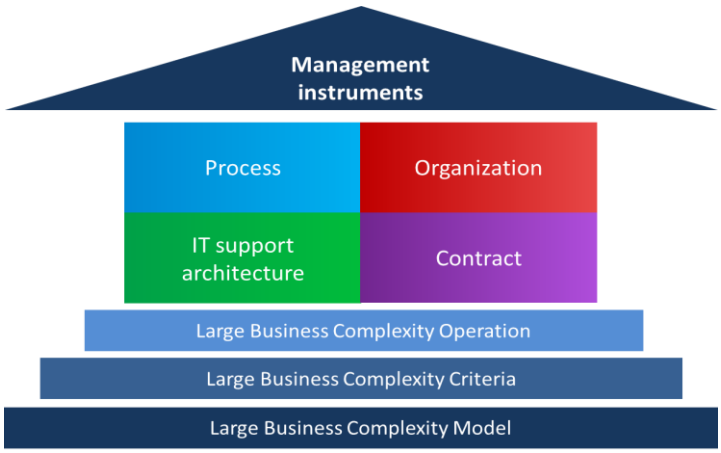

Fig. 4.1. House of Large Business Complexity Management (own schema)

The model is the core of the "*Complexity House*". It indicates all relationships that are relevant in a large-scale business projects (e.g., "*Outsourcing projects*"). Here, the various "*phases of the project*" and the "*on-going operation*" of an outsourcing project and the different perspectives of the parties are taken into account. The "*Large Business Complexity Management Model*" provides the framework for the other elements of the "*House of Large Business Complexity Management*". The constitutive elements of the model will be described in the following chapters.

4.2. Large Business Complexity Criteria

The *Complexity Criteria* are used to structure the evaluation criteria in the project phases and for on-going operations. These are based on the current scientific state, adapted to the scope of this research. At this level, an assessment model, defined on the basis of the *Complexity Criteria*, is applied. In the following text, the criteria are also named *ComMC (Complexity Management Criteria)*.

4.2.1. Preparation and derivation of the Complexity Criteria

In the first design step, the *Complexity Criteria* described by (Schoenberg, 2014) are valued. The basis for the evaluation process represents the results of the previous research in this thesis. The concrete steps are:

1. Definition of criteria (definition and interpretation);
2. Review of the relevance aspects in accordance to the present research context and objectives (definition of *rf* = *relevance factor*);
3. Justification for assessment of the relevance (arguments for an evaluation of the relevance factor), and
4. Decision (result), whether this criterion is further used in this research (values 3 to 5).

The first design step results are shown in Table 4.1 (without the definition and the argumentations). In **Annex 12**, the details of the analysis are shown.

Tab. 4.1. Complexity drivers for large-scale projects, e.g. IT Outsourcing (own table)

Complexity drivers structure (adapted after (Schoenberg, 2014))			**Result**
View	**Cluster**	**Criteria**	**rf**
External complexity drivers	Society complexity	1. Economic and environmental factors	3
	Demand complexity	2. Diversity of customer requirements	5
		3. Individuality of the demand	5
		4. Market dynamics	3
	Procurement complexity	5. Number of suppliers	4
		6. Procurement strategy and concept	5
		7. Fluctuations in demand	5
		8. Uncertainty of the delivery or quality	5
Internal complexity drivers	Target complexity	1. Number of tracked targets in parallel	4
		2. Dynamics of the target adjustment	5
	Costumer structure complexity	3. Heterogeneity of customers and customer groups	3
		4. Level of participation	4
	Product and product program complexity	5. Structure of products	4
		6. Dynamics of the product changes	3
	Process complexity	7. Number of interfaces and design	5
		8. Degree of crosslinking of the processes	5
		9. Degree of standardization	5
	Organization	10. Number of hierarchy levels	5

Complexity drivers structure (adapted after (Schoenberg, 2014))			**Result**
	complexity	11. Degree of centralization	5
		12. Number of organizational units	4
	Structure complexity	13. Number of distribution levels	4
		14. Number of stock, staff, equipment, ...	5
		15. Communication systems	4
		16. Vertical integration	5
	Planning and steering complexity	17. Frequency and level of detail of the management and control area	3

The explanations for the theoretical construct *Complexity Criteria* are:

1. The "*rf = relevance factor*" is the evaluation, based on the results of the previous results of this PhD research (evaluation of the use case: large business environment as outsourcing projects).
2. The result of the analysis mirrored and continued the research state in this thesis; in the following steps, only criteria will be applied with a value from 3 to 5 and they will be specified in the next step. The logic to sort out the criteria, which were assessed with a value of 1 and 2, supports the objective to enable a practical application (see also 80/20 rule from (Brown et al., 2010)).
3. The "*internal and external*" perspectives, both of the customer's and the service provider's point of view, are used in the derivation of the complexity and development model. The reason for this is that all potential effects should be considered.

Table 4.2 describes the evaluation criteria.

Tab. 4.2 Description of the criteria to evaluate the complexity drivers (own table)

Evaluation description for the analysis	
0	The criteria are not relevant for the application in large business situations, like IT Outsourcing projects.
1	The criteria have an implication to the scope of this research, but are very weak, indirect and partly relevant.
2	The criteria are relevant for the scope of this research, but are weak, indirect or partly relevant.
3	The criteria could be important for the application in large business situations, like IT Outsourcing projects; the effects depend on specific environmental aspects, e.g. customer and contract-based aspects.
4	The criteria are important for the application in large business situations, like IT Outsourcing projects and the effects are direct and strong.
5	The criteria are of greatest importance for the application in large business situations, like IT Outsourcing projects.

4.2.2. Enrichment of the Complexity Criteria with dimensions

In the second design step, first, the evaluation dimensions (based on Balanced Scorecard logic) are defined and then the dimensions are mapped with the results previously obtained. The result of the instrument is named: "*ComMBSC*" *(Complexity Management Balance Scorecard).*

Based on the "*Balanced Scorecard Model*" of Robert S. Kaplan and David P. Norton, the four dimensions are adapted for the PhD research context: "*large-scale business projects*" (Table 4.3).

Tab. 4.3. Definitions of the perspectives for ComMBSC in large-scale projects (own table)

No	Perspectives / dimensions	Short definitions of the perspectives for large-scale projects
1	Learning & Growth (LG)	In this dimension, the maturity of the establishment and on-going development of complexity management (in the organization of the contractor) will be evaluated.
2	Business Process (BP)	In this dimension, the business processes of each contractor, regarding complexity related aspects, are evaluated.
3	Customer (C)	In this dimension, the complexity is evaluated, which is caused by the customer project itself.
4	Financial (F)	In this dimension, the maturity level of efficiency of complexity management is evaluated (in each organization of the contractor) to achieve the targets.

In next step, the dimensions are assigned to the selected complexity criteria.

A unique defined table of values for the monthly review supports, operative and simple, is presented in Figure 4.2 (as an own developed Excel tool for the operationalization of the proposed model implementation). With the initial joint determination of the values as shown in Table 4.4, the uniform value patterns between the parties are calculated. The reference point of each "*criteria factor*" is always 1. In **Annex 12**, the arguments for the evaluation are shown.

Tab. 4.4. Complexity drivers for large-scale projects, with dimensions (own table)

Complexity Drivers – enriched with dimensions				**LG**	**BP**	**C**	**F**
View	**Cluster**	**Criteria**	**rf**				
External complexity drivers	Society complexity	Economic and environmental factors	3			X	
	Demand complexity	Diversity of customer requirements	5			X	
		Individuality of the demand	5			X	
		Market dynamics	3			X	
	Procurement complexity	Number of suppliers	4			X	
		Procurement strategy and concept	5			X	
		Fluctuations in demand	5			X	
		Uncertainty of the delivery or quality	5		X		
Internal complexity drivers	Target complexity	Number of tracked targets in parallel	4				X
		Dynamics of the target adjustment	5				X
	Costumer structure complexity	Heterogeneity of customers and customer groups	3			X	
		Level of participation	4			X	

Complexity Drivers – enriched with dimensions				LG	BP	C	F
	Product and product program complexity	Structure of products	4		X		
		Dynamics of the product changes	3		X		
	Process complexity	Number of interfaces and design	5		X		
		Degree of crosslinking of the processes	5		X		
		Degree of standardization	5		X		
	Organization complexity	Number of hierarchy levels	5			X	
		Degree of centralization	5			X	
		Number of organizational units	4			X	
	Structure complexity	Number of distribution levels	4				X
		Number of stock, staff, equipment, ...	5				X
		Communication systems	4				X
		Vertical integration	5				X
	Planning and steering complexity	Frequency and level of detail of the management and control area	3				X

							Potential to support the targets of Complexity Management												Results	
Complexity Management Balanced Scorecard Summarize the attributes associated with each measurement in the Balanced Scorecard			Attribute	Target value	Current assesment (ca)	Weighting factor = Relevance factor (rf)	Value table for monthly assesment												Reference value	Criteria - Current Value
							Reached value 1	Criteria factor 1	Reached value 2	Criteria factor 2	Reached value 3	Criteria factor 3	Reached value 4	Criteria factor 4	Reached value 5	Criteria factor 5				
Learning & Growth (L&G)	LG 1	criteria	e.g Number / month	e.g. 3	1	2,5	1	1	2	1	3	1	4	1	5	1	2,5	2,5		
	LG 2	criteria	e.g. Percent	e.g. 80	0,9	3	60	1	70	1	80	1	90	1	100	1	3	2,7		
	LG 3	criteria	e.g. Percent / asset	e.g. 80	1,2	5	60	1	70	1	80	1	90	1	100	1	5	6		
	LG 4	criteria	e.g. Percent / services	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	LG 5	criteria	e.g. Number	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
Business Process (BP)	BP 1	criteria	e.g. Number / services	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	BP 2	criteria	e.g. Percent / recipients	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	BP 3	criteria	e.g. Percent / stakeholder	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	BP 4	criteria	e.g. Percent / stakeholder	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	BP 5	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
Customer (C)	C 1	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	C 2	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	C 3	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	C 4	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
Financial (F)	F 1	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	F 2	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	F 3	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
	F 4	criteria	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		
																Monthly Complexity Index (mCI)			11	11,2

Fig. 4.2. Complexity Management Balance Scorecard - ComMBSC (own schema)

The procedure to collect and evaluate the data is described in detail in **Annex 9.** The content of the "value table for monthly assessment" has to be defined by negotiation between the participating organizations. By this negotiation, the organizations are forced to create a common understanding of each of complexity management criteria.

The criteria „reached value 1" means an insufficient support of the complexity criteria, while „reached value 5" represents an over-achievement. The common agreement about each of the target values has to be on an optimum cost-benefit level. In calculating this "optimum level" two aspects have to be taken into consideration:

- The effects of this measure on the special business situation complexity
- The effects of this complexity on the fulfilment of the business needs of the organizations

The dimension "*Learning & Growth (L&G)*"criteria supports the "*operational phase*" of the Complexity Management, which is presented in Chapter 4.3. These dimensions are the basis for the application of the management tools for control and management by complex criteria.

Explanations on the *Complexity Management Balanced Scorecard* logic (related to Figure 4.2) are briefly summarized in the following:

- In the column "*criteria*", the agreed criteria for the respective dimensions are formulated;
- In the column "*target value*", the desired target values are defined;
- The monthly delivery results are assigned to the values clusters in the value table (yellow columns);
- The value, which is nearest to the intended values in the value table, is used;
- The result of this mapping is entered in the column "*current assessment*" and produces the value: "*ca*";
- The value of "*ca*" is multiplied with the "*relevance factor = weighting factor*" (rf);
- The result is calculated and presented in the column of "*criteria current value in results*";
- The criteria and the target values are to be designed so that the target value is 1; this means that at 100% target achievement: "*rf = criteria current value"*;
- The reference value corresponds to the "*relevance factor = weighting factor"*(rf);
- All individual results are respectively added;
- The *Monthly Complexity Index (mCI)* is the summation of all "*criteria current values*". This value can be compared with the target value (summing all reference values).

The mathematical formula of the *Monthly Complexity Index (mCI)*is:

$$mCI = \sum_{i=1}^{n} \mathrm{ca} \times \mathrm{rf} \tag{4.1}$$

The application in business environment of the ComMBSC is shown in Chapter 4.4.

4.3. Large Business Complexity Operation

Top objective of this layer is the organizational implementation of complexity management in the participating organizations, as well as at the organizational

interface. In this layer, the target values (reference value and weighting factors) for the complexity criteria are defined, as compared with the actual values, and the result evaluated. Based on the evaluation, appropriate measures are put across the organization. A key component of this layer is the establishment of an inter-organizational "**Complexity Management Board – ComMBoard**". The overall tasks for the operational phase are the following:

- Create and carry out the system for managing the complexity, with the main topics:
  - Principles of Complexity Management;
  - Objectives of the Complexity Management;
  - Complexity Policy;
  - Leading role of Complexity management from the Service provider;
  - Mode of Complexity Management action at the organizational interface between the involved parties;
- Carry out (permanently) the instruments of Complexity Managements;
- Organization of the "*Complexity Management Board*".

A detailed description of the activities and responsibilities is developed as a draft contract (template), in terms of research, and attached in **Annex 9**.

4.4. Dimension: Process

High volume and extended change projects in which different companies and organizations agree on a close cooperation is always associated with numerous process adaptions. To perform a complexity analysis and assessment, the processes need to be defined, documented and they have to be transparent to the stakeholders. As described in the previous chapters, the corresponding level for the complexity management has to be used; it is also recommended that the transparency has to be supported by the presentation of different layers. This level must represent at least the quantity and quality of the interfaces within the organization, but also in a transparent manner, the interactions between organizations. The forms should include at least the details listed by (Jobst, 2010) in order to fulfil the appropriate preliminary work for complexity management (according to (Jobst, 2010, p. 75-76) and the debate presented in Chapter 3.2.8):

- Identification, name (object and performing);
- Description and content of the business process;
- Party customer (internal or external);
- Input (triggering event, transferred funds);
- Output (end event, transferred funds);
- Conventions (physical resources, information systems, information);
- Flow chart;
- Interfaces (for the parent and child process models as well as external processes);
- Company organizational units;
- Time and place;
- Process owner;
- Purpose;
- Restrictions and framework conditions.

At this point, due to the necessary limiting of this thesis, no further detail is executed.

4.5. Dimension: Organization

For Complexity Management, organizational aspects are relevant from several perspectives.

First, a degree of organization transparency must support the "*Complexity Criteria*" creation or definition, in order to rate the intersections within the organizations, but also between the organizations. In addition, connected to this action is the identification of the managers' role in the process that has to be evaluated (intersection of the dimension processes).

