Organization and Governance of Business Rules Management Capabilities

Koen Smit

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Preface

During my undergraduate programme Business Informatics at the HU University of Applied Sciences Utrecht I first learned about the Business Rules Management domain, being part of a research specialization under the supervision of Martijn Zoet. Soon after graduating, I got a call from Martijn to ask whether I wanted to have a job as a research assistant to support the end stages of his Ph.D. research project, which focused on methods and concepts for Business Rules Management.

In the following two and a half year I followed the Master programme Business Informatics, but was also engaged in lecturing undergraduates at the HU University of Applied Sciences Utrecht, while also participating in several research projects and publications of papers, under guidance of Martijn Zoet. These were challenging times as my work-life balance was permanently in favor of work. However, this enabled me to make large steps, learning a lot of important things. Related to this, I remember my main supervisor Johan Versendaal saying to me: "*Here you will grow up quickly.*" A year later, Johan and I had a meeting during the Bled eConference in Slovenia where he asked me if I would be interested in starting a Ph.D. on Business Rules Management after I finished my master's programme. During the end of this period, I finished my master's with a yearlong research project on modifiability of business rules architectures, which was also the trigger to write down a research proposal for the coming years.

Getting my approval to start with my Ph.D. research project was a long and tiresome road to take, but after a full year we finally were ready to start the real journey. During this journey, I met countless people that contributed in some way or another. However, there are some people that I want to specifically thank here.

Two people were very important for the success of this journey. First, I would like to thank my main supervisor Johan Versendaal for getting me into this position in the first place, but also for his diplomatic interventions, enthusiastic support, and expert advice and reviews during my studies. As a Ph.D. student, Johan always reserved time for me and was available when I needed him. Secondly, I would like to thank my daily supervisor Martijn Zoet for keeping up with me and guiding me through my journey, without him I surely would not have come this far. Martijn and I discussed for countless hours during the evenings and weekends to deliver research work on time. His devotion and enthusiasm increased my motivation when we had setbacks along the way. I would also like to thank Raymond Slot and Marlies van Steenbergen for their contribution regarding the Enterprise Architecture perspective.

Also, my general appreciation goes out to everybody at the HU University of Applied Sciences Utrecht for supporting me and making this Ph.D. project possible and achievable. Especially, I would like to thank my (former) colleagues Matthijs Berkhout, Adri Köhler, Sam Leewis, Ruben Post, Matthijs Smakman, Nini Salet and Gerritjan Boshuizen for supporting me and listening to me when I had business to complain or discuss about. Furthermore, I would like to thank everyone from the Dutch government agencies that participated in our research studies. Thank you for your cooperation and valuable time while contributing to the various research studies conducted as part of this journey! I would also like to thank the numerous students from different universities that participated in my research studies, without them I would still be collecting data or writing papers.

Furthermore, I would like to express my gratitude towards the reading committee, prof. Ronald Batenburg, prof. Hans Mulder, prof. Remko Helms, prof. Stef Joosten, and prof. Rob Kusters for their dedication during the finalization stage of my Ph.D. Also, I would like to express my thanks to the anonymous reviewers that provided me with invaluable feedback on my research papers in the past years. Related to this, I would also like to thank all the various co-authors of these research papers.

Of course, finishing my Ph.D. project and writing this thesis was impossible to achieve without the encouragement and blessing of my family and friends, losing some friends during the past years was sometimes hard, but also resulted in the creation of new friendships. Many thanks go to my parents, Hans Smit and Anita Smit, and my brother, Bas Smit. My parents always provided me with everything needed for getting the best out of me during my studies. Although it was sometimes hard to understand what I was exactly researching, they always were interested in my achievements. Furthermore, I would like to thank my girlfriend, Sharon van der Linden as well as Ollie an Sammy for supporting me through the years and putting up with the weird schedules and the days, even holidays, during which I was speaking at conferences over the world. Lastly, I would also like to express my gratitude towards a very good friend, Joris Mens. Joris and I know each other for a long time and have studied, graduated from three programmes (college, under-graduate, and graduate) and worked together intensively in the past years. I learned a lot from him during the time we were collaborating, but also when meeting in our spare time for a good laugh.

Contents

1 INTRODUCTION

In the previous decades, the amount of digitization of products and services, has increased significantly. These products and services increasingly add value for humans in their work and private lives. An example of a product could be a high-tech toothbrush that captures and analyzes brushing behavior so that suggestions can be given to improve dental health. An example of a (digital) service is a bank that offers an online pre-scan to determine whether a potential customer is eligible for different types of mortgage products.

To design and develop such (digital) products and services, organizations need to take into account compliance along with several other factors. Managing compliance includes an organization being capable of ensuring its (digital) products and services are based on the relevant legal sources. Analysis of organizations that are responsible for (digital) products and services shows that organizations are successful in this; at the same time they also struggle to maintain compliance, which shows that there are still challenges to overcome (Breaux, 2009; Daniel et al., 2009; Zoet, Welke, Versendaal, & Ravesteyn, 2009).

Compliance in organizations can be supported by procedures, protocols and Information Systems (IS). For IS, compliance can be achieved by separating the concern of business logic from other concerns, such as the application source code, business processes, and the business' underlying data and data models (Dijkstra, 1974; Ossher & Tarr, 2001; Tarr, Ossher, Harrison, & Sutton, 1999). In theory and practice, see for example the Decision Model and Notation standard (Object Management Group, 2016b), business logic is often associated with a decision. To give meaning to the general term 'decision', a definition by the Object Management Group (OMG) is provided: "*A conclusion that a business arrives at through business logic and which the business is interested in managing*" (Object Management Group, 2016a). To be able to make a decision, business logic is executed by a human, a machine or a combination of both. Business logic can be defined as: "*A collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016b). Separating business logic from the other concerns is in line with earlier conclusions provided by Boyer & Mili, (2011), Graham, (2007), Morgan, (2002), Zoet, (2014). One approach that addresses the separation of business logic from other concerns is Business Rules Management (BRM) (Zoet, 2014). BRM can be defined as a systematic and controlled approach that supports the capabilities 'elicitation', 'design', 'specification', 'verification', 'validation', 'deployment', 'execution', 'evaluation' and 'governance' of business rules (Boyer & Mili, 2011;

Morgan, 2002; Schlosser, Baghi, Otto, & Oesterle, 2014; Zoet, 2014), see Figure 1-1. In this context, a capability is defined as: "*an ability that an organization, person, or system, possesses*" (The Open Group, 2011). How a capability is realized by an organization depends on the situation in that specific organization, i.e. what technology or tooling is available, the maturity of the available technology, the available knowledge, and the available resources.

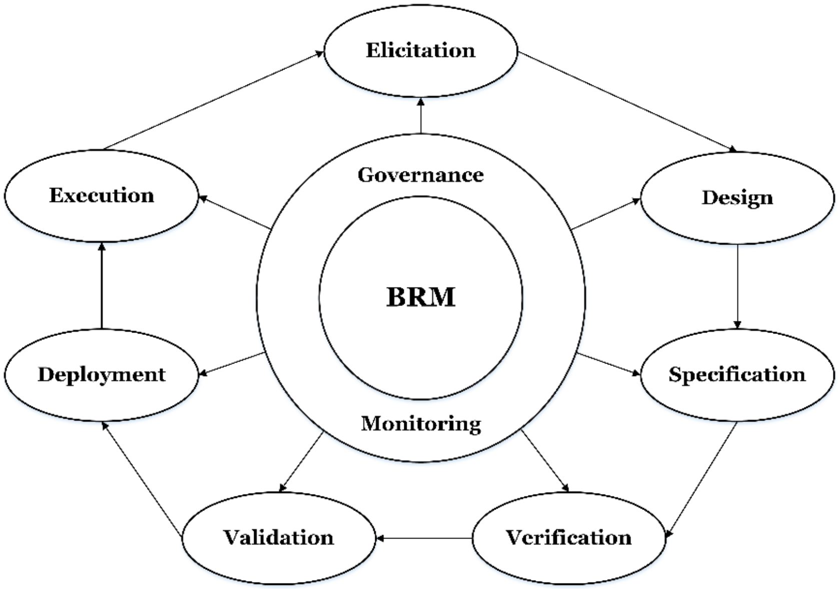

Figure 1-1. Business Rules Management Capabilities

Organizations that implement these BRM capabilities encounter various challenges while doing so. To adequately identify and analyze these challenges, it is important to give meaning to the different IS aspects which affect the implementation of BRM capabilities. This thesis further explores these challenges by first detailing the research motivations, research questions, research approach, and by elaborating on the studies executed.

One type of organization in which an increasing number of BRM implementations occur are governmental institutions. These organizations deliver public administration services which are specified in laws and regulations. Based on the laws and regulations, the business processes, and decisions (that are executed) and the data (that is registered to deliver a particular service) are restricted. As laws and regulations change constantly, for example, due to societal developments, the public administration services also need to change. The research presented in this thesis is conducted in the context of the Dutch Governmental domain. The Dutch governmental domain offers an excellent opportunity to conduct exploratory research due to several reasons. First, governmental institutions utilize automatic decision-making using business decisions and business logic to handle the large amount of service requests for the large variety of services they deliver. Second, governmental institutions need to be 100% compliant and need to be able to provide evidence that their products and services do so, else, governmental institutions do not lead by example.

1.1 Motivation

Societal and business triggers

As elaborated below, in practice we see that:

- BRM-tooling, like BRMS, is still immature;
- Collaboration between BRMS vendors is lacking;
- There is limited knowledge on how to apply BRM in practice.

As a consequence:

- Organizations do not strategically and structurally embed BRM;
- Rather few successful implementations of BRM-Systems (BRMS) are known.

BRM-tooling, like BRMS, is still immature; Collaboration between BRMS vendors is lacking

Supported or automated decision-making is often implemented and maintained by software referred to as Business Rules Management Systems (BRMS) (Liao, 2004). Regarding the BRMS market, we observe little progression amongst vendors. Many of them seem to specialize on building software to support one or a limited collection of BRM capabilities (often limited to the elicitation, design, specification, verification, and validation capabilities or solely the execution capability, see Figure 1-1). We observe that a lot of BRMS seem to lack the functionality to properly support the governance of business logic throughout the whole lifecycle, from legal source to implemented product or service. This is also reflected in the BRM and Decision Management Landscape published by Zoet (2016) that demonstrates the lack of BRMS supporting an integral BRM solution. One could argue that this promotes collaboration and alignment between vendors. However, currently, this is not the case. Collaboration between BRMS suppliers would be beneficial as a combination of their specialized products would be better able to support the translation of legal sources into products and services for both governmental and commercial industries. We further observe the lack of professional comparison between the different BRMS. For example, Gartner, Forrester and similar industry analysts all feature detailed analysis and comparison of Database Management (DBM) tooling, Business Process Management (BPM) tooling, Business Intelligence (BI) tooling, and Content Management Systems (CMS). However, there is no analysis whatsoever on BRM-related tooling.

There is limited knowledge on how to apply BRM in practice

The availability of proper educational programs on a subject is an indicator for the maturity of a research domain: the current supply of BRM-related educational programs indicates the nascent state of knowledge and expertise in the BRM domain. In the Netherlands, compared to the supply of educational programs related to, for example, DBM, BPM and BI, the availability of BRM-related educational programs is rather limited. However, as separating business logic was already indicated by others (Boyer & Mili, 2011; Graham, 2007; Morgan, 2002; Zoet, 2014), educational programs can also help organizations on how to organize their BRM capabilities in a separate way.

Based on our observations of the governmental domain in the past years, we identified a significant shortcoming in collaboration between Dutch governmental institutions, which is also stated as an area for improvement by the Dutch government (Dutch Ministry of Economic Affairs, 2017) as well as a collection of 90 Dutch municipalities seeking to improve their digital services (van der Ent & de Vries, 2017). While governmental institutions are becoming increasingly aware of the advantages of aligning their BRM related activities, much redundant work is still performed, thus precious organizational resources are wasted. For example, acquiring BRMS is performed on an individual basis within the governmental domain. However, knowledge already exists on BRMS tender projects, which have been performed by other Dutch governmental institutions; yet this knowledge is not structurally shared.

More investments in proper design of the capabilities related to the organization and governance of business logic will contribute to a higher maturity level of BRM in general. Also, more investments are required given recent trends in legislation. (Semi-)automated digital decision-making will become increasingly strict in the future. This will especially be the case in regulated industries such as banking, insurance, government and medical. An example of a law that will impact organizations significantly is the General Data Protection Regulation (GDPR), which goes into effect in May 2018 (European Union, 2016). One of the key changes this law enforces is the requirement to provide, in a transparent and understandable way, all stakeholders with supervisory authorities and customers with information about the decision-making process (GDPR article 12). Also, organizations are being more restricted with regards to automated individual decision-making (GDPR article 22). This means that organizations that apply (semi-)automated digital decision-making must invest in making their business decisions and underlying business logic explicit and communicate them with all stakeholders involved. Additionally, making business decisions and underlying business logic explicit is not sufficient as laws and regulations constantly change. Organizations should therefore be able to properly govern their decision-making as well. Failure to comply with GDPR can result in significant fines, up to 20 million euro or four percent of the organization's worldwide turnover (European Union, 2016).

Scientific triggers

Research literature on BRM is still limited, though recent years have shown an increase in scientific publications. In the current body of knowledge regarding BRM, two main triggers for this research have been identified. The first scientific trigger entails the focus of the research that was and is still being performed and published in the current body of knowledge. Most publications published up to this date are often characterized by a technical orientation (Information Technology). They address topics like the integration of business rules with business processes, e.g. (Charfi & Mezini, 2004; Knolmayer, Endl, & Pfahrer, 2000; Rosenberg & Dustdar, 2005; zur Muehlen & Indulska, 2010), and the construction of formal languages and models (Bajwa, Lee, & Bordbar, 2011; Herbst, Knolmayer, Myrach, & Schlesinger, 1994; Taveter & Wagner, 2001). Fortunately, in the last decade, a transition is taking place towards the management of business rules, addressing business architecture, processes, capabilities and competencies (Boyer & Mili, 2011; Schlosser et al., 2014; Zoet, 2014). Yet, there has been a predominant focus on technical-oriented research in the previous decades. This partly explains why organizations are confident regarding the execution of business decisions and underlying business logic, while struggling to properly implement capabilities to process and govern legal sources into implemented business logic.

In earlier research focused on BRM, Zoet (2014) utilized the Ontological Foundations of Information Systems Framework (OF-IS), which is coined by Weber (1997) and was later supplemented by Strong and Volkoff (2010), see Figure 1-2.

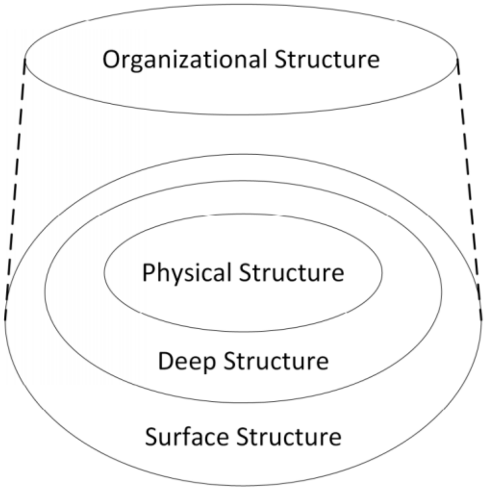

Figure 1-2. OF-IS (Strong & Volkoff, 2010; Weber, 1997)

Their framework contains four structures of which each addresses a different aspect within IS implementation. The first structure focuses on the *organization* and describes the roles, control and organizational culture represented within organizations or within solutions. In our context, for example, it would be the use of BRM reference processes that structure the process of designing and specifying business logic (Schlosser et al., 2014). The second structure focuses on the *surface* and describes the elements that are available in an IS to allow users (other machines or humans) to interact with the IS. For example, multiple languages or standards exist to represent business logic, i.e. the Semantics of Business Vocabulary and Rules (SBVR) (Object Management Group, 2008), Decision Model and Notation (DMN) (Object Management Group, 2016b) or The Decision Model (TDM) (Von Halle & Goldberg, 2009). The third structure focuses on the *deep structures* and describes real-world systems, their properties, states and transformations. For example, this could be a meta-model that describes the states and cardinality of elements that are used in the language to represent business logic during the design and specification processes. The fourth structure focuses on the soft- and hardware *(physical structure)* used to implement the IS and describe the physical technology and software in which the deep structure is embedded. For example, refer to Oracle's Policy Automation suite (Oracle, 2018), Blueriq's Decision Management suite (Blueriq, 2015) or Usoft's Business Rules Engine (Usoft, 2018). Evaluation of the current body of knowledge according to the structures of the OF-IS Framework by Weber (1997) and Volkoff (2010) shows that most scientific contributions from the past decades focus on the physical structure, and not on the deep, surface and organization structures.

Because of the low maturity of the knowledge base about studies with an organizational orientation, organizations started to develop and experiment to support the implementation of BRM capabilities themselves. This scientific trigger entails the (direct) applicability of the scientific contributions in the current body of knowledge. Simply stated, most scientific contributions have a strong theoretical orientation, but lack adequate consideration of the practical perspective as well. This argument is in line with a conclusion stated in the work of Nelson et al. (2008: *p. 3*): "*studies provide beginnings of a business rules research program, but collectively the research often overlooks major steps in BRM and fails to focus on business rules specific challenges and the larger context that rules play in organizations*." This phenomenon is also discussed in the work of Kovacic (2004), as well as Nelson, Raiden & Sen (2008), who state: "*with so much emphasis towards the technological aspects, we can lose sight of the management of information systems considerations.*" Additionally, in 2005, Arnott and Pervan (2005) concluded, after studying 1,020 papers, that the field had lost its connection with industry some time ago and research output with practical relevance was scarce. In 2014, Arnott and Pervan (2014) (re-)analyzed a collection of 1,466 papers to conclude that a transition is taking place towards a more practical-oriented approach, however, a strong connection between theory and practice is still lacking.

Summarizing the scientific motivations of this study, the current body of knowledge does not show a well-balanced mix of research by addressing all four structures of the OF-IS Framework: technical versus organizational research (Strong & Volkoff, 2010; Weber, 1997).

1.2 Research question

Based on the research triggers, the main research question in this thesis is as follows:

MRQ: ***How can business rules management be organized and governed?***

As the maturity of the body of knowledge on BRM (especially with regards to the organizational, deep and surface layers) is nascent (Edmondson & Mcmanus, 2007), the approach in tackling this MRQ is to take an explorative perspective; furthermore we focus on governmental institutions responsible for the implementation of law and regulations. Based on the societal, business and scientific triggers, three main parts are identified, which are each represented by a separate Research Question (RQ). Each part contains one or more chapters that represent a scientific contribution.