A second aspect is the identification of the stakeholders, who must be integrated into the Complexity Management in a targeted manner. "*Stakeholders are homogeneous interest groups who are involved directly or indirectly in the project or have an interest in the success or failure of the project*" (according to (Reichert, 2015, p. 126) and the considerations presented in Chapter 3.2.7).

A third aspect is that the measures that are initiated for the Complexity Management System have to be organizationally, purposefully placed and reacted there.

4.6. Dimension: IT support architecture

The "*IT support architecture*" supports the process management and the whole organization to provide the business processes. For this reason, this dimension is also of great importance from different perspectives:

At first, the "*IT support architecture*" equally affect the organizational and process changes. This means that a transparency degree of "*IT support architecture*" must be given to rate the complexity (in the original and target status).

The second aspect is that the "*IT support architecture*" can be a positive driver itself to effectively implement and support measures in the organization and in the processes. A major success factor, in project management are the communication measures, related to the IT system (see also (Hassan et al., 2015b) and (Basu et al., 2012)).

The third aspect is the fact that due to the changed allocation of organizational roles of individual value chain and process changes; also changes of the "*IT support architecture*" for the business processes are needed. Specifically, this means that the service provider must provide, in one or more alternatives, the services, so that the customer can react and order (e.g., IT support). The customer needs to change the IT infrastructure to the extent that the customer organization (including IT support) may execute orders to the service provider and receive bills and handle them internally.

4.7. Dimension: Contract

The first aspect of this dimension is the fact that for outsourcing projects, a contractual agreement is made between the parties involved. This agreement constitutes the entire basis of the business relationship. Usually, contracts consist of two parts: regulations for migration phases (Transition and Transformation) and arrangements that define and describe the agreed services. Furthermore,

organizational, process and IT specific regulations for the various phases are regulated. Due to numerous factors and uncertainties (in a large business environment) in the phase contract conclusion, the contracts are always incomplete. The integration in the outsourcing relationship develops over time and the use of modes of integration, largely depends on the strategic priority of the parties (Kaipia & Turkulainen, 2016).

The second important aspect of this dimension is the issue that the characteristic of the service provision is part of the contractual agreement. In addition, a lot of further contractual regulations and relevant topics could affect complexity (for the service provider and also, for the customer).

The third relevant aspect is that the complexity management should be agreed between the parties to support the targets of the Complexity Management System. The contractual agreement (as shown in **Annex 9**) is proposed in this PhD research, based on the previous results, and serves as an additional contractual regulation between the parties; an adjustment of the existing contractual regulations of the parties is not necessary.

4.8. Management tools

The management tools support the status of complexities transparency. Furthermore, these instruments help to identify appropriate measures to operationalize and to monitor their implementation in the participating organizations. The instruments support the application at the interface between customer and service provider and are described in detail in **Annex 9**. The instruments are:

- **Complexity management criteria (ComMC):**
  The development and agreement purpose on "*Complexity Management Criteria*" is to achieve a common understanding of success-critical complexity relevant criteria between the involved parties. These criteria are the basis for further instruments of complexity management;
- **Complexity Management Balance Scorecard Balance (ComMBSCB):**
  The target of the "*Complexity Management Balanced Scorecard Balance*" is to create an annual overview evaluation of the complexities for the involved parties Top Management;
- **Complexity Management Balance Scorecard(ComMBSC):**
  The "*Complexity Management Balanced Scorecard*" is the monthly measure management tool, designed in order to control the achievement of the defined complexity criteria. This "*Complexity Management Balanced Scorecard*" is the basis for the "*Complexity Management Balanced Scorecard Balance*";
- **Complexity Management Measures list (ComMMeasures list):**
  The target of the measures list is to manage identified measures and ensure transparency regarding the progress and the effectiveness and to control / monitor the implementation;
- **Complexity Management Communication (ComMCom):**
  The target of the instrument, communication, is to inform constantly the stakeholders from the involved parties about complexity relevant aspects;
- **Complexity Management Stakeholder Analysis (ComMStA):**
  The target of the stakeholder analysis is to identify, maintain and integrate the stakeholders of the involved parties for complexity relevant topics, to ensure

that the interests of the stakeholder are adequately taken into account and also, satisfy;

- **Complexity Management Audits and Review (ComMAR):**
  The target of this instrument is to ensure an external and independent review process of the "*Complexity Management System*".

Because of the limitation of the PhD research focus, only the complexity-specific instruments are defined and described in detail in this thesis.

Based on the basic model of the procedure in IT Outsourcing projects, the schema in Figure 4.3 shows a completed overview of the "*Business Complexity Management Model" ("Large Scale Business Complexity Model", LBCM*), with different strategy components.

4.9. Conclusions

The "*House of Large Business Complexity Management"* completes previous complexity models, which mainly focused on the criteria development; the link with traditional management tools enables active management and control of existing complexities in a business environment. Based on the current state of complexity management research, complexity criteria were changed / adapted to the focus of this PhD research and were elaborated a specific bundle of weights for use in large-scale projects. The developed tools allow a holistic approach between the organizational units involved and are very concretely defined and described. Through an explicit contractual additional regulation of complexity management, the activities are legitimized and thus become an integral part of the contract. The consideration of complexities in the dimensions ensures a holistic, but also differentiated view on complexities issues. In the modelling of the "*House of Large Business Complexity Management*", the previous state of research is considered diverse; this state of research has been enriched by the other necessary disciplines (as presented in Chapter 3).

Objective OP2 achievement
A design of a holistic complexity management model for a large-scale business environment was created, based on the requirements identified and described in Chapter 3 and the derived and transformed suitable complexity criteria for the PhD research focus. The result was an all-encompassing the "*House of Business Complexity Management Model*", together with a designed approach for implementation (Excel tool that integrates all the presented management tools for the complexity management). The proposed model has been enriched with appropriate management tools and methods.

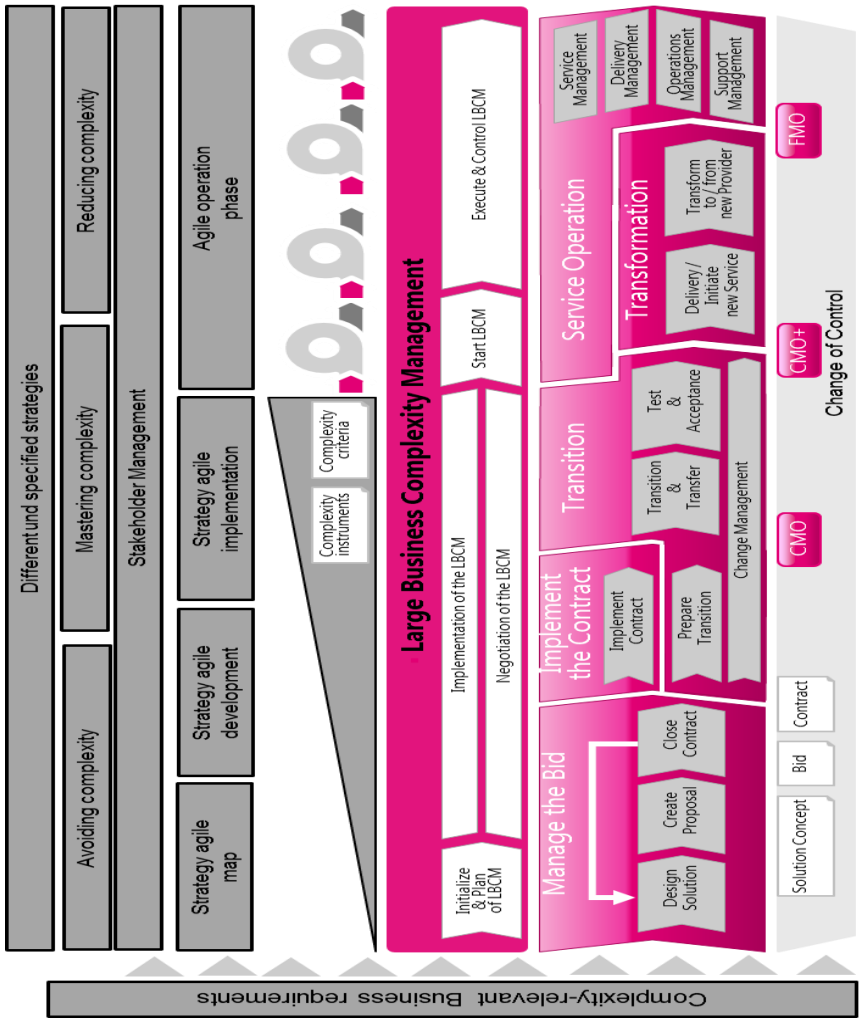

Fig. 4.3. Business Complexity Management approach in IT Outsourcing projects (own schema)

5. EXPERIMENTAL RESEARCH - EXPLOITATION OF THE BUSINESS COMPLEXITY MANAGEMENT MODEL IN AN OUTSOURCING PROJECT

In Chapter 5, the research results of Chapter 4 are used in a specific case. For exploitation of the designed model, initially a number of project characteristics will be defined. The data used are "*fictitious*" and exclusively used for the purpose of analysis and evaluation, in order to test and validate the proposed model.

5.1. Experimental use case – research results and debates

5.1.1. Description and remarks of the experimental case study

A concrete use case is considered for the experiment. It corresponds to a typical situation in a large-scale business environment, as the high-volume IT Outsourcing deal situations is; the "**Order to cash process**" is considered; the description of the business situation and the reasons for this selection are:

- The process is changed by the new relationship in any kind of cases in outsourcing agreements;
- There is a new organizational interface for this process;
- Due to numerous recipients of the services within the customer, a large number of organizational interfaces has to be designed.

The analyzed business environment is characterized by the following issues:

- The services drafted in the contract, including their delivery model, and will be detailed in the upcoming Transition and Transformation phase over a period of approximately two years.
- The project has an estimated duration of 3 years.
- The organizations focus only on implementation of the project and ensure the daily business.
- Each organization has more than 30,000 employees. Customer has allowed 8,500 employees to order IT services to the Service provider. There are 850 employees (so called, transferees), who change the organizational membership from Customer to Service provider and also take with them their previous tasks with the "order to cash process". The customer operates in 28 countries worldwide, divided into six company business units, with heterogeneous structures and individual processes and 2,500 cost centers in total;
- Between Customer and Service Provider, eight languages have been agreed upon in the communication of both organizations;
- A central "Order to cash Process" is basically aimed at, but there are numerous country and unit-specific characteristics in the customer organization;
- A central governance model exists on a high level. Complexity management is organized centrally by both participating organizations; five contact persons are named for this purpose. A contractual agreement to complexity management has been made on the basis of template presented in Annex 9;

- For one year, the complexity management tools (presented in this thesis) have been implemented in the operating phase, after a three-month initial phase;
- The organizational and procedural conditions for the legwork for a complexity management are fulfilled by both organizations;
- Industrial production is organized as a mass one due to the number of orders (about 1,300 orders / day from decentral customer). Product portfolio consists of (configurable) IT Service for end user (desktop and infrastructure service).

Identified fields of Complexity, regarding the case study:

- *Company size and internationality:*
  Due to the large size and the international positioning of the involved companies (customer and provider), the problem of placing "complexity-relevant information in all sub-organization in time" is generated.
- *Fragmented organization:*
  Complexity-relevant issues are not transparent and not reported from decentral sub-organizations to a management level.
- *Limited focus:*
  Due the focusing on the high amount of task in the project and daily business, complexity management is neglected.
- *Unclear delivery model:*
  The ongoing development of the delivery model leads to various negative issues. On one hand the focus of the scope changes from project implementation to contract negotiations and on the other hand ongoing operation requests of the business has to be fulfilled by using additional resources, which are not calculated in a time and budget perspective for the project.
- *Customized product configuration:*
  Individualized product configurations (e.g. on hierarchy or country level) increase the effort to design, provision, operate and maintain the portfolio for all involved process owners within the global organization.
- *Dynamics environment:*
  In a long-term project, a lot of requirements, defined at the project start, are changed during the project progress, due to the high volatile external environment of the customer.
- *Heterogeneous customer groups:*
  A high degree of individualization and therefore significant differences within one company result in many inconsistent requirements related to processes, roles and delivery fulfillment.
- *Loss of planning ability:*
  Because of moving targets (changing requirements), the initial project plan has to be adapted frequently. This leads to an uncontrollable and unpredictable project management, where measuring against a baseline is not possible.

All these fields of complexity contribute to the fact, that the organizations, which are part of the project, are affected on various levels: time, budget and quality. This means that both organizations will have distinct market disadvantage.

5.1.2. Application of the Large Business Complexity Model

According to the proposed model and methodology, Figure 5.1 presents a course of development of the Complexity Management Scorecard.

Monthly course of Complexity criteria			Reference value	Results of the Current values of the Criteria												
				Jan	Feb	Mrz	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez	average
Learning & Growth (L&G)	LG 1	Number of communication measures and training measures	2,5	2,5	2,5	2,5	2	2	2,5	2,5	3	2,5	2,5	3	3	2,54
	LG 2	Quality assured and in time deliveries for creating CBSC	2,5	2,25	2,25	2	2,75	3	2	2	2	2,75	2,75	2	2,5	2,35
	LG 3	Participation rate on Complexity Management Board	2,5	3	2,75	3	3	3	2,75	2	2	3	2,75	2,75	2,75	2,73
	LG 4	Summary of issues of the results of the Complexity Management in Project TOP reporting	2,5	4,25	3,25	3,25	4,25	4,25	1,5	3,25	3,25	4,25	3,25	3,25	4,25	3,52
	LG 5	Defined measures from the Complexity Management Board are implemented in time	2,5	2	2,5	2,5	2,5	2,75	2,25	2,25	2,25	2,75	2,75	2,5	2,5	2,46
Business Process (BP)	BP 1	Number of uncertainty of the delivery concept beetween Customer and Service provider	5	6	6	6	4	3	3	3	4	3	6	6	3	4,42
	BP 2	There are a maximum of 3 different product structures agreed and to support in operation	4	2,4	3,2	4	3,2	3,2	4	4	3,2	3,2	4	3,2	4	3,47
	BP 3	The dynamics of contractual agreed product changes is limited	3	1,8	1,8	1,8	1,8	1,8	1,8	1,8	2,4	2,4	1,8	2,4	2,4	2,00
	BP 4	Number of interfaces between Customer and Service provider is limited	5	3	5	4	5	5	5	4	5	6	7	6	5	5,00
	BP 5	Number of crosslinked main processes between Customer and Service provider is limited	5	7	6	6	7	5	5	6	7	4	3	3	3	5,17
	BP 6	The degree of main process standardization should be high	5	4	4,5	4	5,5	4,5	4	5,5	4,5	5,5	4	4,5	6	4,71
Customer (C)	C 1	Number of changes, based on (social) economic and environmental factors	3	1,8	1,8	2,4	1,8	2,4	3	1,8	3	1,8	3	3	3	2,40
	C 2	Number of changes, with relevant diversity of Customer requirements should be limited	5	7	6	5	7	6	7	5	7	5	5	7	7	6,17
	C 3	Number of changes, with relevant individuality of Customer requirements should be limited	5	6	5	5	6	5	6	4	5	5	4	6	7	5,33
	C 4	Number of changes, caused by market dynamics, should be limited	3	3,6	3	3	2,4	2,4	3,6	3,6	4,2	4,2	3,6	3	2,4	3,25
	C 5	Number of suppliers for the same or similar Portfolio should not effect the project	4	5,6	4,8	4	3,2	4	3,2	4	4	4	4	4,8	4	4,13
	C 6	Number (permanent) of Complexity-relevant issues in the procurement strategy / concept	5	3	3	3	3	3	4	4	3	4	3	4	4	3,42
	C 7	Number of incidents, regarding fluctuations in demand	5	3	3	4	4	4	3	3	4	3	4	3	4	3,50
	C 8	Number of problems in delivery provisioning, regarding heterogenity of customersgroups	3	1,8	1,8	2,4	1,8	1,8	2,4	2,4	1,8	2,4	3	3,6	3	2,35
	C 9	Number of services, which has got a signifikant level of participation of the Customer	4	3,2	4	4	4	4,8	4,8	4,8	4	4,8	3,2	4	4	4,13
	C 10	Number of known problems in delivery provisioning, regarding number of hierarchy levels	5	4	5	4	5	5	5	5	4	5	5	3	4	4,50
	C 11	Number of "degree of centralization", regarding the recipients of the service delivery	5	6	4,5	5	6	4,5	4,5	5	6	4,5	4,5	4,5	4,5	4,96
	C12	Number of known problems in delivery provisioning, regarding of organizational units	4	5,6	5,6	5,6	5,6	4,8	4,8	5,6	5,6	4	4,8	4	5,6	5,13
Financial (F)	F 1	Number of tracked targets in parallel (milestone on level 1 and 2)	4	2,4	2,4	3,2	2,4	2,4	2,4	2,4	2,4	3,2	3,2	2,4	3,2	2,67
	F 2	Number of changes, regarding adjustment og targets (milestone on level 1 and 2)	5	3	3	4	4	4	4	4	4	4	4	3	4	3,75
	F 3	Number of distribution levels, which has to maintain in the master data	4	3,2	4	4	4,8	4,8	4	4,8	5,6	4,8	4	4,8	4,8	4,47
	F 4	Number of unclear assets (stock, staff, equipment, ...)	5	5	5	5	5	6	5	5	6	7	7	6	7	5,75
	F 5	Degree of coverage of the stakeholders in communication activities via IT systems	4	4	4	3,2	3,2	3,2	3,6	4	4	4,4	4,8	4,4	4,8	3,97
	F 6	Degree of involvement of the line organization in the project (vertical integration)	5	6	6	6	5,5	5	5,5	4	4	4,5	4,5	4	4	4,92
	F 7	Proportion of the project activities in terms of effort for project reporting	3	3	2,4	3	2,4	3,6	3,6	3	3	2,4	3,6	2,4	3,6	3,00
		Summary:	120,5	115,4	114,05	114,9	118,1	114,2	113,2	111,7	119,2	117,4	118	115,5	122,3	116,2

Fig. 5.1. Monthly course of Business Complexity criteria (own schema)

5.1.3. Interpretation of the results

Table 5.1 briefly shows the possible and necessary recommended options and actions, based on the evaluation, with results from simulated data for the adopted use-case scenario.

Tab. 5.1. Results of application of the Complexity Management model (own table)

Criteria	Assessment and Option of action
LG 1	The communication measures and training measures are carried out on a stable level; determined and reached annual target are on the same level. No specific measures required.
LG 2	There are slight fluctuations during the year in deliveries for creating the CBSC; measures for sustainable stabilization are recommended.
LG 3	The participation rate on the Complexity Management Board is on a good level; there are slight fluctuations in the months of summer. No specific measures required.
LG 4	The results of the Complexity Management are sufficiently covered by the project TOP reporting (above the agreed level). No specific measures required.
LG 5	Defined measures from the Complexity Management Board are implemented in the agreed level of the parties; there is a stable constant level. No specific measures required.
BP 1	There are higher fluctuations during the year; stabilizing measures to decrease the number of uncertainties are recommended.
BP 2	This criterion is almost always evaluated as "too low". There are measures to permanently raise the level required, or a review of the defined objective.
BP 3	The criterion "*Dynamics of contractual agreed product changes*" is not adequately fulfilled. A positive trend can be seen, but still below the reference value, it is recommended to set up new measures, or to verify the definition of the criterion.
BP 4	The execution of the criterion "*Number of interfaces between customer and service provider is limited*" is valued permanently on the same level as the reference value. No specific measures required.
BP 5	Starting from the month of October, there is a negative jump. The cause has to be checked and appropriate measures for improvement taken.
BP 6	The evaluation of the criteria: the degree of main process standardization is evaluated on a rather sufficient level. No specific measures required, but to observe.
C 1	The criterion "*Number of changes, based on (social) economic and environmental factors*" permanently reached a too low value. The cause has to be checked and suitable measures for improvement taken.
C 2	The criterion regarding "*Number of changes, with relevant diversity of customer requirements*" is always fulfilled on a high level; no activities are needed.
C 3	The criterion is evaluated sufficiently on a good level, no specific measures required.
C 4	The criterion is evaluated sufficiently on a good level, no specific measures required.
C 5	The criterion "*Number of suppliers for the same or similar portfolio is permanently evaluated on a high level*", no activities necessary.
C 6	The criterion "*Number (permanent) of complexity relevant issues in the procurement strategy / concept*" reached permanently a too low value. The prospective different causes have to be checked and suitable measures to improve taken.

Criteria	Assessment and Option of action
C 7	The criterion "*Number of incidents, regarding fluctuations in demand*" reached permanently a too low value. The cause has to be checked and suitable measures to improve taken.
C 8	Starting on a low level, in the several last months, the condition of this criterion is evaluated on a suitable level. No specific measures required, but to observe.
C 9	The criterion is valuated, with stabile character, on a target-oriented level, no specific measures required.
C 10	The criterion is valuated, with stabile character, on a target-oriented level, no specific measures required.
C 11	The criterion is valuated, with stabile character, on a target-oriented level, no specific measures required.
C12	The criterion "*Number of known problems in delivery provisioning, regarding organizational units*" is evaluated permanently on a high level, no activities needed.
F 1	The criterion "*Number of tracked targets in parallel*" is evaluated permanently on a too low level. Redesign of the definition of the criterion or measures to improve necessary.
F 2	The criterion "*Number of changes, regarding adjustment of targets*" is evaluated permanently on a too low level. Redesign of the definition of the criterion or measures to improve necessary.
F 3	The criterion is valuated, with stabile character, on a target-oriented level, no specific measures required.
F 4	The trend of the evaluation of this criterion is stable, with a positive development.
F 5	The trend of the evaluation of the criterion "*Degree of coverage of the stakeholders in communication activities via IT systems*" is stable, with a positive development.
F 6	Starting on a good level, there is a slowly negative development in the criterion: "*Degree of involvement of the line organization in the project (vertical integration)*"; taking measures to improve becomes necessary.
F 7	This criterion will be assessed on average at a satisfactory level; measures for the permanent stabilization, however, are recommended due to the fluctuations.

Visualizations support the understanding and a swift interpretation of results. The following graphs pursue these goals.

- The "*Criteria - Current values*" presents the summary of all monthly values;
- The "*Results of all criteria in one month*" allows comparing all criteria quickly;
- The graphic "*Analysis per dimension*" compares the dimension with each other.

The reports illustrated in Figures 5.2, 5.3 and 5.4 represent the most important results' visualization. Depending on suitability and individual requirements, additional or different reports can be generated on a monthly basis.

The report shown in Figure 5.3 is suitable for the preparation of monthly Complexity Management Board to obtain a consolidated view of the complexity status of each month.

An additional presentation is an extra reporting, separated by the different dimensions of the proposed model (Figure 5.4).

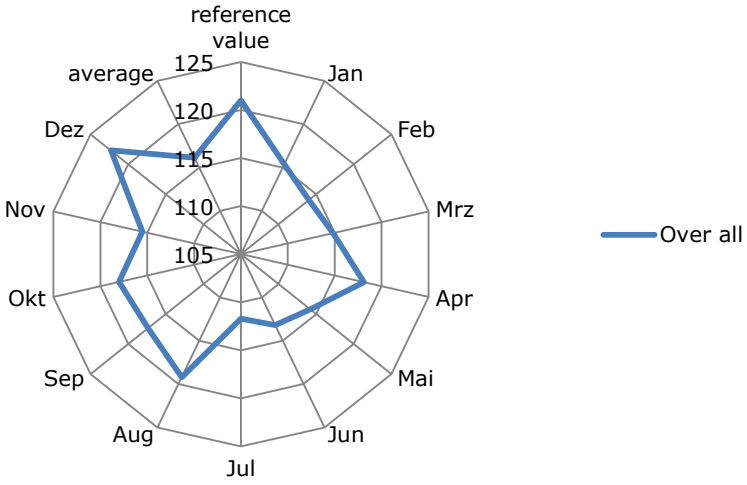

Fig. 5.2. Overall view: Course of Business Complexity criteria (own schema)

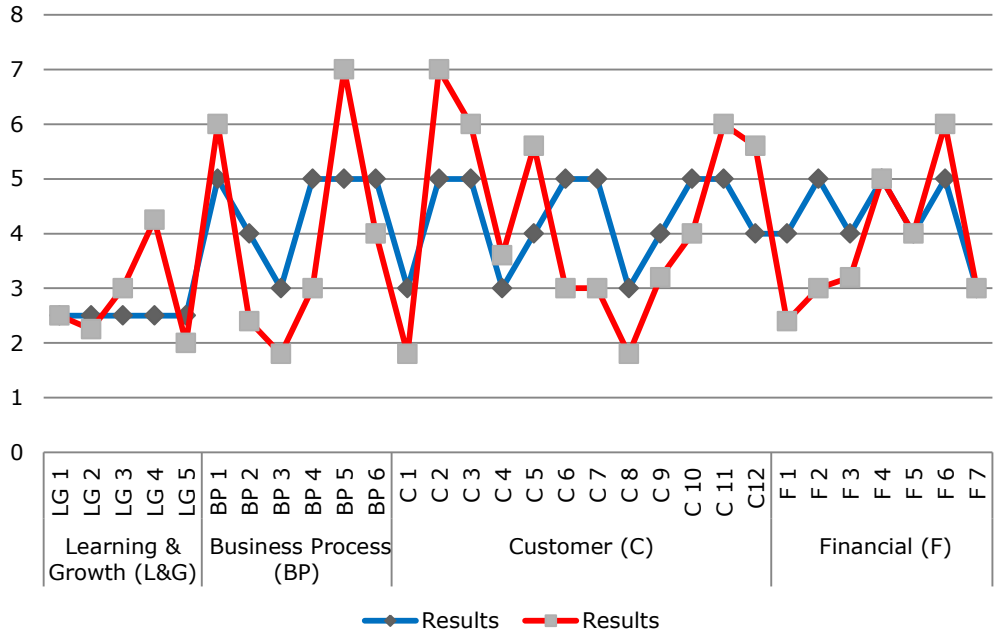

Fig. 5.3. Overall view: Course of Business Complexity criteria (own schema)

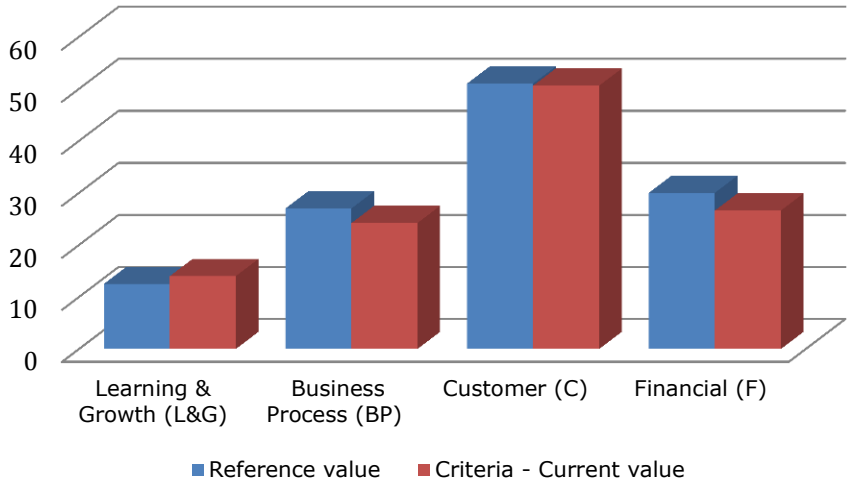

Fig. 5.4. Analysis per dimension: Course of Business Complexity criteria (own schema)

The different dimensions of the "*House of Large Business Complexity Management*" are defined and graphically displayed in Figure 5.5 (level 1 of the BPM). In this case, the design of the "*Order to cash Process*" takes place at various levels. In **Annex 13**, an "*Order to Cash–Process*" on level 5is presented.

The *Ishikawa diagram* also supports the analysis relative to *cause and effect* consideration and analysis; this approach is useful in order to establish the corrective measures. The diagram in Figure 5.6 shows the result of the analysis, presented in the use case context.