Part one: concepts and principles for Business Rules Management

RQ-1: ***What are the compliance and functional requirements for Business Rules Management implementations?***

The first step in answering RQ-1 is to define the concept of a business rules management implementation. While a sufficient amount of research contributions focuses on the technical implementation of a BRMS or BRM engine, little contribution is made with regards to the organizational perspective. Schlosser, Baghi, Otto, and Oesterle (2014) describe a functional reference model with the help of three perspectives (architectural, functional, and process). However, they do so from a high level of abstraction. Therefore, chapter two in this thesis aims to construct a reference process that is detailed enough to be applied by organizations while adding valuable knowledge on BRM processes to the body of knowledge. To be able to do so, the following research question is answered in chapter two:

> SQ-1: *Which (sub-)processes constitute a Business Rules Management reference process for the Dutch governmental agencies?*

The definition of a BRM reference process is a first step towards a proper implementation of BRM in an organization. As BRM is often implemented with the goal to enhance control on compliance, organizations must consider the measures that contribute to compliance. Similar studies have been conducted, for example, in the business process management domain (Ghose & Koliadis, 2007; Rikhardsson, Best, Green, & Rosemann, 2006). To the knowledge of the author, the current body of knowledge only contains a limited amount of scientific contribution on compliance measures related to BRM. We could evaluate specific instances of a compliance solution which would reduce the generalizability of our results. Instead, we look at the design principles that ground the instantiation of specific compliance solutions, which limit the choices an organization has when implementing BRM. To be able to do so, the following research question is answered in chapter three:

> SQ-2: *Which principles are essential in designing a compliant business rules management solution?*

In addition to compliance, one of the main drivers for implementing BRM is the translation of legal sources into computer-executable code to support (semi-)automated decision-making. The translation of legal sources is complex and requires business decisions and underlying business logic to be adequately specified or modified according to a given syntax and semantic model, depending on the language used. This goal resembles the verification capability. Since the introduction of the DMN standard, organizations are increasingly adopting (and adapting) the standard. The current body of knowledge contains some (scientific) contributions on how business logic should be verified (Buchanan & Shortcliffe, 1984; Von Halle & Goldberg, 2009). However, none do so in relation to the DMN standard or with the goal to deliver a complete set of possible verification issues that should be taken into account. To do so, the following research question is answered in chapter four:

> SQ-3: *Which verification capabilities are useful to take into account when designing a business rules management solution?*

To support the implementation and execution of BRM capabilities at organizations, software is often used. The scientific contributions in the current knowledge base predominantly focus on the technology perspective. This results in organizations being able to properly define requirements for the execution of business logic using information technology. In addition, organizations are interested in the functional support that BRMS can effectuate to realize the elicitation, design, specification, verification, and validation capabilities, which are absent in the current body of knowledge. This is also stated in the work of Schlosser, Baghi, Otto, and Oesterle (2014), who describe that "*companies are unsure about what they need to consider when dealing with BRM. Literature hardly provides answers to this question.*" Therefore, to provide a solution for this knowledge gap, the following research question is addressed in chapter five:

SQ-4: *Which functional requirements should be taken into account with regards to the different capabilities as part of BRM?*

Part two: Business Rules Management implementation challenges

RQ-2: ***What are the BRM implementation challenges for governmental institutions?***

While there are success stories, many organizations implementing BRM face numerous (unexpected) challenges along the way. Scientific research that identifies challenges in a certain research field are quite common. For example, see the challenges regarding Enterprise Resource Management (Gargeya & Brady, 2005), the challenges regarding Business Process Management (Lönn & Uppström, 2013), or the challenges regarding (inter-organizational) Supply Chain Management (Lambert & Cooper, 2000). The identification of such challenges is of critical importance to organizations in terms of developing a realistic understanding of what problems organizations might face. Moreover, it will also serve to inform academia and practice on what potential new research directions are needed in the area of BRM and related topics, for example: (Bandara, Indulska, Chong, & Sadiq, 2007). In the current body of knowledge, to the knowledge of the authors, no scientific contributions exist that identify implementation challenges. Part two comprises three studies that cover six of the total of nine BRM capabilities presented in Figure 1-1, namely (SQ-5) elicitation, design, and specification, (SQ-6) verification and validation, and (SQ-7) governance. The following research questions are answered in chapters six, seven and eight:

SQ-5: *Which implementation challenges do governmental institutions encounter while implementing the elicitation, design and specification capabilities of business rules management?*

SQ-6: *Which implementation challenges do governmental institutions encounter while implementing the verification and validation capabilities of business rules management?*

SQ-7: *Which implementation challenges do governmental institutions encounter while implementing the governance capability of business rules management?*

Part three: Business Rules Management governance

RQ-3: ***How can a BRM implementation be evaluated?***

To measure the effects of a BRM implementation in a systematic and controlled manner, an adequate management control system should be in place. A management control system enables organizations to support positive change in organizational culture, systems and processes related to the BRM capabilities (Amaratunga & Baldry, 2002). With regards to BRM, two aspects should be evaluated consistently: the process of transforming legal sources into computer-executable business logic (internal) and the actual execution of business logic to support business decisions, i.e. the different possible scenarios. To the knowledge of the authors, evaluation of both aspects are themes that are not discussed in the current body of knowledge. Because of this, organizations often only measure standard business process variables such as lead time, but lack any in depth information to improve BRM capabilities in place. To guide organizations in developing and improving their evaluation capability, the following research question is answered in chapter nine:

> SQ-8: *Which performance indicators are useful to measure the BRM processes?*

In addition to the measurement of BRM specific indicators, an important capability that contributes to compliance with regards to (semi-)automated decision-making is the ability to trace any business decision executed to their underlying legal sources, or trace what business logic is dependent on which legal sources, for the purpose of impact assessment. This ability is referred to as traceability management. Whilst traceability management seems rather mature, for example, in the domains of requirements engineering (Gotel & Finkelstein, 1994), software artifacts (Gao, Zhu, Shim, & Chang, 2000), and the protection of copyrighted material (Staddon, Stinson, & Wei, 2001), the body of knowledge regarding BRM still lacks any scientific contributions that explore or describe traceability management in detail. Because of this, it is important that a study contributing to the body of knowledge starts off with an explorative perspective to find out which elements in which application areas are useful to take into account as part of traceability management. To be able to do so, the following research question is answered in chapter ten:

SQ-9: *Which elements are useful to trace with regards to legal requirements in the context of the Dutch government?*

1.3 Research design

Based on the motivations and research questions for this study, an appropriate research design is selected. As addressed earlier in this thesis, one of the challenges is the maturity of the research domain. Research domain maturity can be classified as nascent, intermediate, and mature (Edmondson & Mcmanus, 2007). The maturity of the BRM research domain is considered nascent (Arnott & Pervan, 2014; Boyer & Mili, 2011; Schlosser et al., 2014; Zoet, 2014). As presented earlier, the BRM research domain has a predominant focus on information technology research and a lack of focus on IS research (Nelson et al., 2008; Schlosser et al., 2014; Zoet, 2014). Additionally, the existing knowledge base is identified as mostly theoretical in nature and could surely benefit from better practical alignment with organizations (Kovacic, 2004; Zoet, 2014).

Research with regards to nascent maturity level research topics should be on provisional explanations of phenomena, often introducing a new construct and proposing relationships between it and established constructs (Edmondson & Mcmanus, 2007). Research in this direction is often exploratory in nature and is characterized by qualitative data collection and analysis techniques. Qualitative research designs often involve inductive approaches to interpret a phenomenon and are concerned with discovering causes noticed by the subjects in the study and understanding their view of the problem at hand (Wohlin et al., 2012). Utilizing inductive research approaches also helps secure the link between theory and practice (Arnott & Pervan, 2014; Kovacic, 2004). Additionally, since practice continuously evolves and matures with regards to the aspect of BRM, an inductive approach supports further theory building within the, relatively small, existing body of knowledge.

Qualitative research aims to capture phenomena and its relationships using one, but preferably more, rich data sources. Data sources are always real-world context-based, and therefore support the exploration of a phenomenon in its natural context. A phenomenon can be explored using first, second, or third-degree data collection techniques (Runeson & Höst, 2009). Exploration using first degree (FD) data collection techniques focuses on techniques that allow direct contact between the researcher and the subject being studied, while second degree (SD) data collection techniques comprise techniques that allow for indirect analysis of the subjects. Third degree (TD) data collection techniques represent independent analysis of already collected data. In this thesis, a combination of all three degrees of data collection is utilized to interpret the phenomena in its real-world context. In this thesis, interviews (FD), focus groups (FD), Delphi studies (FD), observations (SD), and documentation or the collection of secondary data (TD) are applied to explore the phenomena. To derive meaningful interpretations from the data collected, an appropriate data analysis technique must be selected. Based on the nascent maturity of the research domain, the need for inductive research, and the use of qualitative data collection techniques, to a large extent grounded theory is applied in this thesis as a data analysis technique. Grounded theory was applied by thematic coding for evidence resulting in suggestive theory.

The results of the studies conducted in this thesis could best be described by IS artifacts that represent a suggestive theory as well as an artifact that could be utilized in environments similar to the researched context, thus practice. To structure the creation of such IS artifacts the design science research framework of Hevner et al. (2004) has been used throughout this thesis. Utilization of this framework structures the development and validation of IS artifacts whilst requiring their relevance to be grounded in practice and their rigor based on the existing body of knowledge. The IS artifacts created in this thesis are: a BRM reference process (chapter 2); a set of compliance principles for decision management (chapter 3); a verification framework for BRM (chapter 4); a functional requirements framework for BRM Systems (chapter 5); a collection of common pitfalls in the implementation of BRM (chapters 6, 7 and 8); a management control framework for BRM (chapter 9); and a traceability framework for BRM (chapter 10). As can be derived from Table 1-1, the artifacts presented in this thesis were created using a combination of different methods of data collection such as interviews, focus groups and secondary data. By doing so, the research results can be compared and validated more effectively, leading to valid theory and artifacts. Therefore, we can state that we applied triangulation in our research.

Regarding the application of the design science research framework, the research presented in this thesis adheres to guidelines 1-4, 6, and 7. Due to the nascent maturity of the research field, the studies presented focused on the application of grounded theory to build theory. Therefore, guideline 5 was only limitedly adhered to. This means that we did not complete the full design science research lifecycle as described in Hevner et al. (2004). Although, for all studies, at least one cycle of validation has been conducted, the application in an appropriate environment to fully evaluate the effectiveness (guideline 5) was not, yet, possible. However, most organizations are, at the time of writing, utilizing the artifacts in practice to re-design their BRM implementations, e.g. the Dutch Tax and Customs Administration, the Dutch Immigration and Naturalization Service, and the Dutch Education Executive Agency. See the future research subsection, 11.3, for the research directions that specifically focus on the continuation of this research by focusing on grounding guideline 5 as well, focusing on measuring the outcomes of using the artifacts presented in this thesis.

1.4 Research method

In this thesis, the studies used a mix of different research methods. In this subsection, the research methods applied are elaborated, see also Table 1-1.

Chapter	Literature review	Focus Group	Delphi Study	Case study	Grounded Theory
1	X				
2	X	X	X	X	X
3	X	X	X		X
4	X	X			X
5	X			X	X
6	X	X	X		X
7	X	X	X		X
8	X	X	X		X
9	X	X	X		X
10	X	X		X	X
11	X				

Table 1-1. Research methods applied per chapter

Literature review

For all studies, a literature review was conducted. The literature reviews were utilized to introduce and position the topics addressed. Such literature reviews help to set boundaries for the theoretical foundations and context of the research question, bringing the research question into focus (Okoli & Schabram, 2010). The scope of a literature review that positions a research question by addressing the theoretical foundations is often characterized by an implicit search process and data extraction process (Kitchenham et al., 2009).

Focus group

Studies described in chapters two, three, four, six, seven, eight, nine, and ten are based on focus group-centered data collection. A focus group is a qualitative face-to-face data collection technique that allows for broad interactions on a topic (Morgan, 1996). It is a more efficient method of data collection than qualitative interviews because, physically, more participants can be involved at a given point in time. Furthermore, utilizing focus groups also allows for cross-participant discussion about a subject to achieve a greater sense of detail about that subject as well as shared decision-making, i.e. validating artifacts (Morgan, 1996). However, the previously mentioned advantages are shadowed by the less private and safe setting than the one between an interviewer and interviewee as part of conducting qualitative interviews. All focus groups conducted in these studies are applied with two goals in mind: 1) to construct artifacts and 2) to validate artifacts constructed in earlier focus group rounds. Both goals are in line with the design of design science study research by Hevner (Hevner & Chatterjee, 2010; Hevner et al., 2004), which describes the creation of IS-related artifacts in the 'Develop/Build' phase and the validation of such artifacts in the 'Justify/Evaluate' phase.

Delphi study

Studies described in chapters two, three, six, seven, eight, nine, and ten are, in addition to the focus group approaches, based on Delphi study-centered data collection. Delphi Study research usually involves group-based data collection in a non-face-to-face setting. It is a technique to reach consensus amongst selected participants using an iterative multistage process (Okoli & Pawlowski, 2004). Due to the decentralized characteristic of the Delphi study technique, a larger number of participants can be included compared to focus groups. The Delphi study technique is mainly applied with the goal of the validation of the proposed artifacts by: a collection of participants who also participated in the focus groups; and additionally, by other experts that were not involved in the focus groups but are knowledgeable on the subject. The secondary goal of applying the Delphi study technique is the mitigation of face-to-face data collection disadvantages caused by the use of focus groups. Therefore, the Delphi study technique, in the context of these studies, is also applied to collect data without the goal of reaching a consensus directly.

Case study

Studies described in chapters two and five are based on case study-centered data collection. Case study research is a technique that can be used to explore a broad scope of complex issues, particularly when human behavior and social interactions are of importance (Pervan & Maimbo, 2005). It can be applied to either theory building or theory testing (Yin, 2013). To explore a given research context, the case study technique can utilize different levels of data collection; first degree, second degree, and third degree data collection. This is an important feature as it allows a study to triangulate different sources in different modes of interaction with regards to the same context (Runeson & Höst, 2009). Both case study techniques applied concern theory building. In the study described in chapter two, the case study technique is applied to gather all available data on existing BRM processes at the participating organizations, using both first and second degree data collection (Runeson & Höst, 2009). In the study described in chapter five, the case study technique is applied to collect data about requirements that organizations formulate with regards to Business Rules Management Systems (BRMS), using second and third degree data collection.

Grounded theory

Studies described in chapters two, three, four, five, six, seven, eight, nine, and ten leverage grounded theory data analysis. Grounded theory is characterized by constantly searching for patterns in data during the collection and analysis of data without using predefined hypotheses (Strauss & Corbin, 1990). Using multiple cycles of coding, grounded theory is used to formulate theory. In the studies conducted, theory building is applied in an inductive manner by analyzing specific instances in order to identify general principles and concepts for theory building with regards to BRM. All studies featured at least three cycles of coding; open coding, axial coding, and selective coding (Böhm, Glaser, & Strauss, 2004; Glaser, 1978).

Multimethod

All studies conducted adhered to a multimethod approach where multiple techniques for data collection and analysis were utilized to create richer and more reliable research results (Mingers, 2001). Given the maturity of the research domain, this becomes even more important as it allows for a rich understanding of the phenomenon and its context being researched (Runeson & Höst, 2009). Multimethod approaches are more favored than single method approaches because they mitigate the weaknesses of each data collection or analysis technique by combining their strengths. For example, as presented in Table 1-1, many studies feature a focus group approach combined with a Delphi study approach to eliminate peer pressure among participants during data collection phases.

1.5 Thesis outline

In this section, the outline of the thesis is presented, featuring three parts each with corresponding chapters.

- **Introduction**

Chapter 1: Introduction

The research topic is positioned in the first chapter by outlining the scientific and practical triggers and the contributions of this study. The research questions are presented with the research approach and the research methods utilized to answer the research questions.

Part one: concepts and principles for Business Rules Management

Chapter 2: A Business Rules Management Reference Process for the Dutch Government

Starting from a higher abstraction while continuing towards more detailed concepts for BRM in later chapters, chapter two contains a proposal for a business rules reference process, specific for the governmental context. The reference process has been created and validated over the course of a year, utilizing five case studies for the initial data collection followed by a three-round focus group for additional data collection and validation of the reference process. The reference process is based on the input of 31 participants in total and led to the creation of two abstraction levels, on the lowest level featuring 20 subprocesses with underlying input and output artifacts. *Chapter two has been published in the proceedings of the 21st Pacific Asia Conference on Information Systems* (Smit & Zoet, 2017)*.*

Chapter 3: Compliance Principles for Decision Management Solutions

By conducting an explorative three-round focus group and three round Delphi study design, the design principles for securing compliance in the fabric of the organizations applying BRM are identified. Based on an earlier study on general BRM design principles (Zoet & Smit, 2016), 44 participants identified 11 compliance principles to take into account when designing or implementing a BRM solution. *Chapter three has been published in the proceedings of the 20th Pacific Asia Conference on Information Systems* (Smit, Zoet, & Slot, 2016)*.*

Chapter 4: A Verification Framework for Business Rules Management

In this chapter, we explore the verification capabilities of several Dutch Governmental Institutions. Using a three-round focus group approach, featuring ten experts, 28 verification capabilities are elaborated in detail, alongside the abstraction levels of the OMG's Decision Model and Notation standard (Object Management Group, 2016b). The results are structured in a verification framework that can guide organizations to design their verification capability. *Chapter four has been published in the proceedings of the 5th International Conference on Research and Innovation in Information Systems* (Smit, Zoet, & Berkhout, 2017b) (Best Paper Award).

Chapter 5: Functional Requirements for Business Rules Management Systems

The last chapter of part one explores a large number of functional requirements from four Dutch governmental institutions to support the artifacts and concepts identified and described in the previous chapters. Based on 759 functional requirements analyzed from four case studies using a grounded theory approach, 34 functional requirement themes were identified that can guide organizations with exploring their needs. *Chapter five has been published in the proceedings of the 23rd Americas Conference on Information Systems* (Smit, Zoet, & Berkhout, 2017a).

Part Two: Business Rules Management implementation challenges

Chapter 6: Challenges in the Implementation of the Elicitation, Design and Specification BRM capabilities

This is the first of three chapters that focus on the challenges identified regarding the implementation of BRM capabilities, specifically regarding the elicitation, design and specification capabilities. Using two three-round focus groups and two three-round Delphi studies featuring 44 participants in total, this chapter identifies 28 main challenges with regards to the implementation of the elicitation, design and specification capabilities at five Dutch governmental institutions. The results enable organizations to take into account such challenges to mitigate them in future BRM implementations. *Chapter six has been published in the Journal of Information Technology Theory and Application* (Smit, Zoet, & Versendaal, 2018).

Chapter 7: Challenges in the Implementation of the Verification and Validation BRM capabilities

In this chapter, we expand the identification of challenges with regards to the implementation of BRM capabilities, focusing on the verification and validation capabilities. Using two three-round focus groups and two three-round Delphi studies featuring 44 participants in total, this chapter identifies 17 main challenges with regards to the implementation of the verification and validation capabilities at five Dutch governmental institutions. *Chapter seven has been published in the proceedings of the 21st Pacific Asia Conference on Information Systems* (Smit, Versendaal, & Zoet, 2017).

Chapter 8: Challenges in the Implementation of the Governance BRM capability

In this chapter, we further expand the identification of challenges with regards to the implementation of BRM capabilities, focusing on the governance (traceability, version, and validity-management) capability. Using a four-round focus group and a three-round Delphi study approach featuring 45 participants in total, this chapter identifies eight main challenges with regards to the implementation of the governance BRM capability at five Dutch governmental institutions. *Chapter eight has been published in the proceedings of the 51st Hawaii International Conference on System Sciences* (Smit & Zoet, 2018).

Part three: Business Rules Management governance

Chapter 9: A Management Control System for Business Rules Management

In this chapter, the mechanisms with regards to the BRM monitoring capability are explored and, based on a three-round focus group and three-round Delphi study approach, fourteen key performance indicators are identified. Additionally, several situational factors that should be taken into account when designing a monitoring component for a BRM solution are derived. *Chapter nine has been published in the International Journal on Advances in Systems and Measurements* (Smit & Zoet, 2016a)*; An earlier version has been published in the proceedings of the proceedings of the eight International Conference on Information Process and Knowledge Management* (Zoet, Smit, & de Haan, 2016)*.*

Chapter 10: A Framework for Traceability of Legal Requirements

In this chapter, the notion of traceability with regards to BRM is explored and the possible artifacts for implementation are identified. Based on five case studies, which were followed by a three-round focus group approach, a traceability framework is created. The traceability framework comprises 22 BRM-related artifacts for which the traceability mechanisms must be taken into account when designing the governance BRM capability as part of a BRM solution. *Chapter ten has been published in the proceedings of the 29th Bled eConference* (Smit, Zoet, & Berkhout, 2016)*.*

- **Conclusion and outlook**
- **Summary & Nederlandse samenvatting**
- **Curriculum Vitae**

Part 1: Concepts and Principles for Business Rules Management

2 A BUSINESS RULES MANAGEMENT REFERENCE PROCESS FOR THE DUTCH GOVERNMENT

Business Rules Management (BRM) is increasingly being applied in the governmental context. However, currently, many of those governmental institutions apply different BRM processes, but are expected to work together in their task of delivering products and services to citizens and companies in the Netherlands. An initiative from the Dutch government was started with the goal to investigate currently applied processes and develop a BRM reference process to promote cooperation. This paper elaborates upon the process of comparison of currently applied BRM processes and development of the BRM reference process for the Dutch government. The resulting BRM reference process consists of seven main processes with twenty sub-processes and a common vocabulary which can guide (Dutch) governmental organizations to design and implement their BRM solution as well as to achieve better cooperation due to increased commonality. In terms of future research, the emphasis should lie on more thorough validation, using quantitative research methods, but we argue that other industries should be explored as well.

2.1 Introduction

Many business services nowadays heavily rely on business decisions and business logic embedded in information systems. Herewith, organizations aim to, for example, increase compliance, modernize IT chains, reduce inconsistent and expensive customer interaction, and facilitate law and policy implementation (Bajec & Krisper, 2005; Shao & Pound, 1999). A business decision is defined as: "*A conclusion that a business arrives at through business logic and which the business is interested in managing*" (Object Management Group, 2016b). Moreover, business logic is defined as: "*a collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016a). Both concepts of business decisions and business logic are often seen in relation to Business Rules Management (BRM), as BRM focuses on the elicitation, design, specification, verification, validation, deployment, execution, evaluation and governance of business decisions and business logic (Bajec & Krisper, 2005; Schlosser et al., 2014; Zoet, 2014).

In the research domain of BRM, most research studies emphasize on the technological aspects (Kovacic, 2004), thus lacks a well-balanced mix of research between technology and methods & techniques to be applied in the context of BRM (Nelson, Peterson, Rariden, & Sen, 2010). In the same light, Arnott and Pervan (2005) conducted an

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extensive literature review with regards to the knowledge base in 2005, concluding that the research domain has lost its connection with industry some time ago and research output with practical relevance was scarce. In 2014, Arnott and Pervan (2014) revisited the knowledge base to conclude that a transition is happening to a more practical-oriented approach, where research studies utilize more design-science as a method, to, amongst other reasons, increase practical relevance. This conclusion was further strengthened by the results of the extensive work on methods and concepts for BRM from Zoet (2014). Based on these arguments, we conclude that the current knowledge base could benefit from more practical-oriented contributions.