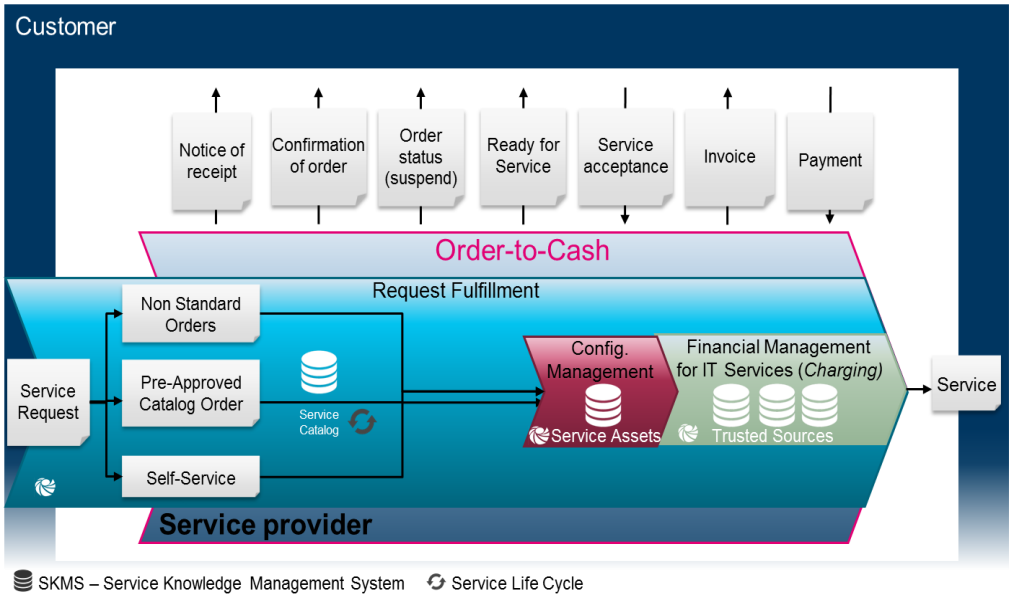

Fig. 5.5. Order to cash Process – level 1 (own schema)

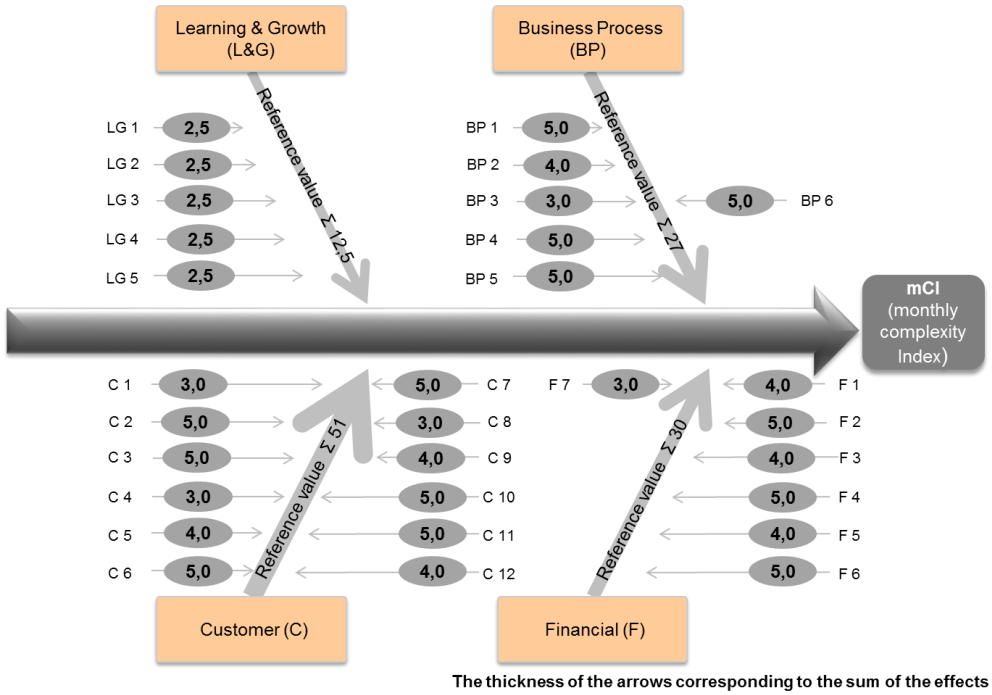

Fig. 5.6. Analysis of the complexity criteria, using the Ishikawa diagram (own schema)

5.1.4. Conclusions

As part of the experimental research, all the criteria were fully represented. In practice, it can be interpreted that all supplying legal units fully deliver the agreed complexity relevant data. In the simulation, the target values, complexity relevant input data and table of values are consistent with the relations between each other.

The design of the Complexity Balance Scorecard (CBSC) allows a quick overview of the status of each complexity criteria. The logic of the value table brings a small-calculated fuzziness; however, it has two major advantages:

a) The fact that the units involved agree on the value table with each other in advance sets up apart to a sufficient extent with the individual criteria;
b) Another advantage is that the value table supports to orient the focus not on mathematical details, but rather on the overall status (thinking in cluster) of the situation and the trend of individual criteria.

The annual overview supports the trend statement, allows identifying trends very clearly and quickly in order to elaborate, and establish appropriate necessary measures; here several developments during the year are seen as: consistently stable level, positive and negative development and jumps in the course. Similar to the simulation, the number of criteria in practice should not be too high, because it is not possible otherwise to have a sufficiently qualified discussion between the involved parties (in the large-scale business environment). The dimensions of the Balance Scorecard (BSC) also, support rapid analysis and targeted guidance on the monthly analysis of the results.

Objective OP3.1 achievement
Reflecting a described use case (IT Outsourcing project), the theoretically designed approach was applied, by simulation of a large-scale business situation. The results were the presentation of the complexity, specific simulation reports of a particular process *("Order to cash process"*) in the case of a large-scale project (IT Outsourcing) and the analysis of the respective outcomes of the Complexity Management Model. The experimental research has proved the utility and the usefulness of the proposed model and the associated methodology (test and validation have been successful).

5.2. Final review of the developed Business Complexity Management model

In the following section, the developed business complexity model is finally evaluated. The review is carried out, in order to check whether the functional and non-functional requirements (identified and presented in Chapter 3.5) are fulfilled. Further evaluations are made by considering the model and the associated methodology applicability issues (aspects) in the experimental research context defined by the use case presented in Chapter 5.1.

5.2.1. Coverage of fulfillment of the defined requirements

In Table 5.2, the functional and non-functional requirements are merged. Compliance with the requirements shall be evaluated qualitatively.

Tab. 5.2. Assessment results of the requirements for a business complexity model (own table)

No	Name	Short description of the functional requirements	Assessment
1	Different factor perspectives	The model has to sustain different and multi-dimensional external and internal perspectives, in order to consider stakeholders' different interests.	In defining the complexity criteria, internal and external perspectives, the customer's and service provider's point of view are taken into account.
2	Complexity management process	The different phases of complexity management process have to be promoted (planning, implementation and on-going review and measures to manage).	The business complexity model and the process model support all phases of large-scale projects (as IT Outsourcing projects).
3	Time perspective	The complexity model has to support business situations and projects with a long-term perspective (at least three to five years).	The business complexity model on the one hand supports the initial phase of a project, as well as the line operation (e.g., through annual ComMBSCB).

No	Name	Short description of the functional requirements	Assessment
4	Open system	Adapted to the specific situation, complexity drivers serve as inputs used to value the complexity. The model must be configurable and have an *open character* to capture the dynamics of the known and unknown inputs.	The logic of complexity system allows a specific adjustment, depending on the customer and project specificities or characteristics.
5	Cause - effect relationships	The model should allow the identification of the correlations and it should support the effects evaluation.	A qualified description of the effects of complexity criteria is included in the derivation and transformation, which were developed for the Complexity Balanced Scorecard.
6	Holistic character	Aspects of the complexity management must support a holistic character for a company, business situation or project.	The business complexity model has in principle no restrictions in perspective. By taking into account the relevant dimensions, a project in a large-scale environment is considered all encompassing.
7	Interdisciplinary	The business complexity model must provide functionality to fulfil the crosscutting nature and the interdisciplinary.	The business complexity model is high-grade interdisciplinary; in the model design, a number of other research disciplines have been included.
8	Derivation of strategic management	The relation with organization's strategic management has to be ensured on the functional level.	The business complexity model contains concrete tools to support strategic management. The organization's functional level is supporting by the design and definition of the complexity criteria.
9	Management of uncertainties	The complexity model must deal with known and unforeseeable uncertainties.	In the complexity criteria and also in the simulation, specific criteria are defined, which take the handling of uncertainties into account.
10	Support of different kind of layers	The model has to encourage the contractual, organizational, processual and IT-related layers.	In the model dimensions "*Contract*", "*Process*", "*Organization"* and "*IT support*" have to be taken into account and defined

No	Name	Short description of the functional requirements	Assessment
			relevant layers and levels for the complexity evaluation. In the use case, this levels are: project, processes, business processes and order to cash process.
11	Ensure independence	The model must be established regardless to the agreed services between the involved parties.	The common Complexity Management Board is essentially in charge of the complexity management. This organizational committee is responsible with the elaboration and implementation of the measurement criteria and the logic of the complexity rating, according to the established objectives.
12	Different level	The complexity of management must be applicable at different levels (strategic, operational).	The business complexity model supports the consideration of different organizational, processual, IT specific and contractual levels.
13	Lack of transparency of inputs	The model must support the fact that not all the features of reality are known. In the lack of transparency, complexity and number of the company's internal and external developments, the existence of other features may be of major importance.	A lack of transparency is considered in the respective definitions of the criteria. The defined approach allows adapting the criteria, if necessary.
14	External domination	Due to the outsourcing contract relationship, there is a predominance of external inputs (directly or indirectly to the client).	In the dimension design of the Complexity Balance Scorecard logic, the identification of the causes was taken into account; one of these dimensions is defined as "*Customer*".
No	Name	Short description of the Non-functional requirements	
1	Application of adapted complexity	The considered criteria for evaluation are the criteria to identify, evaluate and	Complexity criteria, based on the current state of research, were evaluated

No	Name	Short description of the functional requirements	Assessment
	criteria	manage complexity in outsourcing projects.	and adapted for the use case: large business environments / projects. The transformed criteria are also used in the exploitation use case of the business complexity model.
2	Support the specific standard phases of outsourcing projects	The complexity model must support the relevant phases in outsourcing projects: contract start, transition, transformation, and FMO operations.	The standard approach for IT Outsourcing projects is enriched to the business complexity model; an adaption of the approach for IT Outsourcing projects is (in all dimensions) not necessary.
3	Applicability and use	The model must be applicable for Service Managers (dealing with the customer and for customer service management).	The overall logic of the business complexity model is understandable for service management and designed in a practice suitable manner. There is no specific knowledge and skills; the derivation of the business complexity model is presented in the thesis.
4	Practicality	Companies must be able to integrate the management of complexity approach in the operational process, which means that input variables in the organization can be identified. The output is used to control if the complexity's required measures can be initiated.	The design of the holistic complexity management model is made for a high degree of practicality. In the "*operation phase"* is described, in detail, how some of the involved units cooperate; also practical, the respective instruments or tools design were shown, for example, the table of values in the CBSC.
5	Methods and tools	The model has to provide methods and tools to be applied in practice.	The business complexity model is accompanied by many instruments to manage complexity, which are also anchored in the contractual dimension.
6	Contractual agreement	The complexity of the model must be designed so that it can be added as an annex to the framework agreement between customer and service provider.	The "*Contract*" dimension of the model and the "*Contractual agreement*" in **Annex 9** takes into account all relevant factors (described in detail).

5.2.2. Review of the use case: large-scale outsourcing projects

There were measurable complexity criteria designed for a monthly review, in the logic of a Balance Scorecard; the application of this model states that all criteria can be applied in a use case. Out of the (mathematical) results, a substantive review can be carried out and on the basis of substantive discussion, concrete measures can be initiated. On the one hand, the total number of criteria allows a full review of the complexities and on the other hand, the number of criteria ensures that the application is feasible in practice. With the help of other visualizations, an even more focused attention to relevant characteristics can be made. So far there exists no standard tool for assessment and management of complexities. The illustrated functions, logic, and input and output options provide a blueprint representation for configuration of an IT support.

5.2.3. Conclusions

The result of the review presents that all defined and created functional and NON-functional requirements are met. Also the carried-out review to analyze the degree of fit regarding the application of the House of Complexity Management Model determines that all functional and non-functional requirements are fulfilled and can be applied in large-scale projects, e. g. IT Outsourcing projects. The application of the use case shows that applicability and practicality is given. Based on the simulated results, concrete measures can be derived and initiated. Moreover, the individual different instruments complement each other.

Objective OP3.2 achievement
The result of the chapter 5.2 was the review, in form of an analysis, if the developed complexity management model has met all requirements and if it has been confirmed by the experimental research in the defined use case. The results were presented in a structured table form.

6. CONCLUSIONS AND ORIGINAL CONTRIBUTIONS

In this last chapter of the PhD thesis, the conclusions of the research work are displayed. Furthermore, the transfer and the completion of the latest state of research in the field are discussed. Finally, a critical appreciation and limitation of the research results will be presented.

6.1. Overall conclusions of the research

The present PhD thesis completes previous Complexity Management approaches and models, and closes the existing research gap; the main focus of the enrichment of existing models are the methods and instruments to manage and control complexities in business environments. In addition, an important added value is the transformation of theoretical complexity management models to a concrete business-environment use case (large-scale projects, e.g. IT Outsourcing projects). Based on the interim results of this research, necessary methods and concepts were described in detail to fulfill a holistic approach of complexity management in large business environments; this was named the "*House of Large Business Complexity Management"*. Standardized strategic management instruments, which should be implemented, like stakeholder analysis, were only listed and integrated into the discussion of this research, because of the defined limitation of the research. This contractual basis, in the handling of complexities, have to be agreed between the organizations involved. Furthermore, this allows a permanent evaluation and managing of the complexities of the involved parties and companies.

Demands, which were derived from the current state of research and necessary additional requirements, which were created through the adopted approach, were summarized and defined in detail. Based on these requirements, the holistic approach named the House of Large Business Complexity Management was developed. In the next step, the theoretical approach was applied in the detailed described use case (large-scale business projects), e.g. IT Outsourcing projects, in form of a simulation. Through a final review, a check was carried out in order to demonstrate if the requirements are fulfilled.

The different objectives and sub-objectives, defined at the beginning of the research (Introduction chapter), were followed and evaluated separately. The result is that all the targets are suffused. The developed procedure allows the concrete implementation in business environments on different and suited organizational levels. The possibility and application of the "House of Large Business Complexity Management" model enabled the service provider to possess complexities and thus have a **Unique-selling proposition (USP)** in the respective market. Furthermore, the frequently listed problems and prevention grounds for concluding an outsourcing contract were eliminated because of an available solution designed in order to avoid the often-mentioned and listed complexity trap.

The House of Large Business Complexity Management can also support a part of the industrial project in the framework of *Industry 4.0*, in case that these projects are of an appropriate size and complexity. The development of these projects are automated and IT-supported networking in the case of various organizations, in order to achieve a compound of different value chain and processes. In the industrial sector, these objectives influence the results of the projects implementation, which have a complexity critical extent, so that the use of the House of Large Business Complexity Management model is justified.

Complexity management is a highly interdisciplinary field of science, so within the present thesis numerous scientific disciplines were taken into account. As a result, the findings of this thesis can be used in the future by designing adequate links to all these scientific areas (see **Annex 1**). The developed complexity model can be used in large-scale business situations, where appropriate adaptation of the complexity criteria is meaningful. The model and the corresponding management tools can be supported in projects where significant organizational, contractual, procedural and IT related changes are to be controlled and managed (according to the dimensions of the House of Large Business Complexity Management model presented in Chapter 4).