BRM is applied in several industries, e.g. insurance, higher education, financial services, healthcare, transportation, utilities, human resources, enterprise resource planning, and the public sector. These industries utilize BRM to support the implementation of products and services concerning the determination of eligibility, assessments, calculations, complex comparisons, inspections with regards to payments, benefits, transfers, rights and obligations, and licenses and permits. Within this context, the Dutch government issued a large research program on how BRM is applied and could be improved. One of the main goals of this research programme was to investigate and make explicit the current best practices of governmental agencies and define a BRM reference process with the goal to 1) provide an overview of the organization's current situation, 2) achieve a common language to describe/discuss their BRM processes and 3) compare practices applied by the participated organizations. A BRM reference process aims to guide the design and implementation of BRM by providing and suggesting activity decomposition, coordination guidelines, and artifacts (Schuster, Georgakopoulos, Cichocki, & Baker, 2000). Translating this to a more practical orientation, a BRM reference process should contain possible business processes, sub-processes, roles, and artifacts that are processed to implement business decisions and business logic.

The current body of knowledge with regards to BRM reference models is limited, but several models already exist. Baggi, Schlosser, Otto and Oesterle (2014) describe three different reference models, one from an architectural perspective, one from a functional perspective, and one from a process perspective. Furthermore, Bajec and Krisper, (2005) describe the perspective of BRM between enterprise modeling and IS development. Zoet and Versendaal (2013) describes BRM processes from a service systems perspective, and Smit and Zoet (2016b) describe BRM from a capability perspective. However, according to Rosemann and van der Aalst (2007), a reference model usually focuses on a specific application area or context, which also increases its chances of successful adoption (Cleland-Huang, Gotel, Huffman Hayes, Mäder, & Zisman, 2014). Therefore, in this paper, we focus on the definition of a BRM reference process for the governmental context. To achieve this, we addressed the following research question: "*Which (sub-)processes constitute a Business Rules Management process for the Dutch governmental agencies?*"

The remainder of this paper is organized as follows: First, we provide insights into the details of reference process design and how it can be contextualized for BRM theory. This is followed by the research method used to construct the BRM reference process. Furthermore, the collection and analysis of our research data are described. Subsequently, our results which led to our BRM reference process, and the BRM reference process itself, are presented. Finally, we discuss which conclusions can be drawn from our results, followed by a review of the research methods utilized and results of our study and propose possible directions for future research.

2.2 Background and Related Work

Business decisions and business logic are an important part of an organization's daily activities. To increase grip on business decisions and business logic, organizations search for a systematic and controlled approach to support the elicitation, design, specification, verification, validation, deployment, execution, governance, and evaluation of business decisions and business logic. Such an approach can be defined as Business Rules Management (BRM), which is a combination of methods, techniques, and tools (Bajec & Krisper, 2005; Boyer & Mili, 2011; Graham, 2007; Morgan, 2002; Ross, 2003; Zoet, 2014). In the current body of knowledge, business decisions and business logic are described using different concepts. For example, derivation business rules, operational decisions, business knowledge, scope design, and derivation structure. In this paper, we adhere to the definitions on business decisions and business logic as provided by the OMG, see section one (2016a; 2016b). In addition, we adhere to the concepts as described in (Smit & Zoet, 2016) to describe the various artifacts to design and specify business decisions and business logic. A business decision can exist out of multiple business decisions, for example, the business decision 'determine the amount of child benefits', which is derived from three sub-business decisions; 'determine wage of parents', 'determine family composition', and 'determine the age of child'. The overall decision is referred to as a scope. The relationships between the four decisions in this example are described by means of a derivation structure. Moreover, business logic describes the knowledge required to execute the business decision. The different concepts to specify business logic are business rules, fact types, and fact values (Von Halle & Goldberg, 2009).

To create a reference process, three possible approaches can be applied; 1) 'reference model combination', 2) 'reference model building', and 3) a hybrid approach (Rosemann & van der Aalst, 2007). The first approach proposes a reference model based on the combination of theory identified from the body of knowledge without involving the application environment in the building process. The second approach proposes a reference model based on the best practices acquired from the application environment without influences from the body of knowledge. The hybrid approach consists of a combination of the two approaches. In this paper, we choose to adopt the hybrid approach.

In addition to the selection of one of three approaches, eight decisions about the characteristics of the reference model need to be taken (Rosemann & van der Aalst, 2007). First, the scope of the model needs to be determined. The scope can vary between a general scope or specific scope for a target domain or application (i.e. the food industry in general versus traceability support of fruit distribution in IT systems). Within the scope of the reference process, the granularity needs to be determined (i.e. number of levels of decomposition detail, processes, sub-processes). The appropriate level of granularity is important as over-generalization of a reference model could lower adoption by the application environment. Furthermore, the views of the reference model need to be determined (i.e. process, data, objects, and organization). This is an important factor as well as different views, carry guidance information for different stakeholders. Therefore, when constructing a reference model, it is important to assess what information needs to be presented for each stakeholder, which is represented in one or multiple views. Based on the views depicted in the reference model, also the degree of integration between these views needs to be determined (i.e. which views are and are not related, and what inter-model relationship types exist). Moreover, the user groups of the reference model in terms of internal versus external (commercial) use have to be determined. Lastly, the manner in which the reference model and related explanation are shared with stakeholders could also influence the adoption, thus both the availability of the model (i.e. paper, tool-based, web-based) and the availability of further textual explanation of the model should be determined.

Since we apply a hybrid approach, we explore the existing literature on BRM (reference) processes. In the work of Zoet and Versendaal (2013), a BRM-related framework is proposed that contains a selection of service systems that focus on the processes of 1) mining 2) cleansing, 3) design, 4) verification, 5) validation, 6) improvement, 7) deployment, 8) execution, 9) monitoring, 10) audit and 11) version of business logic along with their corresponding input data, goal, output data and responsible roles. Furthermore, the work of Schlosser, Baghi, Otto, and Oesterle (2014) presents a somewhat different view of the application of BRM by proposing a functional reference model, focusing on a comprehensive view of the possible functionality of BRM based on design science research. Their functional reference model contains three perspectives; 1) BRM Process Perspective, 2) BRM Functional Architecture Perspective, and 3) BRM Business Goal Perspective. Within the BRM Process Perspective, several tasks are identified and elaborated; 1) requirements analysis, 2) authoring, 3) change management & validation, 4) monitoring, 5) deployment & implementation, and 6) execution. Furthermore, several artifacts which are relevant during these tasks are mentioned, i.e. a business vocabulary, business process models, a rulebook, and business requirements. Bajec & Krisper (2005) aimed to describe a BRM scenario to support managing business logic in organizations in which they depict and elaborate upon the relationship between IS development, BRM and enterprise modeling. Their BRM scenario contains a selection of seven BRM processes; 1) acquisition, 2) capturing, 3) modeling, 4) analysis and classification, 5) consistency validation, 6) implementation and 7) maintenance and monitoring. In the work of (Smit & Zoet, 2016), a selection of nine capabilities is described that represent the BRM problem space; 1) elicitation, 2) specification, 3) design, 4) verification, 5) validation, 6) deployment, 7) execution, 8) monitoring, and 9) governance. See also the work of (Boyer & Mili, 2011; Graham, 2007; Morgan, 2002) for literature on BRM in which activities as part of BRM are described implicitly, or not in relation to BRM processes but to BRM in a general sense.

2.3 Research Method

The goal of this research is to propose a BRM reference process which can guide the design of BRM solutions at governmental institutions in the Netherlands. As stated in the previous section, eight decisions need to be taken before the reference model can be defined: 1) the scope of the model, 2) the granularity of the model, 3) the views in the model, 4) the degree of integration between the views, 5) the user groups addressed, 6) the internal versus external use of the model, 7) the availability of the model, and 8) the availability of detailed explanation with regards to the model. Each of the eight decisions will be discussed in the context of this study.

The scope of the BRM reference process, as elaborated upon earlier, is the Dutch government, in the context of governmental agencies. The reference process utilizes two levels of abstraction to illustrate processes and sub-processes and corresponding artifacts and limits the view to the process and artifacts views combined in both abstraction levels. The reference process aims to guide all stakeholders which are involved in the process, from law and policy authors until the roles responsible for the actual usage of the products and services containing the business decisions and business logic, however, the definition of such roles can vary largely between organizations so we choose not to define them in this research to ensure our research results do not impose certain roles and responsibilities. The intended use of the reference model is internal, however, the results could be utilized to develop other instances for other industries, thus will be made available for external use as well. Furthermore, the reference process and accompanied documentation derived from this study will be made available by means of a digital report in which all processes, sub-processes, goals, input per process, output per process, activities, input per activity, output per activity, and artifacts are elaborated upon in detail. As the target group for this reference process is the Dutch government, the digital report is required to be produced in Dutch.

In addition to the goal of the research, also, the maturity of the research field is a factor in determining the appropriate research method and technique(s). In this study, BRM is considered in combination with the research field of reference processes. The maturity of the reference model-research field, in general, is very mature. However, the research field of BRM, in general, is less mature to nascent (Kovacic, 2004; Nelson et al., 2010; Zoet, 2014). The focus of research in nascent research fields should lie on identifying new constructs and establishing relationships between identified constructs (Edmondson & Mcmanus, 2007).

To achieve our goal, we analyze the design and application of BRM processes in five case studies at five governmental agencies. Based on this round of data collection, a BRM reference process is constructed and proposed. Then, to increase the generalizability of the BRM reference process, three rounds of validation are conducted in the form of a focus group where subject-matter experts of all five case organizations participated.

Case study research is selected so that the researchers were able to gather data on how BRM is implemented in practice. Therefore, the case studies are exploratory of nature. The organizations are selected from a pool of Dutch governmental institutions that provide public administration services based on laws and regulations that are provided by the Dutch legislative governmental branches. Our study comprised a holistic case study approach, see also the work of (Runeson & Höst, 2009), featuring one context, the design and application of BRM to support decision making, and five cases within this context. The unit of analysis are the BRM processes of the individual case organizations. As the case study approach is exploratory of nature, the data collection and analysis consisted of secondary data (analysis) and semi-structured interviews, which is a combination of first and third-degree data collection. This approach has several advantages and is thoroughly discussed in (Runeson & Höst, 2009).

Adequate research methods to explore a broad range of possible ideas and/or solutions to a complex issue and combine them into one view when a lack of empirical evidence exists consist of group-based research techniques (Delbecq & Van de Ven, 1971; Okoli & Pawlowski, 2004; Ono & Wedemeyer, 1994). Examples of group based techniques are Focus Groups, Delphi Studies, Brainstorming and the Nominal Group

Technique. The main characteristic that differentiates these types of group-based research techniques from each other is the use of face-to-face versus non-face-to-face approaches. Both approaches have advantages and disadvantages, for example, in face-to-face meetings, provision of immediate feedback is possible. However, face-to-face meetings have restrictions with regard to the number of participants and the possible existence of group or peer pressure. To eliminate the disadvantages, we combined the face-to-face and non-face-to-face technique by means of applying case studies and three focus group meetings. In our study, the focus group sessions are conducted to validate and further refine the proposed BRM reference process.

2.4 Data collection and analysis

Data for this study is collected over a period of eight months, between May 2014 to December 2014, through five case studies and a three-round focus group design. Between each focus group round, a team 0f researchers consolidated the results for further elicitation, refinement and validation in the following focus group round. Both methods of data collection and analysis are further discussed in the remainder of this section.

2.4.1 Case Studies

The case studies at the individual organizations were performed over a period of four months, between May 2014 and August 2014. The case studies were designed to be performed in three phases. The first phase comprised the collection of secondary data at the case organizations. The second phase comprised the analysis of the secondary data that was collected in the first phase. The third and last phase comprised the field observations and semi-structured interviews at the case organizations which provided the research team with the possibility to clarify aspects that were identified to be missing in the secondary data provided by the case organizations in the first phase. The selection of the participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In the context of this study, this means that the phenomenon studied is represented by organizations and individuals within these organizations which deal with the design and execution of BRM processes, either manually or automated to handle large amounts of products and services. The five governmental agencies that participated in this research are, from here on, labelled as organization A, B, C, D and E. Combined, the participated organizations serve approximately 17 million clients and companies in the Netherlands with a large variety of e-services like the application, assessment, and notification regarding benefits, subsidiaries, visa's, permits, tax returns, vouchers, loans, grants, screenings, etc. The five governmental agencies are similar in nature in terms of business processes and how law and regulations must be implemented.

The first phase was carried out by a total of five research teams of two or three researchers per case organization, which visited the organizations to collect the secondary data. This yielded a large amount of secondary data which took the research teams two months to structure and analyze completely in the second phase. The analysis of the collected secondary data resulted in a lot of topics to be discussed or further clarified in the third phase of the case studies. During the third phase, we conducted in-depth semi-structured interviews at each case organization. At each case organization, a minimum of two subject-matter experts have been interviewed (in some cases three subject-matter experts were included). The subject-matter experts were asked to go through the BRM processes at their organization and were posed questions by the researchers when needed. The interview protocol has been tailored to each case organization to achieve the maximum result. For example, one interview with two subject-matter experts from case C focused on gathering more information on which artifacts were verified and validated in their corresponding processes as this was impossible to identify from the secondary data collected from this particular case organization. The interviews were all audio-taped and were protocolled within 48 hours. The results from the case studies were consolidated into a BRM process model of each of the participated organizations which served as important input for the focus group rounds.

2.4.2 Focus Groups

After the analysis and consolidation of the case study results were completed the focus groups were prepared and conducted between September 2014 and November 2014. As this study is part of a larger research project, the set-up of the focus groups is similar to that of (Smit & Zoet, 2016) but will be repeated to further clarify and ground our work in this study. Before a focus group is conducted, first, a number of key issues need to be considered: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities and 6) the protocol of the focus group.

Before the focus groups were initiated, the research team started with the preparation of the topics to be discussed to ensure the BRM reference model is validated appropriately. Therefore, based on the individual BRM process models of the case organizations that were built and validated during the case studies, a first version of the BRM reference model was constructed. This was achieved by a coding process. For example, organization A had the following activity: 'Define derivation structure', while organization C applies the activity: 'Define relationships between decisions', and organization D applies the activity: 'Define decision tree'. In the coding process, the term 'define derivation structure' has been selected as the preferred concept, therefore the last two concepts have been re-coded.

During the coding process, we applied Mill's method of agreements and differences, which is an ordinal comparison method focused around the statement that the cause of a phenomenon is the characteristic or combination of characteristics found in each case (Mill, 1906). This means that when a certain activity only occurs in a process of one case organization it's still added to the reference model. The reason for this is that the reference process guides organizations with multiple possibilities in capabilities to choose from.

The goal of the focus group was to assemble and validate the BRM reference process for the Dutch government. We utilized the same selection of Dutch governmental institutions which collaborated in the case study stage, also to increase generalizability. Based on the written description of the goal and consultation with employees of each government agency, participants were selected to take part in the three focus group meetings. In total, seventeen participants took part, which fulfilled the following positions: two business rules architects, five business rule analysts, two policy advisors, three BRM project managers, one tax advisor, two enterprise architects, and two business consultants. Each of the participants had, at least, five years of experience with the design and application of BRM solutions. Each focus group round was chaired by one experienced facilitator. Besides the facilitator, three to five additional researchers were present during the focus group meetings. One researcher participated as 'back-up' facilitator, who monitored if each participant provided equal input, and if necessary, involved specific participants by asking for more in-depth elaboration on the subject. The remaining researchers acted as a minute's secretary, taking notes. They did not intervene in the process. All focus group rounds were video and audio recorded. The duration of the first focus group session was 129 minutes, the second 180 minutes and the third 162 minutes. Each focus group meeting followed the same overall protocol, each starting with an introduction and explanation of the purpose and procedures of the meeting, after which ideas were generated, shared, discussed and/or refined.

Prior to the first round, participants were informed about the purpose of the focus group meeting and were invited to study the case organization-specific BRM reference process, which was derived and consolidated from the case study results. In addition, the first version of the BRM reference process that was constructed from the collection of case-specific BRM processes was also included. All participants were asked to bring any comments, which came up while studying the results, with them to the first focus group meeting. The first round started with the presentations of the case-specific BRM process models derived from the case study results. After the individual presentations, participants discussed the usefulness of each (sub-)process in the BRM processes. Also, additional (sub-)processes were proposed. For each proposed (sub-)process, the 1) name, 2) description, 3) rationale, 4) artifacts and 5) organization-specific examples or instantiations were discussed and noted. After the first focus group, the researchers consolidated the results. Consolidation comprised the construction of the second version of the BRM reference process and the detection of redundant (sub-)processes (i.e. conceptually equal (sub-)processes). The results of the consolidation were sent to the participants of the focus group two weeks in advance for the second focus group meeting. During these two weeks, the participants assessed the consolidated results in relationship to four questions: 1) "Are all (sub-)processes described correctly?", "2) Do I want to remove a (sub-)process?" 3) "Do we need additional (sub-)process?", and 4) "Does the (sub-)process contribute to the BRM reference process for the Dutch government"?" This process of conducting focus group meetings, consolidation by the researchers and assessment by the participants of the focus group was repeated two more times (round 2 and round 3). During the third focus group meeting (round 3), saturation within the group occurred, leading to the consolidated BRM reference process for the Dutch government.

2.5 Results

In this section, the results of the conducted case studies and focus group sessions are presented. First, we report on the results of the case studies. This is followed by the results from the comparative analysis in which the case study results are compared. Lastly, we report on the results of the focus group meetings, which had the goal to validate our findings and come to a BRM reference process for the Dutch government.

2.5.1 Case Study Results

As mentioned in the data collection and analysis section, five case studies were conducted in three stages. Based on the analysis of both the secondary data and interview results, a BRM reference process is created that visualizes how the BRM processes are designed per case organization, see for example Figure 2-1 and Figure 2-2. In our results, we refer to a (sub-)process and artifacts in their singular form, while, in practice, it is possible that (sub-)processes are referred to in their plural form.

In total, the results of the case studies identified multiple similarities and differences between the involved case organizations. However, due to space limitations, we do not cover each individual difference but summarize the differences into topics. See the identification of similarities and differences in Table 2-1. In the comparison we identified whether the (sub-)process is 1) explicitly or 2) implicitly positioned in the BRM processes of the case organization, or 3) is not included. An example of a (sub-)process that is implicitly positioned in the BRM processes of case E is the process "Verify business rule", which is performed by the case organization. However, in their context, a 'product' is verified, which contains the business rule together with other components, thus is implicitly positioned in the BRM processes of the case organization.

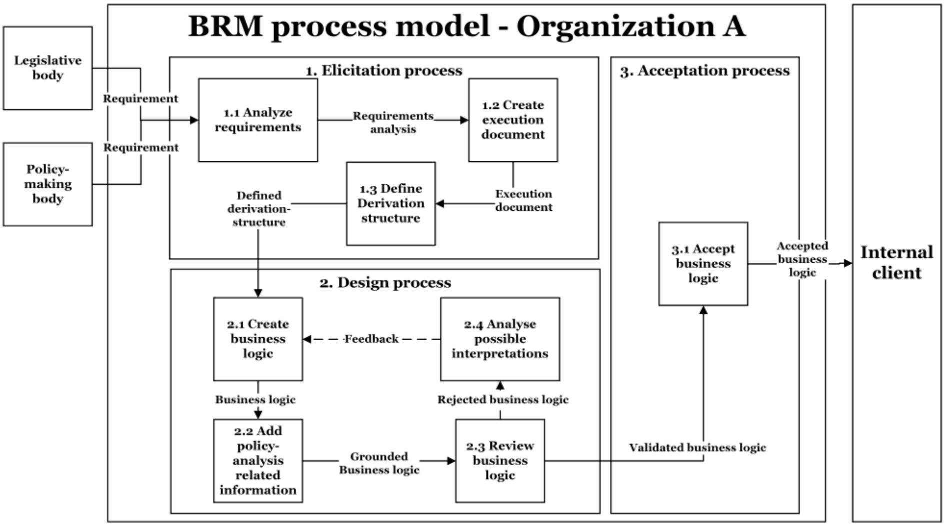

Figure 2-1: BRM process model consolidated from organization A

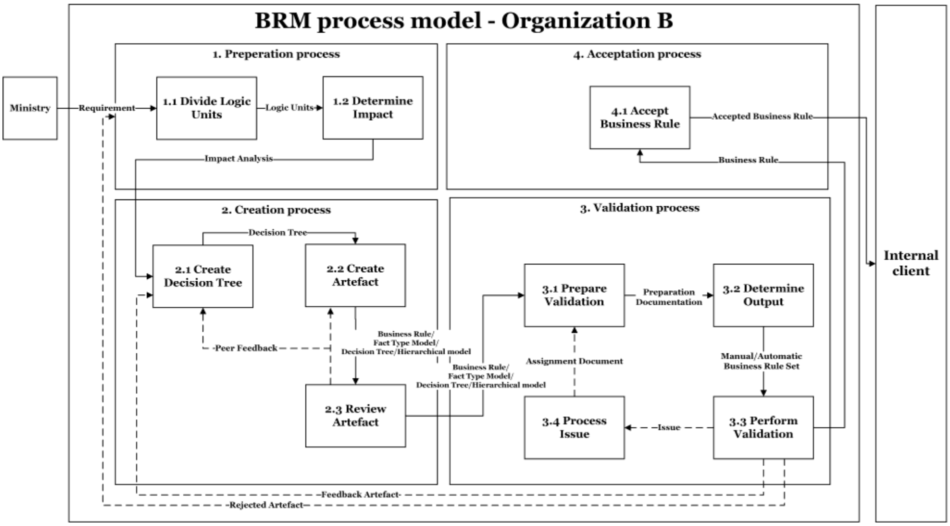

Figure 2-2: BRM process model consolidated from organization B

Another activity that has to be performed by the research team as part of the consolidation is the transformation/mapping of the large variety of concepts applied by the case organizations to uniform concepts with clear definitions from literature. For example, a derivation structure is referred to as a 'decomposition' by case E, a 'knowledge model' by case C, an 'artefact' by case B, and a 'decision tree' by case D.