By using the CBSC in large-scale project situation, the involved parties are capable to predict complexity as well as to prevent of the complexity trap. Furthermore, this model enables to avoid, to manage or to reduce complexity, as a management strategy.

6.2. Own original contributions of the research

The main original contributions of the thesis to the studied research and knowledge field are:

- The analysis and synthesis of the main and relevant references in the field of complexity management for large-scale business environment. These have concluded to an inventory of the most well-known and accepted definitions of the concepts in the field, together with the description of the main approaches of complexity management - Chapter 2;
- The description of the complexity management research topics in relation with the large-scale business environment dynamics a phenomenon (research results and gaps from the academia and practitioners, large spread of the outsourcing processes and the Industry 4.0 framework actual implications) – Chapter 2;
- The analysis and synthesis of the literature dedicated to the large-scale service-oriented projects (particular to outsourcing process and phenomena and to IT Outsourcing projects specifics) in order to better describe and delimitate the research context – Chapter 2;
- The analysis of the relevant theories and approaches related to complexity management provided by different connected disciplines (research subjects as: service provisioning management, customer integration and customer relationship management, systems engineering, network management, general management and strategic management, innovation management, project management, business process management, IT science and contract management) that have proved the need for interdisciplinary researches and that could be the basis for other researches in the field. The created knowledge

pool has provided strong arguments for the creative solution of the designed business complexity management model – Chapter 3;

- Design and implementation of two preliminary studies (two proposed diagnosis approaches):
    - Correlation of complexity driver with the EPM model (see Study 1);
    - Strategic methods to manage large outsourcing projects (see Study 2).

  These preliminary researches enable the better understanding and characterization of the complexity problems that occur in practice and also, confirmed and complete the findings of (Bauernhansl et al., 2014) - Chapter 3;
- Identification and formulation of the functional and non-functional requirements of the designed business complexity management model in large-scale business environment, based on the literature review, the analysis of the available approaches (provided by different disciplines) and the preliminary studies and practical observations - Chapter 3;
- The design of a business complexity management model called the "*House of Large Business Complexity Management*" and an associated methodology for the practical exploitation, including managerial methods and tools and an Excel tool for the operationalization of the implementation. This is the main contribution to the theoretical researches in the field of complexity management, in the case of large-scale business environment – Chapter 4;
- The proposed model for business complexity management testing and validation through a use case (IT Outsourcing project) that have proved the fulfillment of the defined requirements (functional and non-functional) and the efficiency and effectiveness of the adopted approach from the practical perspective (including the propose combination of designed methods and tools) – Chapter 5.

6.3. Critical review of the research

The research target (context) was related to the large-business environment, in the use case IT Outsourcing projects. Because such projects are implemented in a minimum of two to five years, there is the situation that a parallel operation (project and operation phases) is needed. In a future research, a separated consideration of these two phases will be valuable to set up more specified criteria of the business complexity model. Furthermore, additional studies with more participants would improve the validity of the results.

An extension of management tools would enrich the various views from different perspectives; thereby the highly interdisciplinary context of the research object will be more equitable. The "*House of Large Business Complexity Management*" application effort will be limited, due to the requirement of a high practicality. As part of this research, the effort has not been exactly determined; this will be recommended for future researches, based on these scientific achievements.

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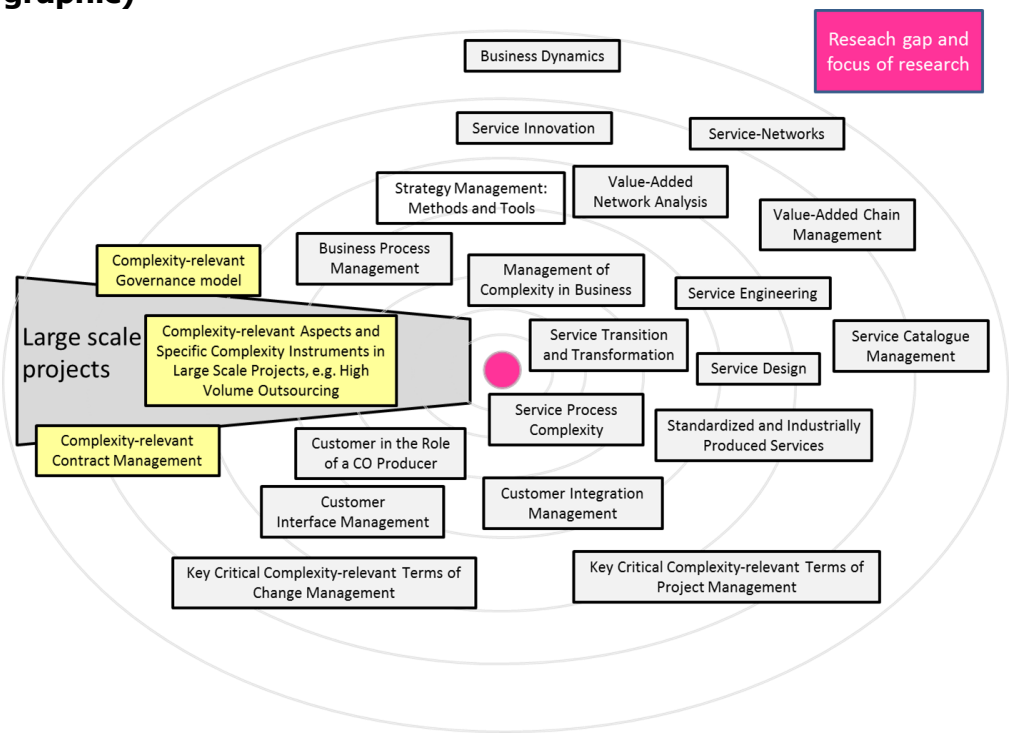
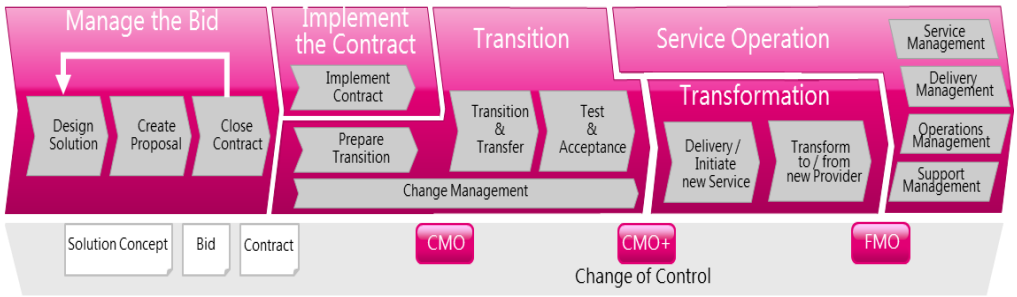
ANNEXES AND SUPPORTING DOCUMENTS OF THE RESEARCH

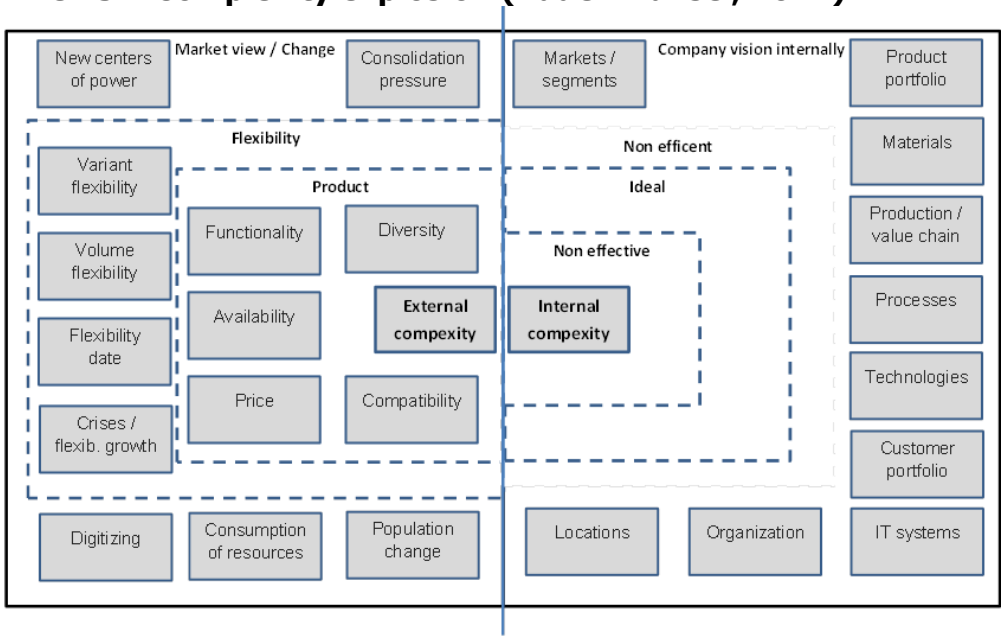
Annex 1 – Focus of research gap and scope of this research (own graphic)



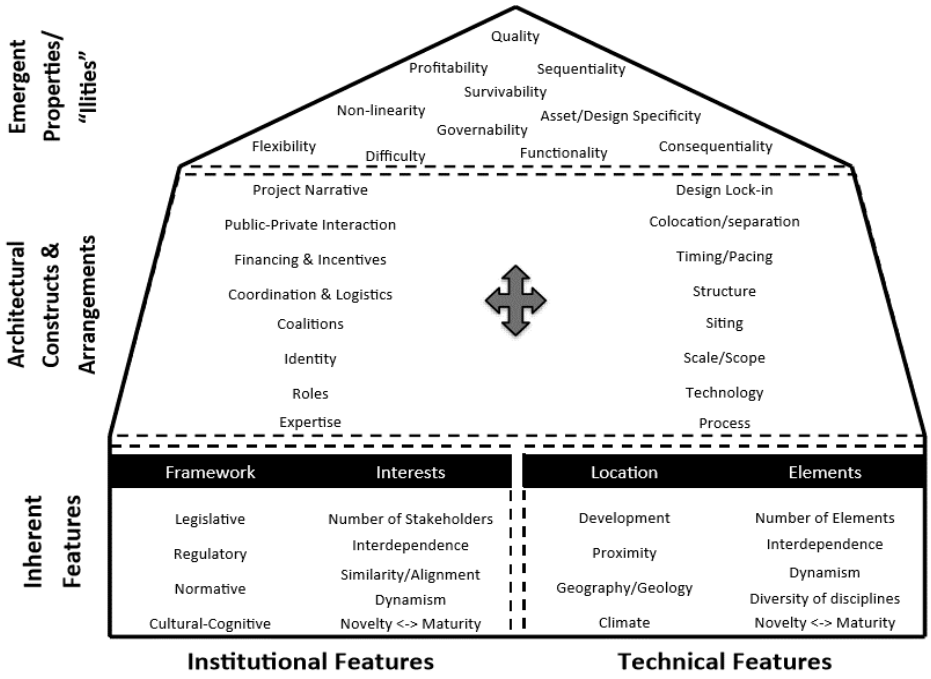
Annex 2 – Generic approach for Outsourcing projects (own graphic)



Annex 3 – Complexity explosion (Bauernhansel, 2014)



Annex 4 – The full house of Project complexity (Lessard et al., 2013)



Annex 5 – Functional modules of complexity (Wildemann, 2013)

Source: Wildemann H., 2013 (adapted for the research purpose and presented in (Rennung, et al., 2014))

Modules	Description
Customer / product portfolio	The portfolio describes a clustering of different products / customers in a system, which can be defined up to a particular individual (share of revenue, profit, growth rates etc.). The process complexity of businesses is largely due to the high proportion of C- customers and products.
Benchmarking	Benchmarking describes the comparative analysis of products, processes, methods, concepts or strategies of competitors with their own parameters. These allows following a complexity comparison.
Product clinic	The product clinic describes a cross-functional, institutionalized place of learning with the aim of optimizing product and process design complexity. The best solutions obtained are then to be used by reverse engineering on their own products and processes.
Process alternatives analysis	Process alternative analysis enables innovation, production planning and order processing and present transparently and thus demonstrate the complexity associated causes.
Configuration analysis	Configuration analysis identified equipment options with low market penetration, which would increase the process complexity disproportionately. This can be done according to customers' preferences; the design of target-group-specific equipment packages in differentiated markets and trim levels.
Function-related product analysis	The function-related product analysis is a prerequisite for reducing the complexity product design. This is done by comparison of end products to functionally similar and –by filtering out dissimilar - optimize the product complexity.
Product classification systems	The foundation of the product classification system is the focus of the guidelines: standardization inward, outward individualization, stability and flexibility with the aim of optimizing and reducing complexity of products and processes. Here are the advantages of joining the opposite directions of individualization and standardization.
Innovation-roadmap	The implementation of an innovation roadmap provides a systematic approach for selecting R&D projects.
Depth of services	The description and knowledge of their own depth of services is an essential requirement for a market-adequate complexity management. A reduction in the depth of performance is the concentration on the core business and thus a shift of complexity on both upstream and downstream value chains.
Simultaneous Engineering	Simultaneous Engineering allows concurrent product and process development and shows an essential lever for the implementation of a preventive complexity management. In practice, this can lead to complexity reduction over the entire development process.
Project management	The complexity of projects can be significantly reduced by an adequate project management by the factors: environment, organization, people and instruments, if they are included in the project management functions.
Development networks	Development networks and, consequently, development

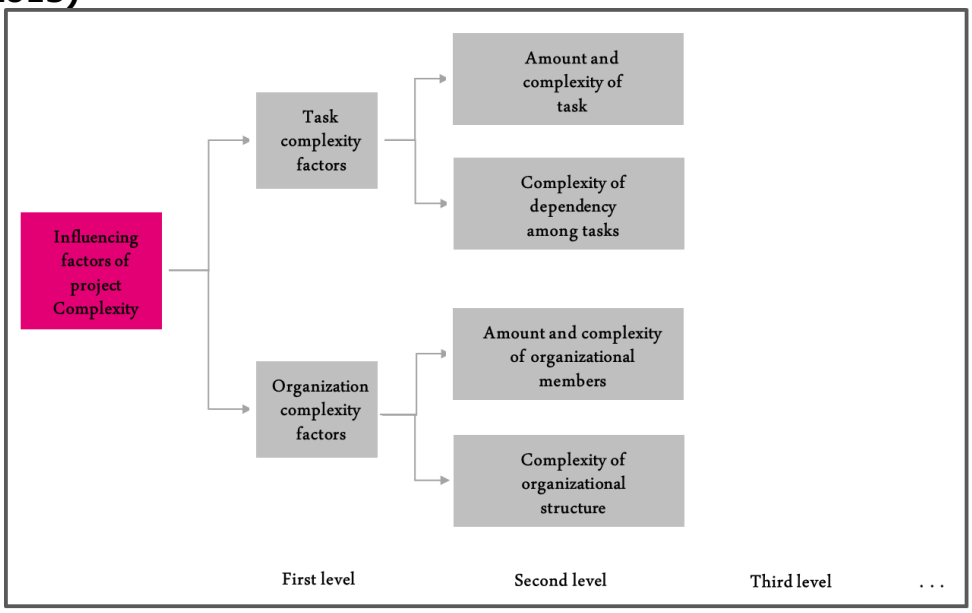
Modules	Description
	partnerships serve the joint management of complexity and can be a guarantee of success for productivity, innovation and sustainable growth in competitive markets.
Sourcing strategy	Sourcing strategy influenced the procurement complexity and should be considered prior to each company's specific background. A distinction is made according to the single, modular or global sourcing.
Procurement potential analysis	Serves the analysis of procurement complexity and thus allows the identification of complexity drivers and are a starting point to reduce complexity. Helpful is the application of portfolio analysis with the corresponding derivative of a recommendation for action.
Supplier integration into the development process	The early integration of suppliers enables the shortening of the product development process through shorter development times, the inflow of external ideas, and efficient use of target costing or the improved make-or-buy decision. Thus, complex obstacles in each upstream process steps can be reduced already at an early stage.
Purchasing organization	The purchasing structure is built up according to a company-specific point of view and aligns with the core processes of purchase, to reduce the complexity of the operational processes. In this case, strategic and operational tasks are separated in order to achieve a complexity optimization.
Production segmentation	Dividing the producing segmentation of production into manageable and clearly defined manufacturing segments will lead to a complexity-optimized design of the production.
Inventory management	Stocks form the temporal bridging between supply and demand and have a direct impact on the success factors of time, quality and cost. Particularly high stocks are often the consequence of inadequate complexity management.
Production network	Production networks combine the efficiency advantages of small business with the classic advantages of large companies. The realization of a production network requires the coordination of information and material flows as a result of delivery and performance interdependencies.
Variant destination point	The variant decision point is determined at the end of the value chain. With only a few standardized modules, a flexible production level can be achieved.
Order processing center	The aim is to reduce the vulnerability of order processing, which is in the complex organizational and informational design. This can be done through the shift from function optimization to the process optimization. The concept of order processing centre constitutes an essential tool for reducing complexity-related errors.
Segmentation indirect areas	Segmentation indirect areas serves to reduce the complexity and leads to product / market-based units in the process chain. This has been the focus of the entire innovation and value chains.
Complexity cost reduction and controlling	The complexity controlling must address the root causes of an increased complexity in the companies and should be based on simple and comprehensible principles. Goal conflicts should be avoided and thus the focus will be directed to the yield strength of the products. With the help of controlling, the costs of projects should be made transparent and enable the early influence on cost drivers.

Annex 6 – Functional modules of complexity - variables (Kato & Schoenberg, 2014)

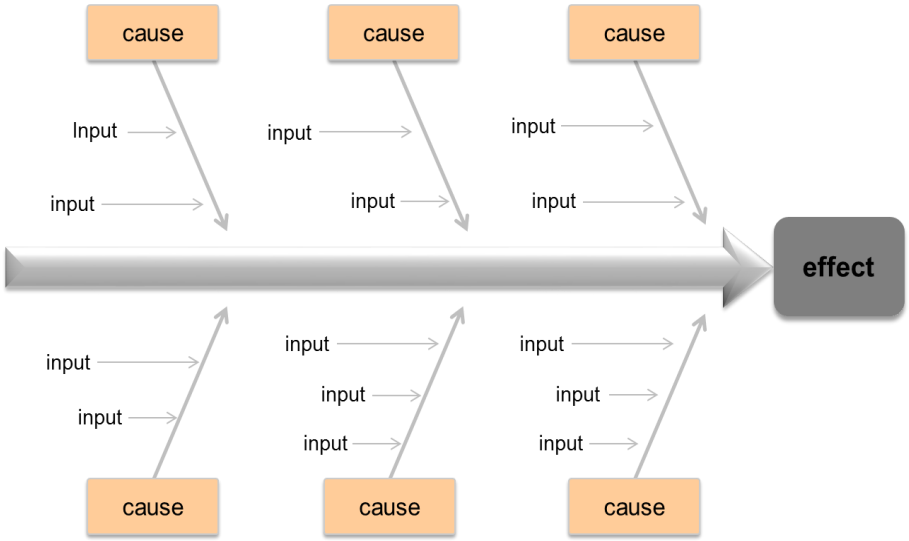
Variables	Definition
i) Supplier's marketing, sales and operational activities influencing relationship	
Account management quality	Perceived contact quality, characteristics, attitude and power of the supplier account manager
Bonding activities	Perceived strength of legal bonds (e.g. contractual agreement) and social bonds (e.g. friendship) with supplier
Commitment of people	Customer's motivation to maintain the current relationship due to positive feelings (employee level)
Communication, Information sharing	Supplier's open info-sharing about sensitive / critical issues and/or advance info-sharing about changes (e.g. price, ...)
Complaint handling	The supplier's complaint handling speed and quality
Cost, price	Direct cost, acquisition cost and operations cost
Customer benefit	Perceived core benefit (e.g. service feature) and add-on benefits (e.g. know how)
Customer involvement	Involvement of the customer decision-making unit for supplier/solution selection
Customer orientation	Supplier's behavior/attitude to put the customer first and nurture the current relationship
Customer status	Perceived privileges by the supplier (e.g. high priority)
Employee turnover	Turnover of the supplier's key contact employee(-s)
Employee satisfaction	Perceived job satisfaction of the supplier's employee(-s)
Expertise, capability	Perceived capability and expertise of the supplier's employee(-s)
Fairness, benevolence	Perceived fairness of the supplier
Flexibility, adaptation	Supplier's capability/willingness to make changes to meet customer needs
Multi-channel integration	Customer's awareness of sales channel options
Pre-service expectation	Excepted service features based on supplier communications as well as past experience, needs and word-of-mouth
Product/service breadth	Breadth of the supplier's service portfolio compared to its rivals
Satisfaction	Overall satisfaction with the supplier
Service performance	Competitiveness of the supplier's service features, reliability and technical/after-sales support
Service quality	Perceived gap between expected service quality and actual service quality
Supplier commitment	Supplier's desire and effort to maintain the current relationship with customer
Supplier initiative	Supplier's proactive actions to improve his/her customers' competitive position
Switching cost	Associated cost, effort, time and risk to switch the current supplier to alternative suppliers
Trust in company	Perceived credibility/reliability, openness and trustworthiness of the supplier (company level)
Trust in people	Perceived credibility/reliability, openness and trustworthiness of the supplier's people
Value	Perceived „benefits-costs"

Variables	Definition
ii) External and conditional factors	
Acceptable alternatives	Availability of acceptable alternative suppliers for the target services
Company size	Supplier's company size relative to the customer's company size
Competitive intensity	Competitive intensity of the market (e.g. service and price competitions between competitors)
Cultural difference	Difference in national culture characteristics between customer and the supplier
Market dynamism	Degree and frequency of changes in the service preferences
Psychological contract	Perceived future tangible outcomes (financial/non-financial benefits) and inputs (e.g. resource and support) promised by the supplier
Relationship length	Length of the customer-supplier relationship
Supplier reputation	Overall reputation of the supplier compared to his/her rivals
Supply complexity	Complexity of customer's needs, supplier's services and purchase decision-making
Supply importance	Strategic, financial and operational significance of the purchase to company

Annex 7 – Influencing factors of project complexity (Lu et al., 2015)



Annex 8 – Blueprint of an Ishikawa Diagram (own graphic)



Annex 9 – Model for a contractual agreement for Complexity Management (own text)

Contractual agreement
for
Complexity Management
based on the contract <...>

Annex for the framework contract
< ... >

[Model]

-confidential-
Version <...>

1 CHANGE HISTORY OF THIS AGREEMENT

The change history of this document during the contract phase is enclosed in Annex 1 of this document.

2 GENERAL INFORMATION

2.1 Contact Person

The contact persons are the responsible for preparing and maintain this document and are listed in Annex < … > of this agreement. All involved parties are entitled and obliged the contact details up to date.

2.2 Further customer-specific information

< … >

3 TABLE OF CONTENT

4 INTRODUCTION

The present agreement for complexity management documents the control of the complexity of the organizational interface between < Customer > and < Service provider >, with the objective of being able to control the complexity of sustainable and to allow continuous quality improvement of IT outsourcing

cooperation. It supplements the arrangements of the Framework Agreement < … >§<…>.

The agreement defines and describes the common objectives of complexity management and enterprise policy, as well as the organizational structures, processes and tools for the joint management of complexity. It is supplemented by the optional management systems of the companies involved, their description is not the subject of this document. General content changes to this Agreement for the control of complexity, carried out under the framework contract < ... > described in the change process.

4.1 Objective of the agreement

The agreement for the management of complexity supports the following objectives. The agreement

- Sets out the objectives and policies for complexity management at the interface between < Customer > and < Service provider > and describes the complexity of management to improve quality of service delivery and the customer-service provider relationship.
- Describes the complexity of the organization at the interface between < Customer > and < Service provider > which is adapted to the different operational levels of cooperation between the parties. This is responsible for the implementation and ongoing development of complexity management guidelines.
- Provides information to the employees of the < Customer > and < Service provider > about arrangements (standards and procedures) that have been set to achieve maximum control of complexities of the workflow and work results.
- Introduces methods, techniques, processes and tools of complexity management and the continuous development.
- Supported in accessing all the elements of complexity management at the interface between < Customer > and < Service provider > and linked to additional documentation.

This agreement applies to all services that the contract § < ... > are performed for < Customer >. For details reference is made to the respective service agreements and annexes of the contract.

4.2 Compilation and Publication of the agreement

The regulation the establishment and publication of this agreement, corresponding to § <…> in the framework contract < ... > conventional agreed regulations.

5 THE SYSTEM FOR MANAGING THE COMPLEXITY

5.1 Principles of Complexity Management

The complexity of management serves the steering and improving the IT service management and delivery processes on the part of the < Customer > and < Service provider >, and the assessment and improvement of the quality of

cooperation. The complexity of management is designed to achieve the complexity objectives are measurable and traceable.

5.2 Objectives of the Complexity Management

In general, the aim is that the complexity of the customer interface for the < Customer > and < Service provider > evaluated, controlled and can be managed. This is achieved among other things by

- The complexity is constantly measured and evaluated,
- Provides constant coordination between < Customer > and < Service provider >
- Be initiated and tracked measures to improve
- AN ongoing development of complexity management is designed, derived from the business requirements of the < Customer >
- The complexity of management in the organization of the < Customer > and < Service provider > is defined as a strategic goal
- Complexity aspects in organizational, process and IT-related agreements will be included in the customer interface.

5.3 Complexity Police

The < Service provider > committed to anchor the mastery of the complexities in the sub-company policy sustainable. Complexity Management will be established in the company's structure of < Service providers>. The < Service provider > committed to maintaining the communication process on the use and development of this complexity management agreement.

5.4 Complexity Management of the < Service provider >

The complexity of management < Service provider > is adapted customized for this complexity management agreement between < Service provider > and <Customer >. The < Service provider > ensures that employees have appropriate certifications and customer-specific knowledge and are each held this up to date.

- CMMI (Capability Maturity Model® Integration) for Services
- IT Infrastructure Library ITIL (ITIL V3)

On demand of the < Customer >, the < Service provider > provides the proof of certification.

5.5 Mode of action of complexity management at the organizational interface

Transparency and controllability of complexities are carried out based on cyclical reviews. For this purpose, various tools for evaluating the complexities can be used. Basis of the review are the commonly agreed Complexity criteria. These criteria are kept up to date permanently between < Customer > and < Service provider > and serve as the basis for the following specific instruments (1 to 7), respectively and the following organizational measure (8):

1. ComMC (Complexity Management Criteria)

2. ComMBSCB (Complexity Management Balance Scorecard Balance)
3. ComMBSC (Complexity Management Balance Scorecard)
4. ComMMeasures list (Complexity Management Measures list)
5. ComMCom (Complexity Management Communication)
6. ComMStA (Complexity Management Stakeholder Analysis)
7. ComMAR (Complexity Management Audits & Review)
8. ComMBoard (Complexity Management Board)

In order to achieve the objectives of complexity management, appropriate measures may be, based on the cyclical reviews, agreed. The implementation of measures also includes the progress, effectiveness and performance review. The methodology for the improvement of complexity management follows the DMAIC (Define, Measure, Analysis, Improvement, and Control) method:

Phase: Define complexity relevant problems and action fields

- Definition problem and focus
- Determine measurable goals for the initiative
- Business situation describing
- Design of a work schedule with responsibilities
- Identify customer requirements
- Relevant process at a high level representing

Phase: Measure und collect complexity relevant data

- Plan for the collection of data defining
- Extract data from systems, or (if necessary) collect sampling
- Performing Stakeholder Analysis
- Determining current process capability

Phase: Analyse the complexity relevant data

- Problem, structured on the basis of data process
- Representing relevant process in detail
- Identification and evaluation of factors to correct the problem

Phase: Improvement of the complexity relevant problem

- Development and agree solution scenarios for the root cause of the problem
- Allocate clear responsibilities
- Design communication and change plan
- Piloting and evaluation of the solution, with taking into account the customer's requirements
- Documented of the solution in detail
- Implementation and enforcing solution Rollout

Phase: Control

- Completion of the measure
- Final evaluation of the measure, for a period to be agreed
- Documentation of the experiences and evaluation for knowledge management

The identified measures are presented in a list of measures.

6 INSTRUMENTS OF COMPLEXITY MANAGEMENTS

6.1 ComMC (Complexity Management Criteria)

6.1.1 Objective

The purpose of development and agreement of "Complexity Management Criteria" is to achieve a common between < Customer > and < Service provider > understanding about, success-critical complexity relevant criteria. These criteria are the basis for further instruments of complexity management.

6.1.2 Procedure

In the context of contract negotiations, the first version of the criteria was jointly developed. The "Complexity Management Board" initiated potentially necessary and appropriate adjustments. Due to the further processing of the criteria of the update cycle is limited to a year. Changes are bilaterally prepared and agreed. To ensure clarity and ease of handling, is the number of criteria, per party, is limited to 20.

Furthermore, each criterion supplemented with a weighting factor.