2.5.2 Focus Group Results

After all case study data was collected, analyzed and consolidated the results of all five case studies were used to prepare the first focus group session. The goal of the focus group sessions was to assemble and validate the BRM reference process, based on the participant's input and feedback.

One of the results of the consolidation was the initial BRM reference process, which was sent two weeks in advance before the start of the first focus group session. The initial reference process yielded much discussion in the first focus group session as the initial reference process did not take into account all the nuances between different processes at the different participated organizations. For example, the majority of the participated organizations did not incorporate the verification and validation processes after all the business decisions and business logic have been created. However, the participants corrected the reference process on how verification and validation is and should be applied. While not all participated organizations applied verification and validation as suggested, all participants agreed that verification and validation should be integrated into the actual design process. This discussion was followed by remarks about the sequentially of the verification and validation processes. Some of the participants argued that verification and validation are performed simultaneously, but also the manner in which both processes were applied was discussed intensely. After the facilitator clarified that the sequentially of both processes are very dependent on the technology applied by an organization, the participants agreed that the verification of an artifact should be performed before the validation of the artifact can be initiated. This was further grounded by the argument of some participants which stated that both capabilities and their underlying processes should not be merged but rather separated, maybe even performed by different roles. For example, a rule author, which is very proficient with regards to a given language to express an artifact is very capable to manually review artifacts on syntax or semantic errors (verification). However, this same rule author could be less capable of determining the actual lawfulness of the artifact (validation), which is in turn performed by a subject-matter expert with regards to that specific legal area. Moreover, many initial labels for processes, subprocesses, and artifacts were discussed upon and corrections were suggested by the participants. This led to the refinement and validation of the reference process after the first focus group session.

The main topic of discussion during the second focus group session was that the reference process contained too much detail in the implementation-dependent section as the participated organizations apply these processes differently. Based on this, the participants decided to only include the first level granularity (process and artifact) with regards to the implementation-dependent section of the BRM reference process. Therefore, the implementation-dependent side (deployment, execution, and partly the governance and evaluation processes) does not contain sub-processes (second-level granularity of the reference process). In addition, the participants stressed that a more explicit reference process is needed with regards to the implementation-independent area of artifact development within BRM. These discussions led to the further refinement and validation of the reference process after the second focus group session.

The last and third focus group session mainly focused on further refinement in the correction of errors or changes in labels for both sub-processes and artifacts. The modifications were discussed with all participants and, where agreed upon, processed into the final BRM reference process for the Dutch government.

2.5.3 BRM Reference Process for the Dutch Government

Based on the data collection and analysis conducted in case studies and focus group sessions we propose the BRM reference process for the Dutch government. As can be observed from Figure 2-3, three different patterns are applied. The dashed areas in the left section of the reference process represent the role and responsibility of the client that instructs requirements. The white areas in the middle section represent the area where artifacts are processed in their implementation-independent language form. An implementation-independent language is defined as: "*a language that complies with a certain level of naturalness but has a delimited predefined expressiveness and is not tailored to be applicable to a specific automated information system*" (Zoet & Versendaal, 2013). The gray areas in the right section represent the area where the artifacts are processed in their implementation-dependent language form. An implementation-dependent language is defined as: "*a language that complies with a specific software formalism, has a delimited predefined expressiveness and is tailored to be interpreted by a particular information system*" (Zoet & Versendaal, 2013).

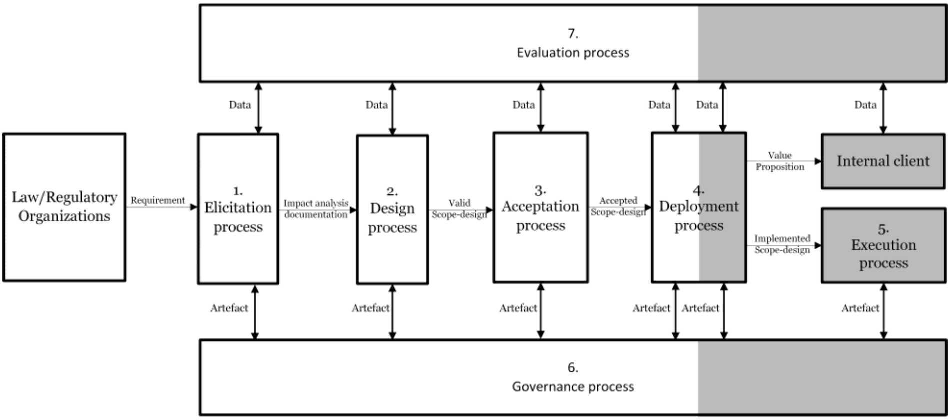

Figure 2-3: BRM reference process – top level abstraction perspective

2.5.4 The Elicitation Process

In the elicitation process, three sub-processes are identified: *1.1 determine scope*, *1.2 identify source,* and *1.3 conduct impact analysis*, see also Figure 2-4*.* The elicitation process, (sub-process 1.1), is triggered by an incoming requirement from one of the clients of the governmental agencies. The goal of this sub-process is to determine the relevant business decisions and business logic. The output of this sub-activity is a selection of sources that need to be analyzed in the subsequent BRM processes. In sub-process 1.2, all sources that correspond with the scope from 1.1 are identified and recorded. Based on both the scope from 1.1 and the relevant sources from 1.2, sub-process 1.3 aims to identify what impact is caused by the (new) requirement. The output of both 1.3 and the elicitation process, in general, is the impact analysis documentation which is input for the *2. Design process*. Impact analysis documentation contains, in detail, what artifacts, or parts of artifacts, need to be created, modified or deleted in order to meet the requirement.

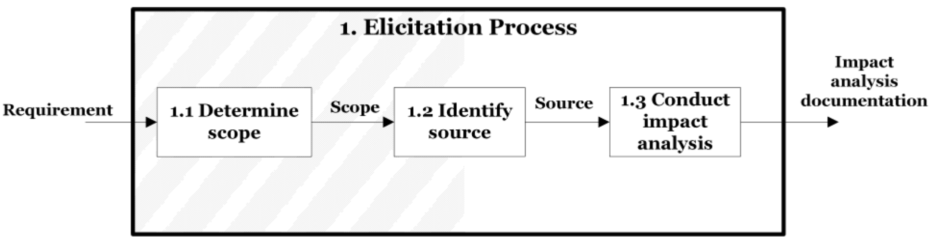

Figure 2-4: Detailed view of the Elicitation Process

2.5.5 The Design Process

In the design process, 14 sub-processes are identified, see also Figure 2-5. Essentially, six artifacts are designed, verified and validated in this process: 1) one or more decision(s), 2) a derivation structure, 3) a fact-type model, 4) business rules, 5) one or more decision design(s), and 6) a scope design. With regards to the first four artifacts, three sub-processes can be identified: define the artifact, see sub-process 2.1, 2.4, 2.7, and 2.10, verify the artifact, see sub-process 2.2, 2.5, 2.8, and 2.11, and validate the artifact, see sub-process 2.3, 2.6, 2.9, and 2.12.

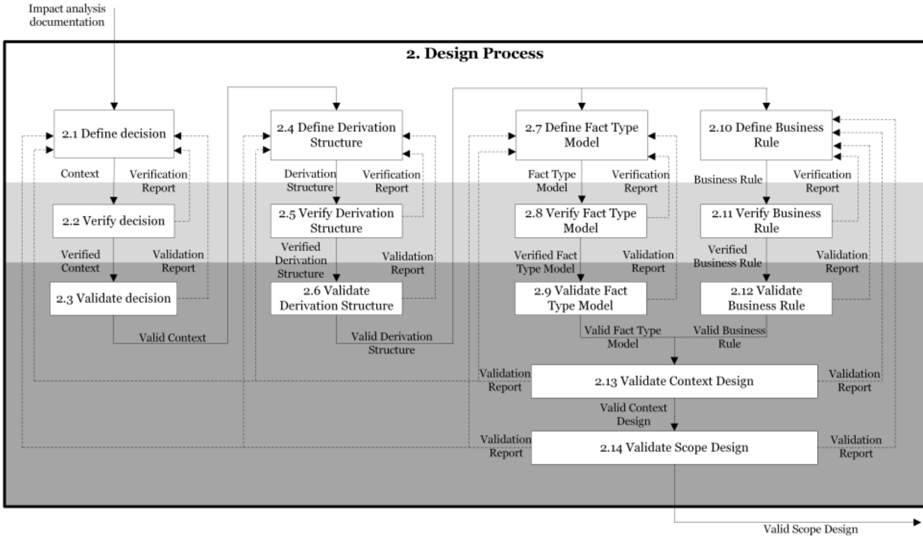

Figure 2-5: Detailed view of the Design Process

The purpose of verification is to determine if the artifact adheres to predefined criteria and are logically consistent (to check for semantic / syntax errors). The purpose of validation is to determine whether the verified artifact holds to its intended behavior (to check for errors in its intended behavior). The goal of the sub-processes 2.1, 2.2, and 2.3 is to create a verified and validated decision. When more decisions are defined, the derivation structure needs to be defined, verified and validated in sub-processes 2.4, 2.5, and 2.6. The goal of a derivation structure is to depict the relationship between different decisions. After the decisions and derivation structure are both verified and validated, the fact-type model, in sub-processes 2.7, 2.8, and 2.9, and business rules, in sub-processes 2.10, 2.11, and 2.12 are created, verified and validated. The purpose of a fact-type model is to have a central repository in which terms, the relationship between these terms, and their definitions for a particular scope are recorded. Terms are used as conditions or conclusions in business rules. Lastly, the sum of all the artifacts in the individual decisions, see sub-process 2.13, and the scope, see sub-process 2.14, are validated once again to ensure all the artifacts combined in both a decision as well as a scope hold to their intended behavior. The output of the design process encompasses the valid scope design, which is the input for the subsequent process, the acceptation process.

2.5.6 The Acceptation Process

The acceptation process consists of a transition between different roles for the sake of segregation of duties. The purpose of the acceptation process is to hand over the scope design to the role(s) responsible for the deployment of the business decisions and business logic. In this process, the role(s) responsible for the deployment have the responsibility to accept or reject the scope design. When the latter one happens, feedback is provided, and the process re-iterates back to either the elicitation or design process.

2.5.7 The Deployment Process

The deployment process is a process in which the accepted implementation-independent scope design is transformed into one or multiple implementation-dependent variant(s). This process can be performed either manually as well as automatically, depending on the actual implementation of the business decision and business logic. A business decision or business logic can be represented by code in an information system, but also as, for example, documentation (i.e. work instructions), websites, manuals, and physical letters.

2.5.8 The Execution Process

The execution process focuses on the execution of the implemented implementation-dependent scope design with the goal to realize the business decisions and business logic as grounded in the requirements submitted by clients. For example, the business decisions and business logic of the scope design 'determine amount of child benefits' could be represented by the actual e-portal where citizens apply for child benefits, the notifications for or communication with citizens regarding the outcome of the decision, and documentation of the business logic implemented and used in the information system(s).

2.5.9 The Governance Process

The governance process consists of validity management, traceability management, and version management. The goal of the governance process is to manage all occurrences from implementation-independent and implementation-dependent artifacts as well as manage the relationship between different artifacts to ensure modifications can be processed. As can been observed, the governance process is positioned along process 1, 2, 3, 4, and 5. Governance, in terms of validity management, traceability management, and version management, is required from the moment a requirement is received from a client as, usually, a lot of artefacts and re-iterations regarding those artefacts are instantiated to execute the business decisions and business logic, see also the work of (Smit & Zoet, 2016). Firstly, the goal of validity management is to be able to provide, at any given time, a specific version of business decisions and business logic that is/was valid at that point of time. Different versions of business decisions and business logic could be valid at the same point in time, see also the work of Boer, Winkels, van Engers, & de Maat (2004). Secondly, the goal of traceability management is to make it possible to trace created artifacts, as parts of business decisions and business logic, to the corresponding laws and regulations on which they are based. Another goal of traceability management is the foundation it forms for impact analysis when new or existing laws and regulations need to be processed into the value proposition. To create a feedback loop with the client that submits requirements, traceability is of importance as it enables the governmental agency to effectively and efficiently analyze the impact a requirement has on the currently implemented business decisions and business logic. Another benefit of traceability is that it enables the demonstration of the legality of the business decisions and business logic towards all stakeholders. Thirdly, the goal of version management is to capture and keep track of version data regarding the artifacts created or modified in the elicitation, design, verification, validation, deployment and execution processes.

2.5.10 The Evaluation Process

In the evaluation process, three sub-processes are identified: 7.1 record data, 7.2 extract data, and 7.3 report key performance indicator, see Figure 2-6. The overall goal of the evaluation process is to manage the quality of all the processes and sub-processes in the reference process. The goal of sub-process 7.1 is to actually store the data from the different processes in the reference process. When data is stored properly, sub-process 7.2 can be instantiated. The goal of sub-process 7.2 is to decompose and structure the stored data so that it can be used for reporting in sub-process 7.3. Lastly, sub-process 7.3 can be instantiated, which results in reported information that is used to control the processes in the reference process, see also the work of (Smit & Zoet, 2016) on a management control system for BRM. An example of a KPI that can be reported on with regards to this sub-process is: "The frequency of executions of an implementation dependent business rule" (Smit & Zoet, 2016).

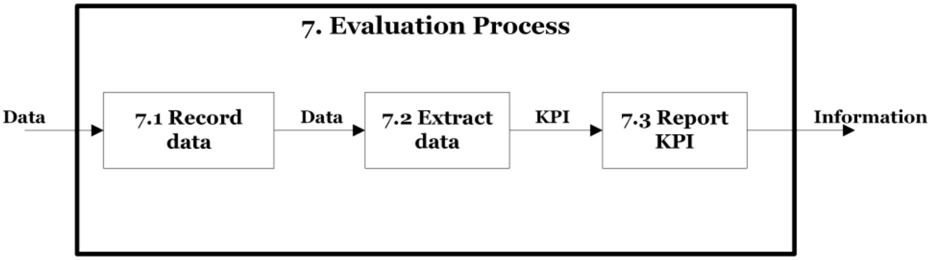

Figure 2-6: Detailed view of the Evaluation Process

2.5.11 Overview of Currently Applied BRM Processes

Further summarized, our findings show design decisions by the case organizations regarding their currently applied BRM processes. First, the results show that the validation capability, but mainly the verification capability are often not included as part of the BRM processes or are included in an implicit manner. The same holds for the acceptation process which is only explicitly applied by two case organizations. Lastly, none of the participated organizations apply any form of monitoring as part of their BRM processes, see also Table 2-1. In this overview, 'Ex' denotes that the activity is explicitly applied by the organization, 'Im' denotes that the activity is implicitly applied by the organization, and a blank cell denotes no explicit nor implicit application of the activity by the organization.

BRM reference process Activity	**A**	**B**	**C**	**D**	**E**
1.1 Determine scope	Ex	Im	Im	Ex	Im
1.2 Identify source	Ex	Im	Im	Im	Ex
1.3 Conduct impact analysis	Ex	Ex	Ex	Ex	Ex
2.1 Define decision	Im	Im		Ex	Im
2.2 Verify decision				Im	
2.3 Validate decision				Ex	
2.4 Define derivation structure	Im	Ex	Im	Ex	Ex
2.5 Verify derivation structure		Im	Im	Im	Im
2.6 Validate derivation structure		Im	Im	Ex	Ex
2.7 Define fact type model		Ex			Ex
2.8 Verify fact type model		Im			Im
2.9 Validate fact type model		Im			Ex
2.10 Define business rules	Ex	Ex	Ex	Ex	Ex
2.11 Verify business rules	Im	Im	Ex	Im	Im
2.12 Validate business rules	Im	Im	Ex	Ex	Ex
2.13 Validate scope design		Im	Im		

2.14 Validate scope design	Im			Im	Im
3. Acceptation process	Ex		Ex		
4. Deployment process	Ex	Ex	Ex	Ex	Ex
5. Execution process	Ex	Ex	Ex	Ex	Ex
6. Governance process	Im	Im	Im	Im	Im
7.1 Record data					
7.2 Extract data					
7.3 Report key performance indicator					

Table 2-1: Comparison of current BRM processes

2.6 Conclusion and Discussion

To conclude our paper we revisit the goal of this research, which is to investigate the current BRM processes at Dutch governmental institutions to derive a BRM reference process for the Dutch government. To fulfil this goal, we aimed to find an answer to the following research question: "Which (sub-)processes constitute a Business Rules Management process for the Dutch governmental agencies?"

In this study, we designed and applied a research approach comprising five individual case studies and a three round focus group. Both research methods were applied to retrieve the BRM (sub-)processes and artifacts as building blocks for the BRM reference process for the Dutch government. In total, 31 participants were involved, which are employed by five governmental agencies in the Netherlands. Our rounds of data collection and analysis resulted in a BRM reference process that can be utilized by Dutch governmental organizations to guide their design and instantiation of their context-specific BRM processes as it embodies a proven template solution for a process for a particular domain, in this case, the application of BRM by governmental agencies. From a research perspective, our study provides a fundament for BRM processes in general, but also provides the knowledge base with an instanced BRM reference process within a governmental context. From a practical perspective, governmental institutions could utilize the results of this study to guide the (re)design of their BRM processes, but equally important, use the reference process to evolve towards a more collaborative mode in which a common vocabulary is developed with the goal to increase commonality. Eventually, more qualitative cooperation between governmental institutions could result in higher quality products and services for citizens and businesses in the Netherlands. Another benefit of this study that was mentioned repeatedly by the participants is the cooperation it facilitated between the different governmental agencies and their employees with regards to BRM.

In contrast, several limitations are applicable to this study, which may affect our results. As the sample group of case organizations and participants is solely drawn from the Dutch government context, our results are limited to be applied in this particular context as well. We argue that government agencies are representative for organizations implementing BRM solutions in general. Regarding this, we strongly suggest that future research should focus on; 1) the investigation of other industries with regards to BRM reference processes and 2) analysis of the amount of similarity or distance between the different BRM reference processes concerning different industries. Also, the sample size of 31 subject-matter experts could be seen as a limitation of this study. Although the research approach chosen for this research type is appropriate, future research should also focus on even stronger validation of the results of this study in the context of the Dutch government, i.e. by applying more quantitative research methods to increase the sample size. This is also grounded by the fact that there are more governmental agencies in the Netherlands that apply BRM, as well as different governmental institutions other that the executive branches, such as central government agencies, province agencies, municipalities, and high councils (i.e. the national audit office).

3 COMPLIANCE PRINCIPLES FOR DECISION MANAGEMENT SOLUTIONS AT THE DUTCH GOVERNMENT

Since decision management is becoming an integrated part of business process management, more and more decision management implementations are realized. Therefore, organizations search for guidance to design such solutions. Principles are often applied to guide the design of information systems in general. A particular area of interest when designing decision management solutions is compliance. In an earlier published study (Zoet & Smit, 2016) we took a general perspective on principles regarding the design of decision management solutions. In this paper, we re-address our earlier work, yet from a different perspective, the compliance perspective. Thus, we analyzed how the principles can be utilized in the design of compliant decision management solutions. Therefore, the purpose of this paper is to specify, classify, and validate compliance principles. To identify relevant compliance principles, we conducted a three round focus group and three round Delphi Study which led to the identification of eleven compliance principles. These eleven principles can be clustered into four categories: 1) surface structure principles, 2) deep structure principles, 3) organizational structure principles, and 4) physical structure principles. The identified compliance principles provide a framework to take into account when designing information systems, taking into account the risk management and compliance perspective.

3.1 Introduction

A business process realizes business objectives or goals, thereby creating value for the organization. Business processes management is used by organizations to manage and execute their coordinated, value-adding activities (Rikhardsson, Best, Green, & Rosemann, 2006). A specific type of activity are decisions (Breuker & Van de Velde, 1994). Nowadays decision management is becoming an integrated part of business process management. An example of this is the recently released Decision Model and Notation (DMN) standard (Object Management Group, 2015). For both business process management as well as decision management compliance issues are an im-

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portant consideration when designing, deploying and executing business processes and/or decisions.

Research investigating the relationship between compliance and business processes is executed, amongst others, by Caron, Vanthienen & Baesens (2013), Ghose & Koliadis (2007), Rikhardsson, Best, Green & Rosemann (2006) and Sienou, Lamine & Pingaud (2008). The purpose of the previously mentioned research is to integrate the business process management discipline and compliance (management). Thereby influencing the manner, in which business processes are designed, analyzed, configured, enacted and evaluated. Now that more and more decision management solutions are introduced, organizations are searching for guidance to design such solutions in a compliant manner. In multiple other disciplines, such as system engineering and industrial engineering, the utilization of principles is an important mechanism to guide the design of products and information systems. A principle is a statement of an organization's belief about how they want to use a specific product or information system. In our context, principles are therefore statements of an organization's belief on how to design decision management solutions taking into account compliance requirements.

Research on compliance and decision management is commonly addressed as a singular oriented problem, meaning that compliance demands focus on a specific problem (Liao, 2004; Wagner, Otto, & Chung, 2002). Yet, previous research has shown that compliance requirements have a common design problem. A common design problem indicates that common problem classes, for which design solutions can be created, exist. In an earlier published study (Zoet & Smit, 2016) we focused on the design problem decision management in general. This research extends the previous study by solely focusing on principles from a compliance perspective. The compliance principles that affect decision management solutions are structured along the following structures: 1) the deep structure, 2) the organizational structure 3) the physical structure and, 4) the surface structure (Strong & Volkoff, 2010; Weber, 1997). With these premises, the following research question is addressed: "Which principles are essential to design a compliant decision management solution?" Answering this question will help organizations better understand the design and management of decision management solutions while taking compliance into account.

The paper is structured as follows: In section two the relationship between operational and compliance risk and its influence on business processes and decision management is discussed. This is followed by section three in which the research method utilized to identify the compliance principles for compliance is elaborated upon. Furthermore, the collection and analysis of our research data are described. Subsequently, our validated collection of compliance principles is presented. Finally, in Section six, conclusions and suggestions for further research are discussed.

3.2 Background and Related Work

Decisions are amongst the most important assets of an organization (Blenko, Mankins, & Rogers, 2010). A decision is: "the act of determining an output value (the chosen option), from a number of input values, using logic defining how the output is determined by the inputs." Examples of decisions are: 1) determine what illness a patient has, 2) determine the risk factor for a specific customer or 3) determine what medicine a patient needs. If an organization can't consistently make and execute the right decision(s), large risks are taken that can eventually lead to high costs or bankruptcy. Following the previous example: imagine what happens when a doctor makes the wrong decision continuously or a customer with a high- risk factor gets appointed a low-risk factor. Decision management always received a lot of interest both from research and practice (Arnott & Pervan, 2005). One of the latest developments is the introduction of the Decision Model and Notation (DMN) in September 2015, by the Object Management Group (OMG). The DMN standard recognizes two levels of abstraction for decisions: decision requirements and the decision logic. The decision requirements level is captured in a decision requirements diagram and is used to identify decisions, the input data and business knowledge needed to make the decision, and the knowledge source on which the decision logic is based. At the decision logic level, the business rules applied to make a decision are specified. The highest level of abstraction; represented with the decision requirements diagram, recognizes four key concepts: 1) a decision, 2) business knowledge, 3) input data, and 4) a knowledge source. The decision logic level has no key concepts, as decision logic could be represented by different representations such as decision trees, decision tables, and/or natural languages. The representation selected to represent the decision logic does not influence the decision requirements level.

The "entirety of all measures that need to be taken in order to adhere to laws, regulations and guidelines within the organization, subsumed as compliance sources" is defined as compliance (Daniel et al., 2009). A rising concern in information systems engineering is compliance management. Managing compliance can be defined as the process of assessing an organizational adherence to a set of legal requirements and expectations (Breaux, 2009). Examples of laws and regulations organizations have to comply with are the Payment Card Industry Data Security Standard (PCI DSS), the Federal Information Security Management Act (FISMA), the Foreign Account Tax Compliance Act (FATCA), the BASEL accord, and the Health Insurance Portability and Accountability Act (HIPAA) (Zoet, 2014). Not adhering to compliance, also referred to as noncompliance, poses organizations with various risks, for example, legal fines, civil fines, re-engineering costs, public harms, consumer churn, and loss of public trust (Breaux, 2009).

Compliance is increasingly affecting the way decisions are designed, specified and executed. Legislation and regulations can precisely dictate or restrict how decisions should be designed, specified and executed. This is, for example, the case with tax laws, which is often defined by national regulations, i.e. calculation of taxes according to income scales. Furthermore, compliance affects decision making in terms of transparency. An example of this form of influence can best be described with how the Dutch government is enforced to provide Dutch civilians with information on with what data, how and by whom decisions are taken regarding applications for child benefits or licenses. The third form of influence that is becoming increasingly important is the exploitation of responsibilities of decision making. For example, in the governmental sector, compliance states that decisions regarding amnesty are convened by the Dutch Immigration and Naturalization Service. However, the law dictates that the minister of justice is appointed as final responsible. Outside the governmental context, the responsibility regarding decisions and their outcomes are often convened with, for example, managers, CFO's and CEO's (Nutt, 1993).

The concept of compliance is researched from different perspectives in which three general views can be distinguished: 1) the analysis of compliance law, 2) the realization of the internal system to establish compliance, and 3) the actual reporting of compliance to the outside world. Research on the realization of the internal system is highly focused on providing design solutions for specific problems classes. For example, Pittet et al. (2000) limit their research to hand hygiene in the healthcare sector whereas O'Grady et al. (2001) focus on the singular problem of catheter-related infections. Research with a broader scope, but still problem class-oriented, is executed by Goedertier and Vanthienen (2006) and Caron et al. (2013) who look at the design of patterns for compliant business processes. In our research, we focus on compliance principles that limit the choices an organization has to create a specific design solution for a specific problem class (Winter, 2011). Therefore, instead of evaluating specific instances of a compliance solution which also reduces generalizability of our results, we look at the principles that ground the instantiation of specific compliance solutions.

Multiple definitions and types of principles are discussed in literature, like scientific principles, normative principles, system principles, and design principles. We will not discuss the differences and/or underlying similarities of those concepts. A detailed view on this is presented in the work of Greefhorst and Proper (2011). In this paper, we solely focus on design principles. A design principle is defined as (Greefhorst & Proper, 2011): "A normative-principle on the design of an artifact. As such, it is a declarative statement that normatively restricts design freedom." A simple example of a design principle for the modeling of business processes is formulated as follows (Johannesson & Perjons, 2001, p17): "Each request needs to be confirmed". This pair of request and confirmation is optionally followed by a notification. Another example of a design principle regarding enterprise architecture is formulated as (Richardson, Jackson, & Dickson, 1990): "Information systems will need to be developed using formal planning and software engineering methodologies."

Greefhorst and Proper (2011), argue that design principles can be interpreted as a rule of conduct, as they guide/direct the enterprise by normatively restricting design freedom. Principles fill the gap between high-level strategic intentions and concrete design decisions. Principles ensure that a solution is future-directed, and can guide design decisions. Furthermore, they document fundamental choices in an accessible form and ease communication with all relevant stakeholders. Based on a design science research approach, Greefhorst and Proper (2011) propose eight steps to define principles: 1) determine drivers, 2) determine principles, 3) specify principles, 4) classify principles, 5) validate and accept principles, 6) apply principles, 7) manage compliance, and 8) handle changes. The first step 'determine drivers' exists out of collecting drivers to serve as starting point to define the principles. Drivers that serve as input for the definition of principles can be risks, goals, objectives, values, issues, potential rewards, and/or constraints. However, many drivers are not explicitly documented, so they have to be collected from stakeholders. After the relevant drivers have been collected they are translated into candidate principles, in the second step 'determine principles'. This step exists out of three phases. First, candidate principles are derived from drivers, domain knowledge, and/or existing principles, after which this list is filtered and the relevant principles are selected. Each relevant principle is further generalized or specified to the right level of abstraction. During the third step 'specify principles' the principles are further detailed. This means that the rationale, implications, and an example are specified. After the rationale, implications, and an example are added, the principles are validated within the organization(s). The next two steps ('apply principles' and 'manage compliance') focus on applying the principles and making sure the organization complies with them. Lastly, Greefhorst and Proper (2011) propose an eighth step: 'handle changes'. They argue that defined principles can change because drivers can change and, therefore, a change management process should be in place. One can also argue that the eighth step is not a separate step but step seven should be connected to step one (creating a lifecycle), since the identification of new and changing drivers is part of step one: 'determine drivers'. In this research, the focus will be on step one, to and including, step five. Step six, seven, and eight are beyond the scope of this research due to the fact that the principles need to be implemented and utilized over a longer period by the participating organizations in order to measure their effectiveness, and, based on feedback, apply changes.

To structure the identified compliance principles, the dimensions and ontological foundations of the extended information systems framework is applied (Weber, 1997).

The extended information system framework has been proposed by Strong and Volkoff (2010), describing that principles can be categorized into four categories: 1) deep structure, 2) organizational structure 3) physical structure, and 4) surface structure. Deep structure elements are subjects that describe real-world systems, their properties, states and transformations (Weber, 1997). Organizational structures are the roles, control and organizational culture represented within organizations or within solutions (Strong & Volkoff, 2010). Physical structure elements describe the physical technology and software in which the deep structure is embedded (Weber, 1997). Surface structure elements describe the elements that are available in the information system to allow users to interact with the information system (Strong and Volkoff, 2010).

3.3 Research Method

The goal of this research is to identify compliance principles that limit the freedom with regards to decision management solutions. In addition to the goal of the research, also, the maturity of the research field is a factor in determining the appropriate research method and technique(s). The maturity of the object under research: compliance principles for decision management is nascent (Kovacic, 2004; Nelson, Peterson, Rariden, & Sen, 2010; Zoet, 2014). Focus of research in nascent research fields should lie on identifying new constructs and establishing relationships between identified constructs (Edmondson & Mcmanus, 2007). Summarized, to accomplish our research goal, a research approach is needed in which a broad range of possible compliance-focused principles for decision management are explored and combined into one view in order to contribute to the body of knowledge, taking into account the five steps of Greefhorst and Proper (2011).

Adequate research methods to explore a broad range of possible ideas / solutions to a complex issue and combine them into one view when a lack of empirical evidence exists consist of group-based research techniques (Delbecq & Van de Ven, 1971; Murphy et al., 1998; Okoli & Pawlowski, 2004; Ono & Wedemeyer, 1994). Examples of group based techniques are Focus Groups, Delphi Studies, Brainstorming and the Nominal Group Technique. The main characteristic that differentiates these types of group-based research techniques from each other is the use of face-to-face versus non-face-to-face approaches. Both approaches have advantages and disadvantages, for example, in face-to-face meetings, provision of immediate feedback is possible. However, face-to-face meetings have restrictions with regard to the number of participants and the possible existence of group or peer pressure. To eliminate the disadvantages, we combined the face-to-face and non-face-to-face technique by means of applying the following two group based research approaches: a Focus Group and a Delphi Study.

3.4 Data Collection and Analysis

Data for this study is collected over a period of six months, through three rounds of focus groups (round 1, 2 and 3: experts focus group) and a three-round Delphi study (round 4, 5 and 6 Delphi study), see Figure 3-1.

Research Team	Experts: Focus Group	Experts: Delphi Study
Round 1: Preperation Focus Group		
Round 2: Consolidation	*Round 1:* Elicitation	
Round 3: Consolidation	*Round 2:* Elicitation, Refinement and Validation	
Round 4: Consolidation	*Round 3:* Elicitation, Refinement and Validation	
Round 5: Consolidation	*Round 4:* Elicitation, Refinement and Validation	
Round 6: Consolidation	*Round 5:* Refinement and Validation	
Round 7: Consolidation	*Round 6:* Refinement and Validation	

Figure 3-1: Visualization of the Research Approach

Between each individual round of the focus group and Delphi Study, researchers consolidated the results (round 1, 2, 3, 4, 5, 6 and 7: research team). Both methods of data collection are further discussed in the remainder of this section.

3.4.1 Focus Groups

Before a focus group is conducted, a number of key issues need to be considered: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities, and 6) the protocol of the focus group. The goal of the focus group was to identify compliance principles for decision management solutions. The selection of the participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In this study, organizations and individuals that deal with a lot of business rules represent the phenomenon studied. Such organizations are often financial and government institutions. During this research, five Dutch government institutions participated. Based on the written description of the goal and consultation with employees of each government institution, participants were selected to take part in the three focus group meetings. In total, twelve participants took part who fulfilled the following positions: three enterprise architects, two business rules architects, three business rules analysts, one project manager, one IT architect, and two policy advisors. Each of the participants had, at least, five years of experience with business rules. Delbecq and van de Ven (1971) and Glaser (1978) state that the facilitator should be an expert on the topic and familiar with group meeting processes. The selected facilitator has a Ph.D. in Decision Management, has conducted 7 years of research on the topic, and has facilitated many (similar) focus group meetings before. Besides the facilitator, five additional researchers were present during the focus group meetings. One researcher participated as 'back-up' facilitator, who monitored if each participant provided equal input, and if necessary, involved specific participants by asking for more in-depth elaboration on the subject. The remaining four researchers acted as a minute's secretary taking field notes. They did not intervene in the process; they operated from the sideline. All focus groups were video and audio recorded. A focus group meeting took on average two hours. Each focus group meeting followed the same overall protocol, each starting with an introduction and explanation of the purpose and procedures of the meeting, after which ideas were generated, shared, discussed and/or refined.

In an earlier study (Zoet & Smit, 2016) we discussed the identification of general design principles for decision management in more detail. In this study, we refer to the results of these round after which we discuss the identification of the compliance principles. The first round of data collection of this previous study yielded 343 general principles. Consolidation of these results eventually led to the deletion of 321 principles, presenting a grand total of 22 consolidated and validated general principles for the design of decision management solutions.

<table>
<tr><td>Principle ID:</td><td>06</td></tr>
<tr><td>Principle label:</td><td>Decisions, business rules, and data are recorded according to two time dimensions</td></tr>
<tr><td>Description:</td><td>Decisions, business rules, and data must be recorded according to two time dimensions. The first time dimension is the system time, the second time dimension is the business time. The business time dimensions record the date when a decision, business rule or piece of data is valid (Bus_Start) and the date its validity ends (Bus_end). The system time records the time the decision, business rule or piece of data is entered into the system (Sys_Start) and when it's updated (Sys_End).</td></tr>
<tr><td>Example(s):</td><td>This example shows a schematic overview of business rule 45 and the registration of system time and business time:
<table>
<tr><th>BR_ID</th><th>Content</th><th>Sys_Start</th><th>Sys_End</th><th>Bus_Start</th><th>Bus_End</th></tr>
<tr><td>045</td><td>A</td><td>04-07-2014</td><td>14-04-2014</td><td>04-04-2014</td><td>∞</td></tr>
<tr><td>045</td><td>A</td><td>14-04-2014</td><td>14-04-2014</td><td>04-04-2014</td><td>14-04-2014</td></tr>
</table></td></tr>
<tr><td>Rationale:</td><td>This compliance principle is useful in situations where decisions are evaluated based on laws no longer in effect. For example, a decision is made in 2013. A citizen objects to the decision in 2015. In this situation, the decision should be evaluated against the business rules utilized in 2013, and not against the business rules being valid in 2015. When a lawsuit is being processed, the system must be able to retrospectively reconstruct the situation with 1) the data of the relevant stakeholder used in 2013 and 2) the business rules applied in 2013.</td></tr>
<tr><td>Classification:</td><td>Deep structure</td></tr>
</table>

Figure 3-2: Example compliance principle result: Decisions, business rules, and data are recorded according to two time dimensions

The 22 general principles are the starting point for this study, the identification and analysis of the compliance principles. Prior to the first round, participants were informed about the purpose of the focus group meeting and were invited to submit their current compliance principles applicable regarding the decision management problem space. Each of the participants submitted the principles who, according to them, affect their compliance demands, in advance to the first focus group meeting. During the first focus group participants got the opportunity to elaborate upon their submitted compliance principles. After the individual presentations, participants discussed the usefulness of each compliance principle. For each proposed compliance principle, the principle ID, label, rationale, classification, and instantiations were discussed and noted, see figure 3-2 for an example. Because these characteristics have been discussed before the main focus was on the rationale for compliance. The first round resulted in 1) the refinement of the principle labels, descriptions, examples, rationale and classification, and 2) the deletion of 11 principles.

After the first focus group, the researchers consolidated the results. Consolidation of the results comprised the detection of double principles and incomplete principles. This process is executed as follows. All compliance principles have been transformed into columns and rows in an (ordinal) comparison table. An example snapshot that was utilized has been added in figure 3-3.

		Compliance principle 3				
		Description	Example	Rationale	Classification	Goal
Compliance principle 21	Description	=/				
	Example		=/			
	Rationale			==		
	Classification				=/	
	Goal					=/

Figure 3-3: Snapshot Meta-Model Comparison Table

For each compliance principle the description, example, rationale, classification, and goal were compared by three researchers, which comprised the back-up facilitator and two 'minutes' researchers from the focus groups. When double principles or incomplete principles were discovered a note was made and was added to the results of the consolidation. In situations where the three researchers didn't agree on the comparison, the fourth researcher, the facilitator of the focus groups, compared the principles and discussed the results with the first three researchers until consensus was reached.

The results of the consolidation were sent to the participants of the focus group two weeks in advance for the second focus group meeting. During these two weeks, the participants assessed the consolidated results in relationship to four questions: 1) "Does the principle affect compliance of the decision management solution?", 2) "Are all compliance principles described correctly?" (in terms of the principle label, accompanied examples, and its rationale), 3)"Do I want to remove a compliance principle?", and 4) "Do we need additional compliance principles?". During the second focus group, the participants discussed the 11 principles. Again, the researchers consolidated the results and send them to the participants two weeks in advance. During the third focus group, the participants discussed the refined 11 compliance principles. The discussion did not lead to new compliance principles and focused on further refinement of the existing compliance principles in terms of descriptions, rationale, classification, and goals of each of the 11 compliance principles.

3.4.2 Delphi Study

Before a Delphi study is conducted, also a number of key issues need to be considered: 1) the goal of the

Delphi study, 2) the selection of participants, 3) the number of participants, and 4) the protocol of the Delphi study. The goal of the Delphi study was twofold. The first goal was to validate and refine existing principles identified in the focus group meetings, and the second goal was to identify new principles. Based on the written description of the goal and consultation with employees of each organization, participants were selected to take part in the Delphi study. In total, 44 participants took part. thirty-two experts, in addition to the twelve experts that participated in the focus group meetings, were involved in the Delphi Study. The reason for involving the twelve experts from the focus groups was to decrease the likelihood of peer-pressure amongst group members as could have been the case in the focus group meetings. This is achieved by exploiting the advantage of a Delphi Study which is characterized by a non-face-to-face approach. The non-face-to-face approach was achieved by the use of online questionnaires that the participants had to return via mail. The thirty-two additional participants involved in the Delphi Study had the following positions: three project managers, one enterprise architect, ten business rules analyst, four policy advisors, one IT-architect, five business rules architects, two business consultants, one functional designer, one tax advisor, one legal advisor, one software engineer, one knowledge management advisor, and one legislative author. Each of the participants had, at least, two years of experience with business rules. Each round (4, 5, and 6) of the Delphi Study followed the same overall protocol, whereby each participant was asked to assess the principles in relationship to five questions: 1) "Are all compliance principles described correctly?", "2) Do I want to remove a compliance principle?" 3) "Do we need additional compliance principles?", 4) "Does the principle contribute to compliance?" and 5) "How does the principle affect the decision management problem space?"

Additionally, to guard consistency of the selection of compliance principles by the participants, both the physical introduction at the start of the focus group meetings and the written introduction for the Delphi study contained literature regarding compliance and principles. This ensures a consistent interpretation of the concepts compliance and principles. The literature utilized regarding compliance and principles is identical to the definitions provided in the literature section of this paper.

3.5 Results

In this section, the identified principles are presented and the reduction of freedom they realize is described. The principles have been categorized along the dimensions of the ontological foundations of the extended information systems framework (Strong and Volkoff, 2010). A visualization of the classification is shown Figure 3-4. Table 3-1 contains the description of a principle taken from the derived list of principles. The example includes: 1) the principle's ID, 2) its label, 3) a description, 4) a short practical example, 5) a rationale, and 6) the classification of the principle. Due to space limitations, the remaining 10 principles are presented per category or a combination of categories by a shorter representation, only describing 1) the principle's ID, 2) the principle's label, and 3) (a short) the description of the principle.