6.1.3 Responsibilities

The responsibility for the ongoing maintenance of the "Complexity Management Criteria" incumbent on, together members of the "Complexity Management Board".

6.1.4 Result & Evaluation

The result is an agreed "Complexity Management Criteria". The "Complexity Management Board" rated (during the balance-year) the criteria. If necessary, adjustments are made for the coming six months-balance.

6.1.5 Measures derivation

Direct measures are not derived from the "Complexity Management Criteria". If necessary, the criteria will be adjusted up to 2 times per year.

6.1.6 Documentation

The documentation of the "Complexity Management Criteria" is carried out using a standard office software.

6.2 ComMBSCB (Complexity Management Balance Scorecard Balance)

6.2.1 Objective

The aim of the "Complexity Management Balanced Scorecard Balance" is to be able to carry a semi-annual evaluation of the complexities in the cooperation relationship between < Customer > and < Service provider > on a top level.

6.2.2 Procedure

The contents of the "Complexity Management Balanced Scorecard Balance" are derived from the results of the "Balance Scorecard Complexity Management". To create the "Complexity Management Balanced Scorecard Balance" these individual results are weighted again separated to allow a required strategic view.

Changes in "Complexity Management Balanced Scorecard Balance" (including the methods and weighting factors) are coordinated within the "Complexity Management Board" between < Customer > and < Service provider >. The "Complexity Management Balanced Scorecard Balance" is created in a 12 monthly cycle. Values for which no updated monthly value exists, be used with the

value of previous reports, in case of new measurement criteria, the same value is-sets how the current value is.

6.2.3 Responsibilities

The < Service provider > is responsible to create the "Complexity Management Balanced Scorecard Balance". The vote and evaluation take place within the control activities by the "Complexity Management Board".

6.2.4 Result & evaluation

The "Complexity Management Balanced Scorecard Balance" is presented within the regulation dates of the "Complexity Management Board" by the < Service provider >. Together, the results of evaluation dimensions are interpreted and evaluated.

6.2.5 Measures derivation

The derived from the valuation of "Complexity Management Balanced Scorecard Balance" measures aimed at improving the respective dimensions of evaluation. The measures will be included in the action list.

6.2.6 Documentation

The documentation of the "Complexity Management Balanced Scorecard Balance" is carried out using a standard office software.

6.3 ComMBSC (Complexity Management Balance Scorecard)

6.3.1 Objective

For objective complexity measure progress of the project and the performance of the < Service provider >, the < Service provider > uses a "Complexity Management Balanced Scorecard". This "Complexity Management Balanced Scorecard" is the basis for the "Complexity Management Balanced Scorecard Balance".

6.3.2 Procedure

The results of individual "Complexity Management Criteria" are recorded each month by a person in charge of the < Service provider >, then multiplied by agreed weighting factors and presented consolidated in a "Complexity Management Balanced Scorecard". The dimensions include the following "Complexity Management Criteria":

- Learning & Growth Perspective: Maturation of working with complexity in the Business relationship
- Business Process Perspective
- Customer Perspective
- Financial Perspective

6.3.3 Responsibilities

The "Complexity Management Balanced Scorecard" is presented to the participants in the monthly "Complexity Management Board" date from < Service provider >. Preliminary, the < Service provider > analyzes potential cause of discrepancies between target and actual values. The more content analysis and evaluation is carried out together (when required) by the parties involved.

6.3.4 Result & evaluation

The further result analysis and evaluation is usually carried out in the appointment of "Complexity Management Board" committee.

6.3.5 Measures derivation

The prioritized measures are represented by < Service provider > in "Complexity Management Balanced Scorecard" and "Complexity Management Measures list". Complexity relevant measures concerning the < Customer > and < service provider > be jointly coordinated and tracked from the "Complexity Management Board".

6.3.6 Documentation

The documentation of the "Complexity Management Balanced Scorecard" is carried out using a standard office software.

6.4 ComMMeasures list (Complexity Management Measures list)

6.4.1 Objective

The aim of the measures list is to make the identified measures transparent regarding progress and effectiveness and to track the implementation.

6.4.2 Procedure

The < Service provider > creates and maintains a consolidated list of measures and take over all complexity related measures in this list, in the context of the progress of the project and the provision of services (the framework agreement §< ... >), which be placed to optimize performance or to eliminate deficits. There are all measures to categorize included in the list of measures, which were identified from < Service provider > for the above formulated purpose:

- From < Customer > and < Service provider > within the Complexity Improvement Process (ComIP) itself,
- From the "Complexity Management Board"
- From other joint boards of < Customer > and < Service provider >, for example Quality Management Meeting and
- As a result, from audits of the Revision and other management reviews.

The measures list is supplemented by statistical analysis options, which gives a quick overview about the status of the picked up measures. The updated list of measures is part of the provided documents by the < Service provider > for the respective "Complexity Management Board".

6.4.3 Responsibilities

The preparation and evaluation of the measures list is the responsibility of the < Service provider >. The list of measures, as well as the results of the evaluation will be presented to all participants in the monthly "Complexity Management Board" appointment and discussed.

6.4.4 Result & evaluation

The result analysis and evaluation of transparency reached concerning progress, effectiveness of the measures and their mutual dependencies and interactions, takes place in the schedule of the "Complexity Management Board" committee.

6.4.5 Measures derivation

In case that deviations can be identified regarding progress and effectiveness, corrective measures from the "Complexity Management Board" will be initiated. Concrete project and service improvements are communicated to the relevant stakeholders.

6.4.6 Documentation

The list of measures is documented as part of the documentation "Complexity Management Board" in electronically editable form and archived. This documentation is provided using a standard office software.

6.5 ComMCom (Complexity Management Communication)

6.5.1 Objective

The aim of the communication concept is to inform constantly the stakeholders from < Customer > and < Service provider > about complexity aspects and significant developments. Furthermore, through a targeted and effective communications about complexity all relevant stakeholders will be sensitized and thus indirectly the Stakeholder supports objectives of complexity management.

6.5.2 Procedure

It will be agreed various communications media between the parties of the "Complexity Management Boards". Specifically, these media are the following:

- Complexity newsletter in paper form (twice a year)
- E-mail distribution (about four to six times per year)
- Special measures by agreement

Following represented, the key process steps for creating the communication activities are:

1. Identification of content:
- Recording complexity relevant topics and articles in a topics storage:
- The initiation can be started from < Customer > and < Service provider >.
- A preliminary decision whether proposed theme is complexity relevant.
2. Editing:
- Selection of topics and articles that should appear in the respective medium
- Editorial content preparation and creation of a draft
3. Releasing:
- Approval process of < Customer > and < Service provider >
- Incorporating necessary amendments to the draft during the approval and release processes
4. Production:
- Create the final version for publication
- Final approval of the < Customer > and < Service provider >
5. Distribution:
- Information on the defined stakeholders about the release date
- Distribution and activation of the communication measure

6.5.3 Responsibilities

The < Service provider > is responsible for carrying out the method described.

6.5.4 Result & evaluation

The results are published in form of each communication activities. Feedback from recipients of < Customer > and < Service provider > is evaluated together in "Complexity Management Board".

6.5.5 Measures derivation

In the configuration of the communication concept in operation, the < Service provider > is strives in coordination with the < Customer > to make (depending on the scope and priority) always an optimal choice of topics content suitable. In addition to the published communications media itself, also topics from the topic storage is managed and documented by < Service provider >.

6.5.6 Documentation

The communication activities list is documented for traceability and archived. This documentation is provided using a standard office software.

6.6 ComMStA (Complexity Management Stakeholder Analysis)

6.6.1 Objective

The aim of this method is to integrate the stakeholders of < Customer > and < Service provider >, suited in the project and the ongoing operation of the service provision by the < Service provider >. This is to ensure that stakeholders support the objective of Complexity management and on the other hand, that the complexity management takes into account the interests of stakeholders and adequately supported.

6.6.2 Procedure

Initial, < Customer > and < Service provider > create a complexity relevant stakeholder analysis. Stakeholder analysis is permanently maintained.

6.6.3 Responsibilities

Each participating organization is responsible for naming of the relevant stakeholders. The maintenance of stakeholder analysis is performed from < Service provider >.

6.6.4 Result & evaluation

The result of the analysis is a current stakeholder representation. The cycle is for the adaptation and modification takes place at least every 6 months. The assessment of the timeliness and assessing whether the stakeholders will be integrated into the appropriate dimensions is carried out jointly between < Customer > and < Service provider >.

6.6.5 Measures derivation

Based on the joint evaluation, concrete measures are derived; these will be included in the list of measures and conducted himself responsible.

6.6.6 Documentation

The stakeholder representation is documented as part of the documentation "Complexity Management Board" in electronically editable form and archived. This documentation is provided using a standard office software.

6.7 ComMAR (Complexity Management Audits & Review)

The regulation described here supplement the regulation of the Framework Agreement, specifically § < ... > and regulation § < ... > about audit.

6.7.1 Objective

The < Customer > is entitled to carry out tests to what extent the Supplementary Agreement §< ... > is done operationally from < Service provider >.

The objective of these tests is to analyze the current state, and if necessary the derivation of recommendations to improve the current state.

Included in the examination, can be among other things:

- Evaluation of the entire complexity management system < Service provider >,
- Timeliness of the role descriptions, internal training requirements and documentation relating to complexity management,
- Procedures and processes, that are needed to provide the complexity management for < Customer >, and
- Evaluation, whether the agreed measures are covered sufficiently with the ongoing projects and the FMO operation.

6.7.2 Procedure

Tests in the framework of this agreement, are divided into audits and reviews. Audits are carried out by officially authorized persons (auditors of the revision of < Customer > and regulated in the flow as follows:

- Audits are usually, either as part of the audit year plan of the < Customer > revision, which is received by the < Service provider > at the latest by the beginning, for information, or in individual cases to follow and identify its origin after a highly critical disruption in the environment of the < Customer >.
- The examiner will announce the conducting of the audits with a lead time of at least ten (10) working days to < Service provider >, any examination will carry out, only to the general business hours of < Service provider > and do not interfere the operation of the < Service provider >.
- The unit of < Service provider > to be examined will grant appropriate access to persons and premises used, and the areas under its control information, documents, data and media lend insight.
- The < Service provider > deliver to the auditor such information, documents and data for confidential use and processing. A transfer of information, documents and data, and within the Organization of < Customer > is not permitted and possible only in exceptional cases with the explicit consent of < Service provider >.
- The test unit of < Customer > informs the < Service provider > after completion of the test on the test result.

- Recommendations from the report is of the < Service provider > check on implementation and take into account in the Continuous Improvement process (CIP).

Reviews can be scheduled in addition to the described audit tests; these reviews are generally used:

- Identify the causes of the deviation of the contractually agreed performance
- Analyze the causes of not reaching project milestones, or non-achievement of guaranteed performance levels in FMO line operation and display.
- Derive measures remedy the complexity related causes or error
- Early identification of suitable optimization potentials
- Identifying potential complexity relevant risks

Reviews are controlled in sequence as follows:

- For performance of reviews, the < Customer > informed the < Service provider >, who is nominated for carry out the review. Complexity-relevant findings and recommendations will be providing in a written report to the participants of the "Complexity Management Board".
- The unit of < Service provider > to be examined will grant appropriate access to persons and premises used, and the areas under its control information, documents, data and media lend insight.
- The < Service provider > deliver to the reviewer such information, documents and data for confidential use and processing. A transfer of information, documents and data, and within the Organization of < Customer > is not permitted and possible only in exceptional cases with the explicit consent of < Service Provider >.
- Recommendations from the report is of the < Service provider > check on implementation and take into account in the Continuous Improvement process (CIP).

6.7.3 Responsibilities

The responsibilities arising from the above description of the review process: Audit and Review. The test report shall be kept confidential between < Customer > and < Service provider >.

6.7.4 Result & evaluation

The results from a test results, reviews and any recommendations for improvement are being held by the examiner or by the audit team in a written report.

6.7.5 Measures derivation

Recommendations from the report, the < Service provider > will check the feasibility and will take over this in the continuous improvement process (CIP) with parallel recording in the measures list.

6.7.6 Documentation

The results and the resulting measures are stored in the appropriate standard document repositories of the parties involved and archived. The retention period is ten (10) years; additional requirements do not exist.

7 ORGANISATION OF „COMPLEXITY MANAGEMENT BOARD"

7.1 Objective and purpose

For the purpose of institutionalizing a partner overarching continuous improvement of the cooperation, the "Complexity Management Board" monitors all "Complexity Management Board" rated ensuring and development of agreed policy complexity and complexity objectives. This is done in addition to the framework agreement < ... >. The basis is the present Agreement Complexity in Annex < ... >. The "Complexity Management Board" is established as a regulating committee.

Objectives are:

- The creation of the basis for the preservation and continuous improvement in the management from complexities
- The creation of transparency regarding complexities
- ensuring target group-oriented communication

7.2 Order and delimitation

The "Complexity Management Board":

- Monitors and analyses the current status of complexity based on the agreed methods, techniques and procedures
- Monitors (high-level) implementation for this patch measures or initiates its own overarching measures to improve the controllability from complexities
- Carry out an assessment of the effectiveness of implemented measures
- Provides an escalation platform for other committees under the cooperation between < Customer > and < Service provider > relative complexity relevant issues.
- grants permission complexity relevant structure and content of planned communications measure in the organization of the < Customer >
- Responsible for the development of the Complexity Agreement.

Important tools for the implementation of this contract are the instruments of the control complexity, which are written in of this agreement. In principle, the instruments are provided from < Service provider > and analyzed and assessed together in "Complexity Management Board". The development and modification of the instruments are aligned and decided in "Complexity Management Board".

7.3 Delimitation

The "Complexity Management Board" does not on their own responsibility to implement the measures. The implementation is up to the established line organizations of the cooperation. Exceptions may be individual, defined by the "Complexity Management Board" himself complexity specific measures.

7.4 Organisation of the committee

The "Complexity Management Board" shall be composed of representatives from various areas of < Customer > and < Service provider >. For this purpose, each party nominates permanent leaders and representatives. All parties may, if necessary individual temporary contact, without prior consultation, call for specialized topics. The management, moderation and writing minutes of the regular meetings of the "Complexity Management Board" leads by the < Service provider >.

7.4.1 Regularly communication

The regulating communication between the parties will take place with the meetings of the "Complexity Management Board". In Annex < ... > of this agreement, the contact details of the permanent contact person listed. Taking care of the contact list incumbent on jointly the "Complexity Management Board".

7.4.2 Ordinary meeting structure

The "Complexity Management Board" meets usually once per calendar month (regular session). The agenda shall be agreed between the parties at least two (2) working days before the meeting of the "Complexity Management Board" and do the final version together with the agreed instruments the permanent members accessible.