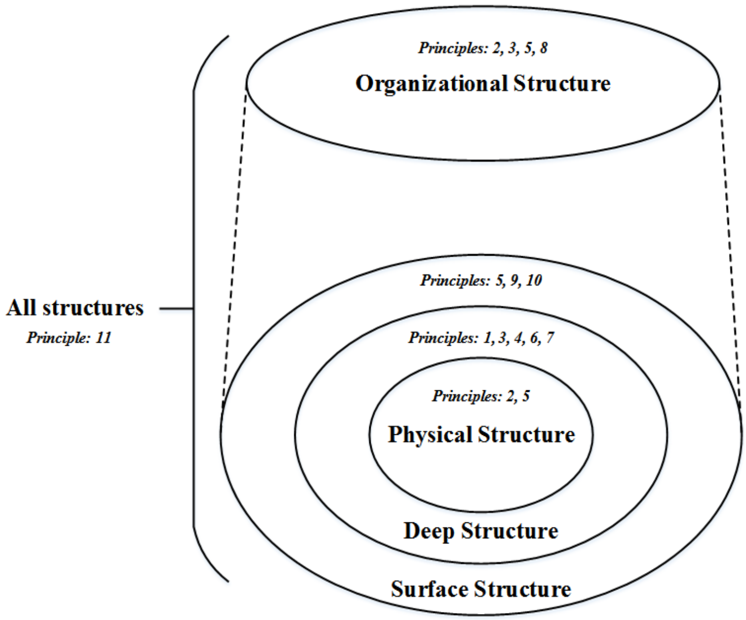

Figure 3-4: Classification of Compliance Principles

3.5.1 Compliance Principles

In this sub-section, the derived compliance principles are presented. The possible overlap of each principle with regards to their classification is depicted in figure 3-4.

Principle 1: IT does not formulate business rules

The first principle prescribes that decisions and underlying business rules should always be specified by an employee from the business domain (non-IT-professional). Examples of roles from the business are: tax specialist, risk specialist or compliance specialist. Employees from the IT department are not allowed to formulate or change the business rule. The rationale behind this choice is the expertise needed to 1) read and interpret laws and regulation and be able to 2) transform the source documents into a decision architecture and business rule (sets) is expertise which differs from IT expertise.

Principle 2: Authorization for decision-making

The second principle prescribes that organizations should implement authorization mechanisms for decision-making so that only authorized employees can make decisions. The rationale behind this principle is that employees which are not allowed to make a specific decision are not able to do so. An example from one specific government agency is that the law prescribes who should take a specific decision. If the decision is taken by another role the application is unlawful.

Principle 3: Ownership of a decision is defined

The third principle focuses on the explicitation of ownership and/or accountability per decision. It can be regarded an extended version of principle 2. Organizations often do not define the roles and responsibilities of employees, functions or departments with respect to a specific decision. Blenko and Roger (2010) identified this problem and addressed this problem by creating RAPID. RAPID is a framework which is used to define which role each department, team or person has with regards to a specific decision. According to their research, ambiguity regarding accountability of decisions could originate from the following four bottlenecks: 1) global versus local, 2) center versus business unit, 3) function versus function, and 4) inside versus outside partners. Furthermore, Blenko and Roger showed that defining roles for decisions increases organizations effectiveness.

Take for example the collaboration between two government institutions concerning the calculation of child benefits. In this particular case both the Dutch Tax and Customs Administration and the Dutch Social Security Agency execute decisions to decide whether a family is eligible for receiving child benefits, the height of the child benefits, and for how long the family will receive child benefits. The Dutch Social Security Agency actually makes this decision to grant child benefits while the Dutch Tax and Customs Administration makes this decision to calculate other benefits.

Principle 4: Each decision and related data need to be traced

The fourth principle stresses the importance of being able to trace how decisions were taken. To be able to do so, the activity's input, applied business rules, and output must be stored. The rationale behind this principle is the ability to check how a specific decision was taken. Take for example a situation where student benefits are wrongfully rejected based on the data and documents delivered by the student. A law in the Netherlands states that students have the possibility to appeal against the decision of a governmental agency. If they choose to file for appeal the governmental agency responsible for providing student benefits needs to evaluate if an error was made and in the case an error was made, correct the error.

Principle 5: Communication with the same standards wherever possible, communication with different standards where desirable

The fifth principle focuses on the utilization of communication standards (BR-related languages). Communication between stakeholders which are involved in the business rules management processes must be aligned. Where possible, the same terms, in different situations should have the exact same definitions. This can be supported by means of a centralized list with definitions that can be utilized by different stakeholders. Where desirable, the same terms have different definitions in different situations. For this, a translation has to be made for each 'different' translation of the definition and added to the definition list.

For example, the Dutch Tax and Customs Administration forces all employees and partners to work with standard communication protocols. As the size of the organization expands, communication regarding business rules and decisions will get more complex. As standards are applied as much as possible, common languages will be adopted, potentially lowering communication issues and improving collaboration between stakeholders regarding business rules and decisions. However, the principle states that for some (critical) instances organizations should be able to utilize different standards (other than the acceptable ones). It goes without saying that this should be avoided as much as possible.

Principle 6: Decisions, business rules, and data are recorded according to two time dimensions

The sixth principle dictates that decisions, business rules, and data are recorded according to two time dimensions, which is described in detail in our example in table 3-1.

Principle 7: All business rules refer to a source

Decisions and underlying business rules are based on one or more sources. By referring the actual business rules to a source, organizations can more easily argue why a specific decision has been made. In addition, it also makes impact analysis of changing laws easier. Take for example laws and regulations regarding taxation of income. In the Netherlands alone, this particular law affects over nine million Dutch citizens. When business rules are utilized in (automated or partly automated) decision services, its design should be based upon sources in all relevant and valid legal documentation. This is important so that none of the business rules utilized in the decision services can be questioned regarding legality by the people affected by the decisions it takes.

Principle 8: Gaming only allowed by gamers

The eight principle prescribes that, where necessary, 'playing' with business rules should be limited. When Organizations are unable to do so clients possibly start to experiment in order to achieve the optimal results for them. An argument that some participants made is that employees should be allowed to game. The argument they list for this is that sometimes, when applying law reasonableness and fairness, is more important than applying the law by the actual letter.

For example, when clients are able to experiment while applying for disability allowances, decisions regarding the eligibility, duration, and the height of the allowances could be changed ('played') to realize more positive outcomes. As stated in the previous paragraph an employee must be allowed to do so.

Principle 9: Transparency concerning decision making for clients and users

The ninth principle stresses that governmental agencies design its services in a client-oriented manner. It is important that clients recognize the services provided and understand the decision-making progress (minimally high-level).

Take for example the process of a request for unemployment benefits. Usually, this process is complex and can run for multiple weeks or months depending on the difficulty of the given situation. A request for unemployment benefits is processed in multiple process activities by multiple departments, employing multiple specialists. To reduce concerns or impatience of clients and users that submitted the request, a portal is available where the progression of the request is shown.

Principle 10: Sharing knowledge concerning the execution of laws, regulations, and policies with employees, partners, and clients

The tenth principle states that organizations should share their knowledge regarding the design and execution of laws, regulations, and policies with employees and clients. With regards to government institutions, this means that they should provide the decision models to third parties as well as the decision services. In the first case, third parties can assess how the actual decision is made while in the second case they can actually use the decision service to make the decision. This would solve the problem that is addressed in principle three. The Dutch Tax and Customs Administration can review the decision service of the Dutch Social Security Agency. If they agree with the model the Dutch Social Security Agency created they can use the decision service. If they don't agree they can discuss the model with the Dutch Social Security Agency and try to come to a consolidated decision model.

Principle 11: Utilize government-wide standards

The eleventh and last principle prescribes the use of government-wide standards. Government standards describe a structured way in which data and business rules should be handled or how processes should be performed. For example, the Dutch government utilizes multiple standards regarding Enterprise architecture, communication, ICT, etc. These standards focus on standardization of activities concerning data management, process management, and rule management. An example of this is the Dutch Governmental Reference Architecture (NORA). It is built on top of a set of basic principles for digital services delivered by the whole Dutch government. Utilizing such widely applied standards potentially results in more efficient and effective collaboration regarding decision management.

3.6 Conclusions and Limitations

In this paper, we aimed to find an answer to the following question: "Which principles are essential to design a compliant decision management solution?" To accomplish this goal, we conducted a study combining a three round focus group and three round Delphi Study. Both were applied to retrieve compliance principles from participants, 44 in total, employed by five governmental institutions. Our rounds of data collection and analysis resulted in 11 relevant compliance principles which should be taken into account when designing a decision management solution. From a research perspective, our study provides a fundament for design principles focused on compliance, which can be applied to create or implement a decision management solution. An important step as the identified principles can now be applied in practice, and their impact can be measured and further evaluated upon. From a practical perspective, our study provides organizations and (enterprise) architects within organizations with a set of principles that can be applied to guide the design of decision management solutions. It offers a framework that can structure thinking about the solution that needs to be implemented, taking into account the compliance perspective.

Several limitations may affect our results. The first limitation concerns the sampling and sample size. The sample group of participants is solely drawn from government institutions in the Netherlands. While we believe that government institutions are representative for organizations implementing decision management, further generalization towards non-governmental organizations, amongst others, is recommended. Taken the sample size of 44 participants into account, this number needs to be increased in future research. Moreover, a possible limitation in our research setup (focus groups and Delphi study) was the difference in minimum years of experience with regards to decision management. This may have led to the participants of the Delphi study not formulating additional compliance principles, they only supplemented the existing compliance principles. This research focused on identifying new constructs and establishing relationships given the current maturity of the decision management research field. Although the research approach chosen for this research type is appropriate, research focusing on further generalization should apply different research methods, such as quantitative research methods, which also allow us to incorporate larger sample sizes to validate our findings. Lastly, future research could focus on the effects of the implemented principles.

4 VERIFICATION CAPABILITIES FOR BUSINESS RULES MANAGEMENT IN THE DUTCH GOVERNMENTAL CONTEXT

The management of business decisions and business logic play a critical role in an organization's daily activities. As laws, regulations and/or internal policies need to be translated into logically correct business decisions and business logic it is essential to govern and guard the logical soundness of the business decisions and business logic specified. This capability is often referred to as verification. However, the current knowledge base regarding verification as a capability is not yet researched in relation to the new Decision Model and Notation standard, developed by the Object Management Group to model and execute decisions and underlying business logic. The purpose of this paper is to identify which verification capabilities are applied in the Dutch governmental context. To identify the different verification capabilities, we conducted a three-round focus group, which led to a collection of 28 verification capabilities. Furthermore, we aimed to adequately specify each of those capabilities by demonstrating them with real-life case examples. The identified verification capabilities provide a framework to take into account when designing business rules management solutions.

4.1 Introduction

Business rules (BR's), as part of business logic, are increasingly being utilized in enterprises as building blocks for (automated) decision making, for example, supporting execution of various types of e-services like applying for an insurance product and applying for social benefits and automated fraud detection at financial organizations. As a result, organizations employ various methods and processes to manage these BR's, often referred to as Business Rules Management (BRM) (Zoet, 2014). An important part of BRM comprises quality control, which focuses on reducing errors in the syntax and intended behavior of the business rules. Thereby improving the quality of the defined and executed BR's (Boyer & Mili, 2011). This particular capability is referred to as verification. Capability in this paper is defined as an ability that an organization, person, or system, possesses. It therefore defines what an organization, person or system does or can do but not how it accomplishes it. In practice, a capability

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can be implemented in different ways, for example manually, partly- or fully automated.

In September 2015, the Object Management Group (OMG) released a new standard for modelling decisions and underlying business logic, the Decision Model and Notation (DMN) (Object Management Group, 2016). As the adoption and use of the DMN increases, the need for verification of BR's, which are a significant component of the decision logic layer in DMN, increases as well. Therefore, in this paper we adhere to the DMN 1.1 standard and aim to explore which verification capabilities are relevant in the verification process of decisions and underlying BR's.

Verification, as a capability in general software development, is an established research field and has received a lot of attention from researchers in the previous decades. In literature, verification of business rules is a capability, executed by a specific component, of expert systems, knowledge management systems, knowledge engineering systems, or knowledge based systems. Regarding these research domains, different scholars and practitioners identify different types of verification capabilities, for example, the work (Buchanan & Shortcliffe, 1984) on verification capabilities for expert systems, in the work of (Deutsch, Hull, Patrizi, & Vianu, 2009), (Puhlmann, 2007) and (W. M. Van der Aalst, 1999) on verification capabilities for business process models, and in the work of (Studer, Benjamins, & Fensel, 1998) and (Vermesan & Coenen, 2013) on verification capabilities for Knowledge Based Systems. Another contribution within the research domain of business logic is the work of Von Halle and Goldberg (2009), which presents multiple principles that refer to capabilities that are applicable when performing verification of business logic, containing business rules.

However, in current literature on business logic, no uniform overview exists. Additionally, the current knowledge base predominantly focuses on theory forming by means of deductive research methods, while inductive research methods to explore the spectrum of the verification capability seem almost non-existent to the knowledge of the authors.

This paper aims to define, from practice, the spectrum of capabilities required for the verification of business logic which can be designed and specified with DMN. To be able to do so, we addressed the following research question: "Which verification capabilities are useful to take into account when designing a business rules management solution?" five large Dutch government institutions participated in a three-round focus group to derive verification capabilities applied in practice. The results form a framework of capabilities regarding the verification of business rules.

The remainder of this paper proceeds as follows. First, we provide, in short, insights into what verification comprises in the context of BRM and how it relates to the other

BRM capabilities. This is followed by the research method utilized to identify the verification capabilities applied in the Dutch governmental context. Furthermore, the collection and analysis of our research data are described. Subsequently, our results, which led to our framework containing 28 verification capabilities are presented. Finally, we discuss which conclusions can be drawn from our results, followed by a critical view of the research method and techniques utilized and propose possible directions for future results.

4.2 Background and Related Work

With increasing investments in BRM, organizations are searching for ways to guide the design of business rules management solutions. A business rule is defined as "a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behavior of the business" (Morgan, 2002). A business rules management solution enables organizations to elicitate, design, specify, verify, validate, deploy, execute, evaluate and govern business rules (Kovacic, 2004; Schlosser, Baghi, Otto, & Oesterle, 2014). When a business rules management solution is designed, each of the nine previously mentioned capabilities need to be designed, implemented and governed. The manner in which way these capabilities are realized depends on the actual situation in a specific organization. This paper is part of a research project in which the focus was to evaluate all nine capabilities of five government institutions. In this paper we focus on the verification capability as other studies (i.e. (Smit & Zoet, 2016a, 2016b; Smit, Zoet, & Berkhout, 2016; Zoet & Smit, 2017)) already focused on the exploration and definition of the other BRM capabilities.

As stated in the introduction section, no uniform overview exists with regards to verification capabilities in the context of BRM. Literature in neighboring fields often define one or more verification capabilities, however, they do not present a uniform overview. Furthermore, the verification capabilities described in neighboring fields are often based on or related to a specific language and therefore less generalizable. For example, regarding software development verification, (Boehm, 1988) and (Ackerman, Buchwald, & Lewski, 1989) describe several verification capabilities, but do not aim to be complete as their work define the boundaries of verification in general and a process to execute verification. Furthermore, for example, with regards to Business Process Management and process modeling. The work of (Holzmann, 1997) and (W. Van der Aalst, De Beer, & Van Dongen, 2005), describe verification as a capability for process model checking. However, they do so in a technical and non-uniform manner. From literature we find that verification capabilities, in a general sense, are often mentioned or described as part, thus often a sub-goal, of a research study, to evaluate the conformance with certain guidelines. To contribute to the current knowledge base, we aim to define the verification capability with regards to BRM utilizing an inductive approach.

A detailed explanation of each capability can be found in (Smit & Zoet, 2016a). However, to ground our research, a summary of the elicitation, design, specification and verification capabilities is provided here. Additionally, we elaborate on how the DMN standard relates to each of these four capabilities. The purpose of the elicitation capability is twofold. On the one hand, the purpose is to determine the knowledge that needs to be captured from various legal sources to realize the value proposition of the business rules. Many possible legal sources from which this knowledge can be derived exist, for example, laws, policies, guidelines, regulations, expert hearings, research outcomes, case law, and internal documentation. Depending on the type of knowledge source(s), different methods, processes, techniques and tools to extract the knowledge are applied (Liao, 2004). The output of the elicitation capability is the collection of knowledge that is required to design the Decision Requirements Diagram (DRD), which is the highest level of abstraction with respect to decision modelling in DMN. The DRD abstraction layer recognizes four concepts: 1) a decision, 2) business knowledge, 3) input data, and 4) a knowledge source. When no DRD exists, elicitation information is collected to specify the four. On the other hand, when a DRD is already in place, an impact analysis is performed to identify the modifications that need to be processed to the existing structure and underlying business logic in the design and specification capabilities. The DRD consists of a combination of business decisions. A DRD is a collection of business logic (in terms of business rules and fact types) with a maximum internal cohesion and a minimal external coherence, which adheres to the single responsibility principle (Martin, 2003). The relationship between different decisions is depicted in a derivation structure. The DRD is the high-level output which the design capability needs realize. After the DRD is created, the contents (business rules and fact types) of each individual decision need to be specified in the specification capability. The purpose of the specification capability is to create the business rules and fact types needed to make the decision, the Decision Logic Level (DLL). The decision logic level has multiple key concepts which are described in two languages the Friendly Enough Expression Language (FEEL) and the Simple FEEL variant (SFEEL). SFEEL is a subset of FEEL, tailored for simple expressions in conjunction to be utilized in decision tables. However, the same concepts of SFEEL and FEEL can be expressed in multiple other languages. For example, Camunda, also supports the use of other languages to define business logic with, such as Javascript, Groovy, Python, Jruby, and Juel. The language selected to represent the decision logic does not influence the decision requirements level. The output of the specification capability is a specified context design that contains decisions, business rules and fact types. After the DRD and DLL are created, it is verified, comprising the evaluation to eliminate syntax errors in both abstraction levels. This is defined as the verification capability. The purpose of the verification capability is to determine if the decisions, business rules and fact types adhere to predefined criteria, for example, conformance to language guidelines, and are logically consistent. If errors are identified, two scenarios can occur. First, the verification issues are resolved in a revision of the designed and specified business knowledge. Second, the verification issues are ignored and the decisions, business rules and fact types are deployed based on the current elicitated, designed and specified business logic. However, verification errors not properly addressed could result in the improper execution of the value proposition in the execution capability later on in the BRM processes, thus posing a possible risk for the organization that employs the business logic (Smit & Zoet, 2016a).

4.3 Research Method

The goal of this research is to identify verification capabilities that are being utilized in practice. Currently, research is conducted on business rules (management), however, the existing knowledge base is rather old and mostly from a theoretical perspective (Kovacic, 2004; Nelson, Peterson, Rariden, & Sen, 2010; Smit & Zoet, 2016a). Additionally, most of the research that is conducted on business rules (management) embraces a deductive approach, while little is known on how verification is applied in practice, which could lead to further theory refinement by means of an inductive approach. An appropriate focus of research in with an inductive approach is on identifying new constructs and establishing relationships between identified constructs from a practical context (e.g. Edmondson and McManus, (2007)). Therefore, through grounded theory based data collection and analysis, in our research we explore verification capabilities applied in practice and combine them into a framework to, on the one hand, guide organizations in the design and execution of the verification capability as part of business rules management, while on the other hand strengthen the currently available knowledge base with insights derived from practice.

To explore a range of possible solutions with regards to a complex issue group based research techniques are adequate (Delbecq & Van de Ven, 1971). Group-based research techniques are useful when the collection of possible solutions need to be combined into one view, backed by empirical evidence that is not present in the body of knowledge. Examples of group based techniques are brainstorming, nominal group techniques, focus groups and Delphi studies. Group based research techniques can be differentiated by the type of approach they utilize, face-to-face versus non-face-to-face approaches to gather research data. Of course, both the face-to-face and non-face-to-face approaches are characterized by their advantages and disadvantages; i.e., in face-to-face meetings, participants can provide (additional) feedback directly.

On the other hand, face-to-face meetings are characterized to be restricted with regard to the number of participants as well as the possible existence of group or peer pressure.

For this study we selected a face-to-face approach to be more appropriate, also facilitating peer-discussion regarding the application of the verification capability at the selected governmental organizations. Earlier experiences of the researchers with similar approaches showed that participants will trigger each other to elaborate more in-depth on why and how a specific capability is applied.

4.4 Data Collection and Analysis

The data for this study is collected over a period of three months, between January 2014 and March 2014. The collected data has initially been categorized based on the beta version of the DMN standard that was published in August 2013. Since no significant changes between the beta and the final version of the DMN standard occurred, we refer to the final 2015 version of the DMN standard in this paper. The data collection was conducted through three rounds of focus groups. Between each individual focus group, the researchers consolidated the results.

When designing a focus group, a number of situational characteristics need to be considered: 1) the goal of the focus group, 2) the selection of representative participants, 3) the number of participants, 4) the selection of the main facilitator and research team, 5) the information recording facilities, and 6) the protocol of the focus group. The goal of the focus group was to identify the current verification capabilities being applied in practice. The selection of participants should be based on the group of individuals, organizations, information technology or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In this study, organizations and individuals that deal with the verification of a large amount of business rules represent the phenomenon studied; examples are financial and governmental institutions. Taking this into account, multiple Dutch government institutions were invited to participate. The organizations that agreed to cooperate with the focus group meetings were the: 1) Dutch Tax and Customs Administration, 2) Dutch Immigration and Naturalization Service, 3) Dutch Employee Insurance Agency, 4) Dutch Education Executive Agency, Ministry of Education, Culture and Science, and 5) Dutch Social Security Office. We believe that this is a representative selection due to several reasons; 1) they apply all degrees of automation to their decision making (i.e. human, a human supported by a machine, a machine supported by a human, and fully automated), 2) they design and execute a large variety of rule types (i.e. derivation, calculation, constraints, process, validation, and decision rules), and 3) they are required to indisputably implement the laws and regulations for all Dutch citizens and organizations.

Based on the written description of the goal and consultation with experienced employees of each government institution, participants were selected to take part in the focus group meetings regarding verification of business rules. In total, ten participants took part in the focus group rounds which fulfilled the following positions: One legal advisor, two BRM project managers and seven business rule analysts. All involved subject-matter experts had a minimum of five years of experience with the verification of business rules. Delbecq & van de Ven (1971) and Glaser (1978) state that the facilitator of the focus groups should have an appropriate level of experience with regards to the topic. Also the facilitator should have experience with the workings of face-to-face group based research techniques.. The facilitator in this research project has a Ph.D. in BRM and has conducted nine years of research with regards to BRM. Furthermore, the facilitator has conducted research while utilizing many face-to-face research techniques before. Additionally, three researchers were supporting the facilitator during the focus group meetings. One researcher was the 'back-up' facilitator. The back-up facilitator monitored whether each participant provided equal input. When necessary, the back-up facilitator involved specific participants by asking for more in-depth elaboration on the subject at hand. The other two researchers acted as minute's secretary, taking notes. All focus group meetings were video and audio recorded. All focus groups were audio and video recorded. The duration of the first focus group was 192 minutes, the second 205 minutes and the third 207 minutes. All three focus group meetings followed the same overall protocol, starting with an introduction and explanation of the purpose and procedures of the focus group at hand, after which verification capabilities were generated, shared, discussed and/or refined.

Prior to the first round, the research team informed the participants with regards to the purpose of the research and meetings at hand, after which the participants were invited to submit their current documentation with regards to verification capabilities regarding business decisions and business logic. Prior to the first focus group meeting, the research team already consolidated similar verification capabilities that were derived from the received documentation. This was to ground and start up the discussion of the first focus group meeting. During the first focus group meeting, participants first explained their submitted documentation and why their verification capabilities were relevant in their context. For each capability, the group discussed whether it was related to business rules management processes in general or not, for example, some of the mentioned results focused more on the verification of process models or data types. The second and last part of the focus group meeting was committed to defining new or missing capabilities where participants thought they were missing from the already identified selection of capabilities. For each proposed capability, it's ID, label, description, rationale, classification, and example(s) were discussed and noted, see table 4-1.

capability ID:	B4.
capability label:	Identical business rules verification.
capability description:	Identical business rule verification checks if a business rule occurs more than once in the exact same appearance in the same business rule set.
capability rationale:	Identical business rule verification is needed as redundant rules account for extra maintenance burden on top of the negative impact they have on performance.
capability classification:	Decision logic level verification
capability example: **(underlined business rules are identical)**	*Decision: Rights for Child Benefits* *1 – The Age of the Child is between 16 and 17* *2 – The Child has the right to receive study benefits* *3 – The Child is registered as part of => 1 household* *4 – The Child is registered as part of => 1 household* 5 *– The Registration Status of the Child is Household of 1*

Table 4-1: Capability B4 – Identical Business Rule Verification

When the first focus group meeting was finished, the researchers started analysis to consolidate the results. Consolidation of the results comprised the detection of incomplete and redundant capabilities. Next, the results of the analysis by the research team were sent to the participants of the focus group meeting fourteen days in advance before the next meeting. During these fourteen days, the participants assessed the consolidated results in relationship to four questions: 1) "Are all capabilities described correctly?" (in terms of the capability label and accompanied examples), 2) "Do I want to remove a capability?", and 3) "Do we need additional capabilities?"

During the second focus group, the participants discussed the derived capabilities. The group started to discuss their usefulness, and, again, whether all capabilities were described correctly. Furthermore, the participants were asked to validate whether the capabilities that were identified to be redundant from the consolidation by the research team needed removal from the selection of relevant capabilities. For example, one of the participants submitted the capability 'illegal value', while another capability labelled 'domain violation' already existed in the results of the first focus group round, which is an equivalent capability. As the end of the second focus group meeting showed signs of saturation amongst the participants the third focus group was redesigned as a validation session in which we solely wanted to validate the results that were derived from the first two focus groups. The discussion in the last focus group therefore focused on further refinement of the existing capabilities in terms of their descriptions, classification, and goals.

4.5 Results

In this section, based on our data collection and analysis, we present our results. In total, the consolidated framework for the verification of business decisions and business logic consists of 28 verification capabilities. Due to space limitations, we present each capability by its label and description. To further structure our derived capabilities, the abstraction layers of the DMN standard are utilized for categorization as some verification capabilities are only relevant in the context of a certain abstraction level of business logic. Lastly, as some derived verification capabilities are relevant in a generic sense, the generic category has been added.

A - Decision requirements level verification

Regarding the highest level of abstraction, the decision requirements level, eight verification capabilities were identified. The first capability is: **Conclusion verification,** which checks if the conclusion fact of an individual decision is used as a condition fact in another decision. In a DRD, this situation can only legitimately occur once, namely with the top-level decision. Additional occurrences indicate an error in the logical completeness. The second capability is: **Condition verification,** which is a reversed form of conclusion verification. It first checks if a condition fact is a ground-fact or derived-fact. If a fact is a derived fact, the test checks if the fact is the conclusion fact of another decision. The third capability is: **Input verification,** which checks if the conclusion fact of an underlying decision is used as a condition fact in the parent decision. Contrary to conclusion verification and condition verification, input verification checks if there are no unnecessary decisions in the decision set. The fourth capability is: **Existing business knowledge verification**, which checks if a decision is accompanied with specified business knowledge. The fifth capability is: **Invalid business knowledge verification**, which checks if each fact value of the condition fact of a decision is also present as a fact value of the linked conclusion fact of the underlying decision(s). The sixth capability is: **Circularity verification**, which checks if a conclusion fact of the parent decision is used as a condition fact in the underlying decision while at the same time, the conclusion fact of the underlying decision is used as a condition fact in the parent decision. The seventh capability is: **Transitive dependency verification**, which checks if the same condition fact occurs twice in a set of three decisions that are connected to each other. The eight capability is: **Conflicting con-**

clusion verification, which checks if there are conclusion facts that are established using different business rules and facts.

B - Decision logic level verification

Regarding the decision logic level, eight verification capabilities were identified. The first capability is: The first capability is: **Identical business rule verification**, which checks if a business rule occurs more than once in the exact same appearance in the same business rule set. The second capability is **Equivalent business rule verification**, which checks for business rules which are expressed different, but have the same outcome. The third capability is **Subsumed business rule verification**, which checks if business rules exist that are more comprehensive compared to a business rule with the same outcome. The fourth capability is: **Unnecessary fact verification**, which checks for facts that are included in a business rule, but are not required to calculate or derive the outcome. The fifth capability is: **Interdeterminism verification**, which checks if there are two business rules with the same condition facts but with a different conclusion. The sixth capability is: **Overlapping fact value range verification,** which checks if condition fact value ranges in a business rule overlap each other which may lead to inconsistent business rule output. The seventh capability is: **Specific partial reduction verification,** which checks if two ranges in business rules can be combined. The eight capability is: **Missing business rules verification**, which checks if there are situations in which a particular inference is required, but there is no rule that succeeds in that situation and produces the desired outcome. Missing business rules can be detected when it is possible to enumerate all possible scenarios in which a given decision should be made or a given action should be taken (Buchanan & Shortcliffe, 1984).

C - Fact level verification

Regarding the decision fact level, eight capabilities regarding verification were identified. The first capability is: **Valueless fact label verification**, which focuses on the label of the fact in the fact vocabulary. It checks whether each fact type label is expressed without any fact values. The second capability is: **Unused fact verification**, which focuses on facts that are present in the fact vocabulary but not utilized in any BR. Unused facts, especially at large amounts, can decrease efficiency as these unused facts need to be maintained just like the facts that are utilized in BR's. Such errors are often caused by the removal of a BR without checking whether the facts are still utilized in other BR's. The third capability is: **Domain violation verification**, which focuses on how fact values are expressed, in terms of its format, against how they should be expressed. This is important as it influences if the executability of the BR of which the fact types are part of. The fourth capability is: **One value-collection verification**, which focuses on collections and the amount of fact values a fact contains.

Less than two fact values in a collection can be caused by 1) not enough fact values are created in the specification process or 2) due to changes to laws and regulations that result in the removal of fact values as part of the collection. The fifth capability is **Exclusivity/overlap verification**, which focuses on the detection of fact values that are not exclusive, thus overlapping each other. This verification capability is only applicable for a fact that comprises a collection of fact values. The sixth capability is **Lexical error verification**, which focuses on the usage of a wrong fact type in BR's. The seventh capability is **Typographical and mechanical verification**, which focuses on spelling, capitalization and punctuation errors in facts and fact values as part of business rules. Lastly, the eight capability is: **Documentation verification**, which states that each fact should be available in the fact vocabulary with a definition and, optionally, alternative definitions. If a fact is added to the fact vocabulary without any documentation, business rule analysts cannot utilize the fact vocabulary as a single point of truth, as double or conflicting facts could exist.

D – Generic verification level

Regarding the generic verification level, four capabilities were identified. The first capability is: **Grammatical conformance verification**, which checks whether all designed and specified components adhere to their language-related guidelines. Regarding business decision modeling, the model should adhere to the DRD guidelines as stated in the DMN standard. The same partially holds for the business logic layer, where different languages can be utilized, which impose different guidelines that should be adhered to. The second capability is: **Declarativity verification**, which checks whether there is no implicit or explicit order in which decisions, business rules, or facts are executed or evaluated. The third capability is: **Omission verification**, which checks if required components on all three layers are missing. For example, decisions in a DRD modeled without a source or input data, or missing operands (i.e. =, >, =<), condition facts, conclusion facts, and fact values. The fourth capability is: **Atomic verification**, which focuses on the atomic design principle. This means that all components need to be normalized in such a state that no further normalization is possible. Therefore it checks whether all components are expressed in their atomic state.

4.6 Discussion and Conclusion

Business rules, as part of business logic, are increasingly being utilized in organizations as building blocks for (automated) decision making. In this research we aimed to find an answer to the following research question: "Which verification capabilities are useful to take into account when designing a business rules management solution?" To accomplish this, we have conducted a three round focus group with five large Dutch governmental institutions. Our rounds of data collection and analysis resulted in a collection of 28 capabilities that, depending on the situation, could be taken into account when designing the verification capability as part of a BRM solution, see Figure 4-1. The collection of derived verification capabilities can be depicted in a framework. The BRM verification capability framework resulted from this study features capabilities for 1) the business decisions level, 2) decision logic level, and 3) the fact level. Additionally, our results presented a fourth category, 4) generic level capabilities with regards to verification. The framework can be further validated and possibly extended by future research.

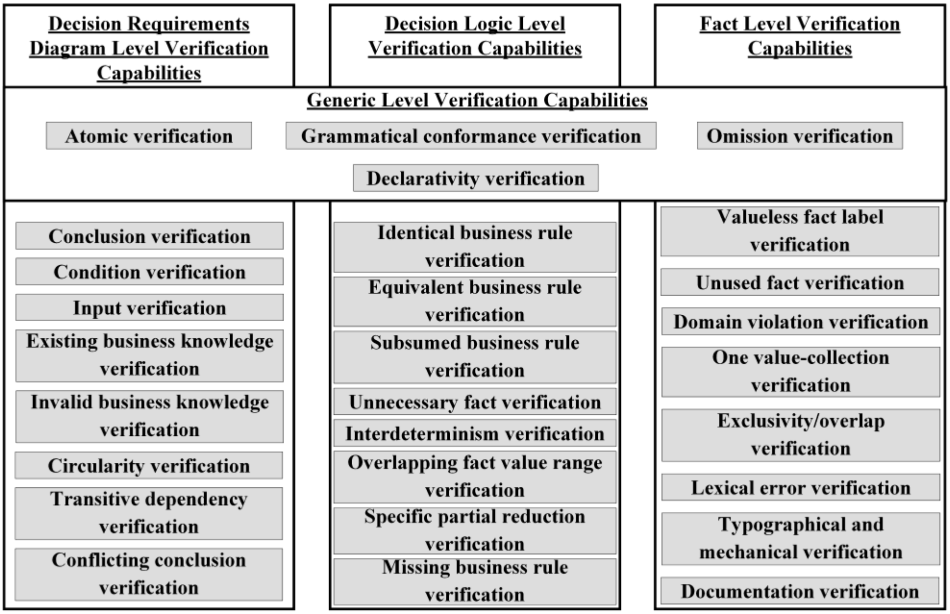

Figure 4-1: BRM Verification Capability Framework

Of course, as is generally true with empirical research, our results are subject to interpretation and are limited to the data available. Multiple threats to the validity of the conclusion are identified. First, the sample of organizations included is solely drawn from governmental institutions. Although we believe that governmental institutions adequately represent organizations that apply BRM, we lack the inclusion of commercial organizations in this study. Moreover, regarding the research method and techniques utilized, our study included a sample of ten verification subject-matter experts. Future research should, therefore, be devoted to including a larger sample, including both governmental and commercial organizations so that the results are more generalizable. Lastly, our results allowed us to identify the relevant verification capabilities in the Dutch governmental context. However, one relevant factor with regards to our results might be the importance of each capability in practice and related situational factors. We stress that future research should focus on finding answers to such knowledge gaps.

5 FUNCTIONAL REQUIREMENTS FOR BUSINESS RULES MANAGEMENT SYSTEMS

Business Rules Management (BRM) is a method designed to transform legal requirements into executable business decisions and business logic. In the last few years, the BRM capabilities have been increasingly supported by a set of software technologies, which are bundled together in a so-called BRM-systems. The aim of this study is to develop a functional requirements themes for BRM solutions. To be able to do so, our data collection and analysis consisted of the collection and analysis of secondary data. With the collaboration of four Dutch governmental agencies, we collected 759 functional requirements with regards to BRM systems. Findings of our analysis show that several essential functional BRM themes emerge, which should be taken into account when selecting or constructing the actual BRM systems. Future research should focus on further validation of the functional requirement themes in both the governmental context as well as the context of commercial industries.

5.1 Introduction

An organization's performance depends upon its ability to manage its business decisions and business logic (Blenko, Mankins, & Rogers, 2010). To get a grip on business decisions and business logic, organizations apply a systematic and controlled approach to support the elicitation, design, specification, verification, validation, deployment, execution, governance, and monitoring of both, see Figure 5-1. The overall method to describe each step is defined as Business Rules Management (BRM), which is a combination of methods, techniques, and tools (Bajec & Krisper, 2005; Ross, 2003). The actual realization in of each capability depends on the type of business logic applied to define the business decisions. For example, to specify predictive models, different activities are executed in comparison when business rule statements are specified. In this research, the focus is on the latter.

More and more software systems to support one or more of the nine BRM capabilities in relationship to business rule statements has become available. Examples of software systems are IAM4, Cognitatie, DecisionFirst Modeler, BizzDesign, Trisotech, Usoft, Camunda, Avola, Pega Systems, Blueriq and Sapiens Decisions. Although the previously mentioned software systems are all labeled as business rules management systems, the actual functionality of each system differs. Previous research has focused on a classification of such systems based on a literature review of 166 articles (Liao, 2004). They define multiple categories like rule-based, knowledge-based, case-based

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reasoning, neural network systems and describe, on a high level, each type of system. Additionally, research has focused on defying the system architecture of business rules management systems as well as the application of business rules components in software architectures (Ly, Rinderle, & Dadam, 2008). In this paper, we adhere to the following definition of a business rule: "a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behavior of the business" (Morgan, 2002).

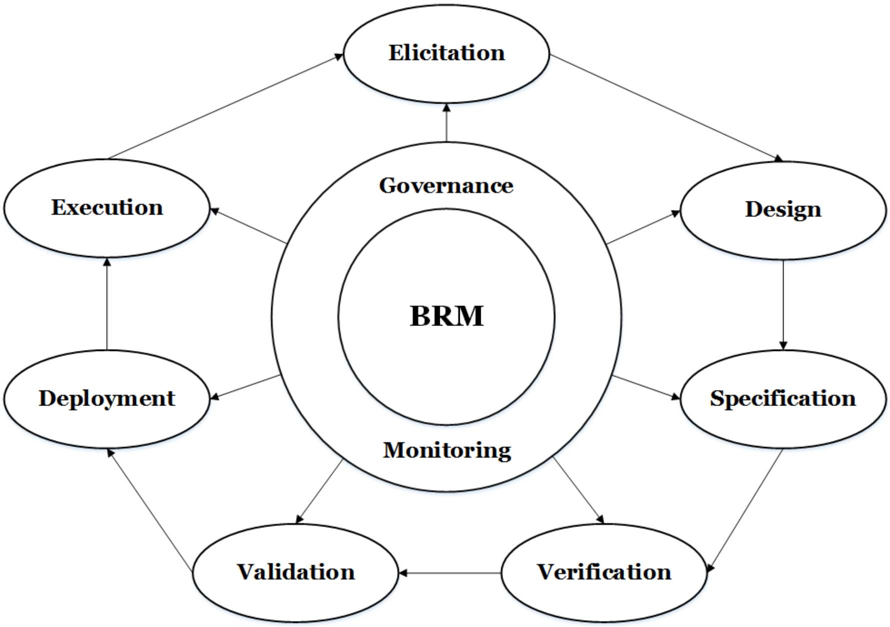

Figure 5-1: BRM Capability Overview

Current BRM research focused on technical implementations such as rule mining tools (Nelson, Peterson, Rariden, & Sen, 2010), different chaining mechanisms (backwards, forwards, hybrid) (Zoet, 2014), rule software architectures (Paschke & Bichler, 2008; Xiao & Greer, 2009), and the application of rules in software architectures (Ly et al., 2008; Min, Kim, Kim, Min, & Ku, 1996). This is also recognized by Schlosser, Baghi, Otto and Oesterle (2014), which describe that "companies are unsure about what they need to consider when dealing with BRM. Literature hardly provides answers to this question." In their research, they create a process, functional architecture, and goal perspective, on a high abstraction level. This study extends the understanding of functional requirements, in the context of BRM, by exploring the required functional requirements for Business Rules Management Systems in more detail.

Similar to previous research, we consider the nine BRM capabilities as the foundation to define the functionalities for business rules management systems. In contrast to previous research, we do not analyze the business rules management systems from a meta-survey, academic literature or business literature perspective, but analyze end-user functional requirements for such systems. With this premises, the specific research question addressed is: "Which functional requirements should be taken into account with regards to the different capabilities as part of BRM?" We aim to answer this research question with the goal to add to the body of knowledge a framework of functional requirement themes that are derived from inductive research rather than deductive research. Additionally, we want to provide organizations, especially in the governmental context, with a collection of functional requirement themes that can guide the process of selection and development of BRM solutions.

The remainder of this paper is organized as follows: First, we provide insights into BRM capabilities and how functional requirements are related to those capabilities. This is followed by the research method used to derive the functional requirement themes. Furthermore, the collection and analysis of our research data, with regards to case study research and three rounds of coding, are described. Subsequently, our results which led to the collection of functional requirement themes are presented. Finally, we discuss which conclusions can be drawn from our results, followed by a critical view of the research methods utilized and results of our study and propose possible directions for future research.

5.2 Background and Related Work

Business decisions and business logic are an important part of an organization's daily activities. A business decision is defined as: "*A conclusion that a business arrives at through business logic and which the business is interested in managing*" (Object Management Group, 2016b). Moreover, business logic is defined as: "*a collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016a). To create added value with business decisions and business logic, several concepts are utilized in theory and practice. For example, a business vocabulary, fact models, a rulebook, and rule requirements (Bajec & Krisper, 2005). However, as our focus in this paper is not to define these different concepts that are utilized in a variety of ways by organizations, we adhere to these concepts as artifacts in a general sense. See, for a detailed description of each of the concepts to design, specify, and execute business decisions and business logic in the work of (Smit & Zoet, 2016b).

As stated in the previous section, BRM consists of nine capabilities. In this paper, a capability is defined as an ability that an organization, person, or system, possesses (Object Management Group, 2016a). A detailed explanation of each capability can be found in (Smit & Zoet, 2016b). However, to ground our research, a summary of the elicitation, design, specification, verification, deployment, execution, governance and monitoring capabilities is provided here, see also Figure 5-1.