7.4.3 Documentation and taking minutes

Each meeting of the "Complexity Management Board" is documented and provided, no later than five (5) working days, to the permanent members of the "Complexity Management Board".

7.4.4 Objection deadlines for decisions

Any decision of the "Complexity Management Board" can be inserted, through a permanent participant, objection. The appeal must be in written form and latest five (5) working days after the protocol, delivered at all designated permanent contact.

7.4.5 Decision making and voting rules

The vote "Complexity Management Board" passed unanimously by the parties. Each party regulates the internal procedure for decision-making himself. The communication of "Complexity Management Board" designated contact person here are representative of each party.

7.4.6 Extraordinary session

If necessary, an extraordinary meeting of "Complexity Management Board" may be convened after consultation of the designated permanent members of the "Complexity Management Board". Depending on the topic, not all permanent "Complexity Management Board" members participate in an extraordinary meeting. However, at least one member from < Customer > and < Service provider > must be represented. About the outcome of the extraordinary meeting, is reported at the latest at the next ordinary Complexity Management Board meeting.

7.4.7 Escalation procedures

Issues that cannot be resolved between the parties "Complexity Management Board" can be presented to the committee < ... > for decision.

Annex 10 – Definitions of EPM core components (Rocha, 2014)

Rocha describes the core components and the framework, which are necessary for the implementation of project governance (Rocha, 2014).

Components	Scope
Strategic Alignment	The responsibility of the EPG is to ensure that the projects are in line with corporate strategies and objectives and that the project is implemented effectively and productively.
Risk Management	Risk management is a systematic process of identifying and assessing business risks and taking action to protect a company. Companies need risk management to carry out a review of possible risks and to avoid incurring losses (due to avoidable errors).
Portfolio management	The portfolio provides a big-picture view. As projects and programmes are engines of value creation, portfolio offers the connection between strategy and execution with clarity about the dangers involved. It facilitates the appropriate sort, adds and removes projects from the entire scope.
Organization	An effective EPG assumes that the leading people to be organized and their contributions are modelled. An appropriate organizational structure, roles and responsibilities are required for all participants.
Stakeholder Engagement	In every company, different parties and interest groups exist, therefore, there are also different expected results from the project stakeholders. There is a communal social need that the company's activities are transparent to make organizational and project decisions comprehensible. For this reason, the analysis of the impact of projects on the social community through a stakeholder engagement plan must be designed, considering external and internal stakeholders.
Performance Evaluation	To achieve an effective project portfolio for EPG, the overall performance of the project is to periodically measure and monitor. This serves as a basis to ensure that the business objectives are consistent with the changing environment during the project.
Business Transformation	Effective business transformation requires a continuous process established to enable the company to implement business strategies to achieve its vision. This requirement is entered into at any time, because vision and strategy must constantly adapt depending on the development of economic influences. Business agility, or the ability to achieve business transformation, is a measure of management and business success and as such essential in the monitoring of the EPG.

Annex 11 – Definitions of complexity drivers (Schoenberg, 2014)

Complexity Drivers		
View	**Cluster**	**Criteria**
External complexity drivers	Society complexity	– Changing values – Environmental awareness – Economic and environmental factors – Political framework
	Demand complexity	– Diversity of customer requirements – Individuality of the demand – Market dynamics – Global requirements
	Competition complexity	– Number of strength of competitors – Changing markets – Competitive dynamics – Globalization
	Procurement complexity	– Number of suppliers – Procurement strategy and concept – Fluctuations in demand – Uncertainty of the delivery or quality
Internal complexity drivers	Target complexity	– Number of tracked targets in parallel – Dynamics of the target adjustment – Maturity of goal achievement
	Costumer structure complexity	– Number of customers and customer groups – Heterogeneity of customers and customer groups – Level of participation
	Product and product programme complexity	– Structure of products – Product and version number – Dynamics of the product changes
	Technology complexity	– Technological change – Availability (innovative) technologies – Technology lifecycle
	Process complexity	– Number of interfaces and design – Degree of crosslinking of the processes – Degree of standardization
	Organization complexity	– Number of hierarchy levels – Degree of centralization – Number of organizational units
	Structure complexity	– Number of distribution levels – Number of stock, staff, equipment, ... – Communication systems – Vertical integration
	Planning and steering complexity	– Communication systems – Frequency and level of detail of the management and control area

Annex 12 – Result of the analysis of the complexity driver for large-scale projects (own table)

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
Society complexity	Changing values	Description of the social change of values that may affect the business.	2	Changes in the values of a society have an indirect impact on a business relationship; since the consideration in this research is an existing business relationship, which is based on a contractual agreement, the relevance is rather rated as minor.
	Environmental awareness	An awareness supports to recognize trends and social environments; thus, the business parties can prepare quickly to a changing environment.	2	Due to the fact that the basis for the project is an existing contractual relationship between the parties, this criterion will be assessed as low (only indirect effect).
	Economic and environmental factors	Economic and environmental factors can develop influence on existing contractual relationships.	3	Due to a variety of potential factors, that criterion is rated higher than the other criteria of these dimension; concrete examples can be, among others: developments concerning the wages of employees, economic fluctuations and extraordinary market developments in relevant areas, which are caused by society.
	Political framework	The political environment can have an impact on a business relationship or project.	2	It is assessed that political factors can indeed have an impact on the contractual relationship, however, this may take rather less on the complexity of the contractual relationship or the effects are more concerned with individual cases, such as a new taxation method.
Demand complexity	Diversity of customer requirements	The diversity of customer requirements may have an impact on the complexity.	5	The impact of the "diversity of customer requirements" is rated very high, because the requirements must be implemented at the organizational interface and also designed, implemented and secured during operation from the service provider (directly and large degree).
	Individua-lity of the demand	"Individuality of customer requirements" may have an impact on the complexity.	5	The impact of the "individuality of customer requirements" is very highly rated, as a variety of stakeholders is involved in a wholesale environment (from all participating units).

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
	Market dynamics	A market dynamic can (as an external factor) have an impact on the customer and the service provider and hence on the complexity of the contractual relationship.	3	Market dynamics can affect, on different ways, all contractors indirectly, potentially heavily on the contractual relationship; for example: differentiation and individualization of agreed services.
	Global require-ments	"Global Requirements" may cause a complexity-relevant impact on the business relationship.	2	Comparable to the criterion of "political framework", these factors will be assessed mainly indirect-effecting or rated as rather country-individual relevant.
Competition complexity	Degree of strength of competitors	The strength of the influence of competitors can have an impact on the complexity of the contractors.	2	The strength of competition is rather low and there is an immediate impact on the outsourcing project. Both parties have agreed on an outsourcing contract, which is the basis for the subsequent project. The competition will continue to try to convince the customer of their services; this then affects the project (and on a low level the complexity).
	Changing markets	Changes in the market, in which the partners may have an impact on the complexity of the joint project.	2	Changes in the market have an indirect effect on the business relationship. The basis of the relationship is the agreed IT outsourcing contract. The effect to the complexity is therefore rather weak; medium impact or long term mainly.
	Competitive dynamics	The dynamics of the competitors in the market, in which the parties are acting, can have an impact on the complexity of the project.	2	The dynamics of the market can have an indirect effect on the complexity of the project; basis of the project is the contract signed between the parties.
	Globali-zation	The development of globalization can influence the complexity of the project.	2	Globalization may indirectly have a medium and long-term (only), impact on the complexity.

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
Procurement complexity	Number of suppliers	The number of participating suppliers can have an influence on the complexity of the project.	4	The number of supplier has a great influence on the complexity of the contract, since the individual suppliers have their own process and IT systems at the customer interface.
	Procurement strategy and concept	The Procurement approach and strategy of the client can have an impact on the complexity of the project.	5	The sourcing strategy and the procurement concept of the customer has a significant impact on the complexity of the contract and the implementation in the project phase, as many aspects of complexity may be included.
	Fluctuations in demand	The fluctuation or the stability of the customer requirements can have an impact on the complexity of the project.	5	Fluctuation or stability of demands is a very important factor in the complexity of implementing contractually agreed services in the project.
	Uncertainty of the delivery or quality	Uncertainties in the delivery model of the customer and the service providers can have an impact on the complexity of the project.	5	Uncertainties can strongly influence the complexity of the project (mainly negatively). In extreme cases, occurring uncertainties could lead to chaos-like conditions.
Target complexity	Number of tracked targets in parallel	The number of parallel (or competing compliant) objectives of the project can affect the complexity of the project.	4	The influence of this criterion is very strong, but also depending on whether the objectives pursued are in compliance or competitive.
	Dynamics of the target adjustment	The frequency and rate of change of set targets of the project may have an impact on the complexity of the project.	5	The "dynamics of the target adjustment" has a very big influence on the complexity of the project, as all measures and activities are aligned to the project objectives; negative consequences, for example: parallel and interim solutions.
	Maturity of target achievement	The maturity of the objectives of the project may have an impact on the complexity of the project.	2	The maturity level of target achievement has little influence on the complexity itself, in the project.

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
Costumer structure complexity	Number of customers and customer groups	The number of customers of the customer and the service provider can have an impact on the complexity of the project.	2	The number of customers and customer groups alone is only partially relevant for the complexity.
	Heterogeneity of customers and customer groups	The heterogeneity of customers and customer groups of the customer and service provider can have an impact on the complexity of the project.	3	The heterogeneity has an extremely strong and direct impact on the complexity of the project. A low level of heterogeneity means numerous agreements, various process and IT-system landscapes and a variety of customized procedures.
	Level of participation	The degree of integration in the respective customer relationship between the customer and the service provider may have an impact on the complexity of the project.	4	In outsourcing projects, there is naturally a high degree of integration and teeth, since various organizational units move from customer to Service provider. This circumstance has a strong degree of complexity result directly and immediately.
Product and product program complexity	Structure of products	The structure of the contract and defined products and services between the customer and the service provider can have an impact on the complexity of the project.	4	The structure of the product greatly influences the complexity of service delivery; concrete examples are the hierarchical levels and the options.
	Product and version number	Dealing with the contractually agreed and defined products and services (in the version levels) between the customer and the service provider may have an impact on the complexity of the project.	2	Dealing with Product Versioning can affect the complexity, if the requirement is to keep parallel version stands currently in the service catalogue.

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
	Dynamics of the product changes	The dynamics and the release cycles of the current product and service portfolio between customer and the service provider can have an impact on the complexity of the project.	3	The dynamics of product changes may have a greater impact on the complexity; in concrete terms, the degree of complexity depends on the degree of dynamics and the steering logic of product management.
Technology complexity	Technological change	The technology development and the characteristics of the technological change of the current product and service portfolio between customer and the service provider can have an impact on the complexity of the project.	2	Technology changes are only indirectly complexity relevant, because the basis for the project is the agreed service catalogue. Technology changes will first be defined as a product.
	Availability (innovative) technologies	The availability of new and innovative technologies, regarding the current product and service portfolio between customer and service provider, can have an impact on the complexity of the project.	2	The availability (innovative) technologies are only indirectly complexity relevant, because the basis for the project is the agreed service catalogue. Technology changes will first be defined as a product.
	Technology lifecycle	The technology lifecycle, regarding the current product and service portfolio between customer and the service provider, can have an impact on the complexity of the project.	2	The technology lifecycle could be complexity relevant, because the basis for the project is the agreed service catalogue. Technology changes will first be defined as a product.

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
Process complexity	Number of interfaces and design	The number of needed and established interfaces and design of between customer and service provider can have an impact on the complexity of the project.	5	The number of interfaces and design are massively complexity relevant, because of increasing the network density and a significant increase in the dependency of various functions and parts of the project.
	Degree of crosslinking of the processes	The extent and characteristic of linking processes can have an impact on the complexity of the project and the business operation.	5	The level of "degree of crosslinking of the processes" increases or decreases compliant to the development of complexity.
	Degree of standardization	The degree of standardization (as a target and the current state) can have an impact on the complexity of the project and the business operation.	5	The degree of standardization has an immediate and direct impact on the development of complexity.
Organization complexity	Number of hierarchy levels	The number of hierarchy levels can have an impact on the implementation of the project and its complexity forms.	5	The number of hierarchy levels has an immediate and direct impact on the development of the complexity of the project, because of the fact that all instruments and methods in the project must be established in all levels.
	Degree of centralization	The degree of centralization (in an organizational perspective) can have an impact on the complexity of the project execution activities.	5	The degree of centralization has an immediate, direct and very big impact on the development of the complexity of the project.
	Number of organizational units	The number of organizational units of the involved organizational units can have an impact on the complexity of the project and the business operation.	4	The number of organizational units could have a direct and strong impact on the complexity of the project, because of the fact that all instruments and methods in the project must be established in all organizational units.

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
Structure complexity	Number of distribution levels	The number of organizational levels of the involved organizational units can have an impact on the complexity of the project and the business operation.	4	The number of distribution levels could be a direct and strong impact to the complexity of the project, because of the fact that all instruments and methods in the project must be established in all organizational units.
	Number of stock, staff, equipment, ...	The number of technical, organizational / personnel and commercial assets, can have an impact on the complexity of the project and the business operation.	5	The number of technical, organizational / personnel and commercial assets could be a mainly indirect but big impact on the complexity of the project, because of the fact that all instruments and methods in the project must be implemented in the organizational structure.
	Communication systems	The number and characteristics of necessary and established communication systems can have an impact on the complexity of the project and the business operation.	4	The communication system is an important management tool in outsourcing projects. This is confirmed by numerous references of theory and practice. Targeted communication measures can ensure a uniform level of knowledge in the project, thus reducing avoidable complexity.
	Vertical integration	The organizational structure and vertical integration of the line organization (of customer and service provider) to the project can have an impact on the complexity of the project and the business operation of each part.	5	The vertical integration of the organizations involved is of great importance regarding the complexity in the project, because of managing the necessary task, responsibilities in the line organization and project structure.
Planning and steering complexity	Communication systems	The communication systems as a planning and steering instrument can have an impact on the complexity of the project and the Business operation.	2	The communication system as a management tool for "planning and steering" may affect the complexity, however, more indirectly and supportive.

Step 1: Preparation of the complexity criteria for this research				
Cluster	Criteria	Definition and interpretation	rf	Arguments for evaluation the relevance factor
	Frequency and level of detail of the management and control area	The frequency and characteristics of project steering and management (e.g. level of detail of the management) with the different management instruments can have an impact on the complexity of the project.	3	The frequency and character properties of the management and steering level could be very important for the complexity in the project. On one hand, the management layer can support to manage the complexity; on the other hand, the steering logic could create complexity from itself.

Source: own text

Annex 13 – Order to cash – simulated, customer specific example, on process level 5 (own graphic)