The purpose of the elicitation capability is twofold. First, the purpose is to determine the knowledge that needs to be captured from various legal sources to realize the value proposition of the business rules (Graham, 2007). Different types of legal sources from which knowledge can be derived are, for example, laws, regulations, policies, internal documentation, guidance documents, parliament documents, official disclosures, implementation instructions, and experts. Depending on the type of knowledge source(s), for example, documentation versus experts, different methods, processes, techniques and tools to extract the knowledge are applied (Liao, 2004). The second purpose is to conduct an impact analysis is if a business rule architecture is already in place. When all relevant knowledge is captured, the business decisions need to be designed in the design capability. The purpose of the design capability is to establish a business rules architecture, which contains the business decisions and how the business decisions are derived to deliver the value proposition (Von Halle & Goldberg, 2009). After the business rule architecture is designed, the contents of the business decisions need to be specified in the specification capability. The purpose of the specification capability is to write the business logic and create the fact types needed to define or constrain some particular aspect of the business. After the business logic is created, it is verified and validated. The purpose of the verification capability is to determine if the business logic adheres to predefined criteria and are logically consistent (to check for semantic / syntax errors). When no verification errors are identified, the created value proposition is reviewed in the validation capability. The purpose of the validation capability is to determine whether the verified value proposition holds to its intended behavior (Zoet & Versendaal, 2013). When no validation errors are identified the context is approved and marked for deployment. The purpose of the deployment capability is to transform the verified and validated value proposition, which is formulated in an implementation-independent language, to implementation-dependent executable business decisions and business logic. An implementation-independent language is defined as: "*a language that complies with a certain level of naturalness but has a delimited predefined expressiveness and is not tailored to be applicable to a specific automated information system*" (Zoet & Versendaal, 2013). In contrast, an implementation-dependent language is defined as: "*a language that complies with a specific software formalism, has a delimited predefined expressiveness and is tailored to be interpreted by a particular information system*" (Zoet & Versendaal, 2013). However, this does not necessarily imply that the actor that utilizes the value proposition is a system, as the value proposition could also be used by subject-matter experts (Zoet, 2014). An implementation-dependent value proposition can be source code, handbooks or procedures (T. Morgan, 2002). The output of the deployment capability is then executed in the execution capability, which delivers the actual value proposition. To realize the added value, human or information system actors execute the business decisions and business logic. Overall, covering the full range of capabilities described earlier, two more capabilities are of importance; governance and monitoring. The governance capability consists of three sub-capabilities; version management, traceability management, and validity management (Boyer & Mili, 2011; T. Morgan, 2002; Smit, Zoet, & Berkhout, 2016). The goal of the version management capability is to capture and keep track of version data regarding the elements created or modified in the elicitation, design, specification, verification, validation, deployment and execution capabilities. The traceability management capability is utilized to create relationships between specific versions of elements used in the value proposition. The goal of the traceability management capability is to make it possible to trace created elements, as parts of the value proposition, to the corresponding laws and regulations on which they are based. Another goal of the traceability management capability is the foundation it forms for impact analysis when new or existing laws and regulations need to be processed into the value proposition. The third sub-capability comprises validity management. The goal of validity management is to be able to provide, at any given time, a specific version of a value proposition. Lastly, the monitoring capability observes, checks and keeps record of not only the execution of the value proposition but also the full range of activities in the previously explained BRM capabilities that are conducted to realize the value proposition. The goal of the monitoring capability is to provide insights into how the BRM capabilities perform and, additionally, suggest improvements (Bajec & Krisper, 2005). To realize the summarized capabilities, functionalities are needed that support the actual execution of the capabilities.

A method to formulate functionalities in software engineering is requirements engineering. Requirements engineering, in general, is a systematic approach to specifying requirements and consists of four stages 1) requirements elicitation, 2) requirements analysis, 3) requirements specification, and 4) requirements validation (Kotonya & Sommerville, 1998). Different types of requirements exist, for example, functional requirements, non-functional requirements, and constraints (Sommerville & Sawyer, 1997). In this paper, we solely focus on functional requirements with regards to BRM systems as a functional requirement emphasizes *what* is required, and not *how*. This is in line with the notion of a capability, which also focuses on *what* (value) an organization can deliver, but not *how* the value is delivered.

Different methods to formulate functional requirements exist, for example, use cases, personas, mockups, wireframing, user stories (Schön, Thomaschewski & Escalona, 2017). The latter is increasingly being adopted. User stories are comprehensible by, for example, both developers and customers and support participatory design by all stakeholders as they are all able to design the behavior of the system. The agile community, in addition to user stories, also distinguish epic's and themes. An epic is a large user story while a theme is a collection of user stories. Furthermore, the utilization of user stories enables empirical design by enabling the designers to make decisions by studying prospective users in typical situations (Cohn, 2004). The organizations analyzed all defined their functional requirements by means of user stories. Therefore, in our study, the unit of analysis is user stories.

5.3 Research Method

The goal of this research is to identify BRM functional requirement themes for the development of BRM solutions in the governmental context. To be able to do so, qualitative research is chosen as our research methodology. To instantiate this, case study research is identified as the most suitable strategy for this research.

Case study research is selected so that the researchers were able to gather functional requirements for BRM solutions in the Dutch governmental context. Therefore, the case studies are exploratory of nature. The organizations are selected from a pool of Dutch governmental institutions that provide public administration services based on laws and regulations that are provided by the Dutch legislative governmental branches. Our study comprised a holistic case study approach, see also the work of (Yin, 2013), featuring one context, the BRM solutions requirements phase, and four cases within this context. The unit of analysis is the BRM solution-related set of functional requirements of the participated organizations. The data collection consisted of secondary data, which is a form of third-degree data collection. According to Runeson & Höst (2009), third-degree data collection is specifically suitable when data such as requirements specification documents are studied, which is the case in our study.

5.4 Data Collection and Analysis

Data for this study was collected over a period of three months, between November 2016 and January 2017, through case studies at four organizations. The selection of the participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In the context of this study, this means that the phenomenon studied is represented by organizations and individuals within these organizations which deal with the formulation or collection of BRM solutions-related requirements. Such organizations are often financial and government institutions. As stated previously, several Dutch governmental agencies were invited to collaborate in this study.

All invited Dutch governmental agencies have in common that they are all executive governmental branches of the Dutch government. These type of governmental organizations are responsible for the execution of a large variety of services like the application, assessment, and notification regarding benefits, subsidiaries, visa's, permits, tax returns, vouchers, loans, grants, screenings, etc. Combined, the participated organizations serve approximately 17 million citizens and organizations in the Netherlands. The governmental agencies are similar in nature in terms of business processes and how law and regulations must be implemented, which is imposed by legislative governmental branches. Due to requests of the participated organizations to be reported anonymously, the four governmental agencies that participated in this research are, from here on, labeled as organization A, B, C, and D. The four participated organizations were invited to gather and send all their BRM solutions-related requirements documents to the research team. The BRM solutions-related requirements were defined by teams within the organizations. Each team minimally existed out of an enterprise architect, business rules architect, business rules analyst, policy or legal expert. Additionally, per individual organization the teams were supported by a Procurement Officer, BRM project manager, business consultant, IT architect and/or external advisors.

Based on the data received, the research team analyzed and structured the functional requirements. As stated in the background and related work section, the functional requirements were already expressed in a user story format, in the form of natural language (in Dutch). To the knowledge of the authors the participated organizations employ the format of user stories as it allows them to work with functional requirements in a practical way, also due to the fact that all stakeholders can understand the functional requirements. The data analysis was conducted in three cycles of coding, following Strauss and Corbin's process of 1) open coding, 2) axial coding, and 3) selective coding (Strauss & Corbin, 1990). The first coding cycle, open coding, consisted of the identification of functional requirements from the secondary data and the registration of meta-data with regards to the functional requirements. Each functional requirement was already registered as a user story, but to ensure optimal analysis we numbered each user story with a unique ID. Furthermore, for each functional requirement we registered their responsible role or owner, feature (what does the role exactly wants with the functionality), feature outcome (what is the benefit of using the particular functionality), organization, and organization's ID (for traceability of the functional requirement towards the original documentation of the case organizations). In this process, two situations occurred: 1) The functional requirements were explicitly documented and could be documented by registering the organization and organization ID, see for example Table 5-1, or 2) the functional requirements were implicitly stated in other functional requirements (nested requirements) or plain text. A simplified example of a nested requirement is as follows: "*I want to be able to import a source, via MS Word, MS Excel, but also in XML format and from the eur-lex.europa.eu platform*." This particular requirement is not properly normalized and actually consists of four individual functional requirements.

The open coding was followed by axial coding. The axial coding round was applied to structure the functional requirements to the BRM capabilities as proposed by (Smit & Zoet, 2016b); the elicitation, design, specification, verification, validation, deployment, execution, monitoring, and governance, which is the coding scheme in this round. Furthermore, the category overall was added to ensure that all functional requirements that could not be assigned to the existing BRM capabilities or where applicable to all capabilities could be coded as well. For example, see Table 1, where both functional requirements, which were identified in the previous coding round, focus on the elicitation of knowledge from sources. Therefore, both functional requirements were coded as elicitation functional requirements.

ID	Role	Feature	Outcome	Organization	Organization reference
44	Policy advisor	I want to be able to select text to link sources.	So that I am able to target parts of text that are decisions	B	PR13_UR_A_24
67	BR analyst	I want to be able to create blocks of text from law.	So that I am able to select and store artifacts	C	BLIKZT-1864

Table 5-1: Example Functional Requirements from the data set

Lastly, the third round of coding, selective coding, was conducted. Selective coding consisted of the identification of themes within the selection of functional requirements which were assigned to the BRM capabilities in the axial coding. As both functional requirements in Table 5-1 describe the annotation of sources, we coded them as *annotate sources*.

5.5 Results

In this section, we present the results of our data collection through the presentation of the BRM functional requirement themes. As described in the previous section, three rounds of coding were conducted. We first provide the descriptive statistics with regards to the results of our coding processes, which is followed by the description of the derived functional requirement themes. The first round of coding, open coding, resulted in the registration of 759 unique functional requirements, which originate from four organizations, see Table 5-2.

Organization	Total number of functional requirements identified
A	241
B	169
C	146
D	203

Table 5-2: Breakdown of Functional Requirements Received from the Case Organizations

From this sample, 224 functional requirements (29,5%) were identified and registered as nested functional requirements in the data set, see for example the nested functional requirement provided in the previous section. Subsequently, the second round of coding consisted of the assignment of the functional requirements to ten BRM capabilities as described in the previous section. The results of the second round of coding (in amounts and percentage of the total sample of requirements) are presented in Table 5-3.

Capability/Case	Org. A		Org. B		Org. C		Org. D	
• *Elicitation*	12	1.6%	42	5.5%	20	2.6%	0	0%
• *Design*	52	6.9%	14	1.8%	25	3.3%	8	1.1%
• *Specification*	62	8.2%	67	8.8%	22	2.9%	122	16.1 %
• *Verification*	20	2.6%	10	1.3%	1	0.1%	4	0.5%
• *Validation*	13	1.7%	4	0.5%	1	0.1%	12	1.6%
• *Deployment*	7	0.9%	1	0.1%	11	1.4%	1	0.1%
• *Execution*	0	0%	0	0%	0	0%	0	0%
• *Governance*	24	3.2%	5	0.7%	42	5.5%	12	1.6%
• *Monitoring*	1	0.1%	11	1.4%	0	0%	3	0.4%
• *Miscellaneous*	50	6.6%	15	2%	24	3.2%	41	5.4%

Table 5-3: Breakdown of Functional Requirements per BRM Capability

The third round of coding resulted in the identification of 37 functional requirement themes, see Figure 5-2. Due to space constraints, the themes derived from our data collection and analysis are presented, per capability, by their name and briefly described upon.

Elicitation themes

The knowledge needed to create business decisions and business logic is elicitated from a variety of different sources, i.e. laws, regulations, policies, internal documentation, guidance documents, parliament documents, expert hearings, implementation instructions, and official disclosures. Each source has a different format and is published by a different organization. Therefore, the functionality to support the *import sources* is one of the main themes within the elicitation capability, either manually or automatically. Additionally, the theme *annotate sources* was identified, which concerns either the manual, but preferably automatic annotation of sources to artifacts used to create business decisions and business logic, i.e. derivation structures, terms, or roles. When all sources are imported and classified, the user must be able to *generate overviews* of (related) sources in order to determine the business decision of the added value that has to be created. Additionally, it is deemed useful that important information, i.e. interpretations, design decisions, and tips, can be captured with regards to the sources. Lastly, the possibility to *perform impact-analysis* is addressed, as it allows the user to determine the impact of modified sources with regards to already implemented business decisions and business logic.

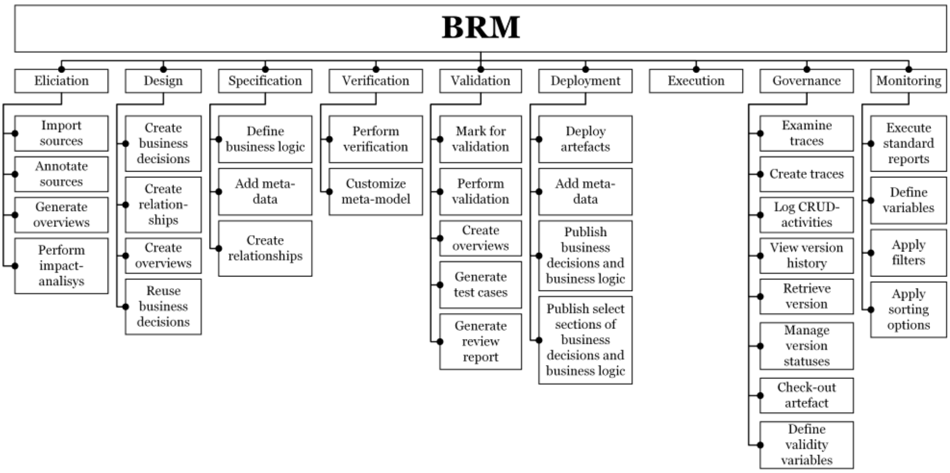

Figure 5-2: Framework of Functional Requirement Themes

Design themes

When the relevant knowledge is delivered from the elicitation capability, the user needs to analyze the knowledge in order to *create business decisions*. Additionally, when business decisions are created, the user needs to be able to *create relationships* to the different business decisions by linking them to each other and specify the relationship type between them. The cohesion between business decisions can be depicted in diagrams that provide the user with the possibility to *create overviews* of the linked business decisions. Lastly, one important theme was the ability to *reuse business decisions* and structures of business decisions, which enable users to work more efficiently by reusing existing artifacts or use them as design templates.

Specification themes

Based on the business decisions created and related to each other in the design capability, the user needs to be able to *define business logic* per business decision. Additionally, the possibility to *add meta-data* to artifacts created in the specification capability is deemed important. For example, with regards to business rules, users want to be able to add traceability links or validity dates. Also, all artifacts need to be related to each other in the specification capability. Therefore, *create relationships* is of importance as it supports the user in the specification processes as well as that it forms a fundamental basis for impact-analysis and traceability over all business logic artifacts.

Verification themes

Verification is related to the creation and modification of artifacts in the elicitation, design and specification activities. In the data, it was found important that a user is able to *perform verification* on request, which is classified as a detective form of verification, see (Smit, Versendaal, et al., 2017). However, the system also must be able to perform verification in a preventive manner so that it is nearly impossible to implement errors in the business decisions and business logic, see (Smit, Versendaal, et al., 2017). According to the data, both forms of verification must be available in the elicitation, design and specification processes. For example, verification in the context of the specification of business logic means that the quality of business rules is controlled by checking and notifying users of errors or enforcing certain business rule patterns, for example, see (Smit, Versendaal, et al., 2017). Lastly, to incorporate changes into the verification functionality, a user must be able to *customize the meta-model*.

Validation themes

As part of validation, a user must be able to *mark for validation*, when an artifact succeeded the verification processes. Furthermore, validation must be supported by enabling a user to *perform validation*, where the user is able to test all relevant combinations of artifacts, i.e. business rules, fact types, and fact values. An important theme within validation is the dependence of cohesion between all the business decisions and business logic artifacts that need to be validated, thus requiring the possibility to *create overviews* to support validation of artifacts. Moreover, the system should assist the user by the automatic *generation of test cases* of the artifacts that need to be validated. Based on the results of the validation, a user (manually) or the system (automatically) must be able to *generate a review report*.

Deployment themes

When the new or modified business decisions and business logic passed both the verification and validation processes, a user marks both for deployment. Business decisions and business logic can be transformed into various type implementation-dependent languages, i.e. in different information systems, but also into work instructions, manuals, and procedures (Smit & Zoet, 2016b). An important theme with regards to deployment is the possibility to *deploy artifacts*. With regards to the deployment of artifacts, a user must be able to deploy an individual artifact as well as a collection of artifacts. Furthermore, a user must be able to *add meta-data* (i.e. version number, user, date of deployment, and validity range) of deployed artifacts. However, this could also be performed in an automatic manner by the system, which is preferred as it eliminates manual input errors by users. Lastly, the *publication of business decisions and business knowledge* is an important theme. All Dutch governmental organizations are forced by law to provide transparency with regards to how a decision is made. Additionally, Dutch organizations and other stakeholders are dependent on the publications of the Dutch governmental agencies as well. However, it is not always desirable to publish all information regarding business decisions and business logic. In addition, the ability to *publish selected sections* of business decisions and business logic is desired within this context.

Execution themes

No specific themes were identified for the execution capability.

Governance themes

The governance capability is one of two overarching BRM capabilities that supports all capabilities, with the exception of the monitoring capability. Governance exists of three sub-capabilities; traceability management, version management, and validity management. With regards to traceability management, a user must be able to select an artifact and *examine traces* of the artifact in a backward and forward direction. For example, a business rule is part of a business rule set, which is part of a business decision that is based upon a collection of sources (backward direction). However, the same business rule is used in implemented products or services, in the form of a letter, source code and user instruction (forward direction). Additionally, a user wants to be able to *create traces* between artifacts.

With regards to version management, the system must *log CRUD-activities* from a user, accompanied with a timestamp, preferred in an automatic manner. For example, when an individual removed version 2.1 of a certain business rule and created a subsequent version, or where the system must log status changes of an artifact (i.e. in progress, to be reviewed, to be deployed). Furthermore, a user must be able to, for all artifacts, *view version history*, and be able to *retrieve (previous) version*. Also, a user must be able to *manage version statuses* known by the system (i.e. add an extra status or modify the label of a status). Lastly, to facilitate effective collaboration between users, a specific user must be able to *check-out artifact* so that other users cannot work on the same artifact.

With regards to validity management, a user must be able to *define validity variables* of an artifact (i.e. this business decision's validity period starts at 03-01-2017 and ends at 08-12-2017. A user must be able to perform this manually, but preferably it is supported by the system in an automated manner as it should be able to analyze the sources in the elicitation processes. However, a user must always have the possibility to override the validity data derived from a source by the system.

Monitoring themes

Monitoring is one of two overarching BRM capabilities and is applied with regards to each of the other eight capabilities to support users with various activities. For example, within the context of verification, a user wants to examine the number of verification errors identified in a given time period. A similar example holds for validation, where a user wants to examine the amount of rejected artifacts that did not meet the criteria and needed further reiteration in the elicitation, design or specification processes. With regards to the monitoring of all the eight capabilities, a user wants to be able to *execute standard reports* as well as be able to *define included variables* of a report in a manual way. To boost the effectiveness of searching for specific information in reports, a user must be able to *apply filters*, either standard or self-defined (i.e. creation date or updates per artifact). Furthermore, a user must be able to *apply sorting options*. Lastly, it is deemed important that all reports can be stored in a wide variety of common formats (i.e. .csv, .xlsx, .pdf, and .docx).

5.6 Discussion and Conclusion

The goal of this research is to identify BRM functional requirement themes for the development of BRM solutions in the governmental context. To be able to do so, we addressed the following research question: "*Which functional requirements should be taken into account with regards to the different capabilities as part of BRM?*" In order to answer this question, we utilized case study research and conducted three rounds of coding, involving 759 functional requirements specified by four large Dutch governmental agencies. From a research perspective, our study provides a fundament for the development of functional requirements and situational factors regarding the application of such requirements. From a practical perspective, organizations, especially in the governmental context, could benefit from the presented BRM functional requirement themes that guide the process of selection and development of BRM solutions.

Several limitations may affect our results. The first limitation is the sampling and sample size. The sample group of case organizations is drawn from organizations only in the governmental domain. While we believe that government institutions are representative for organizations selecting and applying BRM solutions, further generalization towards non-governmental organizations is recommended. Furthermore, our sample size of 759 functional requirements from four organizations is limited, however, appropriate for research studies at the current maturity stage of the BRM domain. With regards to the sample, examination of the coverage statistics presented in Table 5-3 shows that there is an anomaly between the number of functional requirements per capability, per participated organization. This phenomena is likely caused by the different role compositions per team of individuals at each organization. Following this, we recommend future studies to incorporate larger amounts of functional requirements, preferably from a mix of different industries to further validate the current set of functional requirement categories as well as to compare between different industries with the goal to provide situational sets of functional requirements. Lastly, in this study, we solely take into account the functional requirements related to BRM solutions. While this scope is appropriate for this particular study, we believe that the focus of future studies should also be on the inclusion of, amongst other types of requirements, non-functional requirements in the context of BRM solutions.

Part 2: Business Rules Management Implementation Challenges

6 IDENTIFYING CHALLENGES IN BUSINESS RULES MANAGEMENT IMPLEMENTATIONS REGARDING THE ELICITATION, DESIGN AND SPECIFICATION CAPABILITIES AT DUTCH GOVERNEMENTAL INSTITUTIONS

Decisions are used by an organization to manage and execute their coordinated, value-adding decision-making and are thereby among an organization's most important assets. To be able to manage decisions and underlying business rules, Business Rules Management (BRM) is increasingly being applied at organizations. As both the maturity of the research field and practice regarding BRM is still nascent, albeit slowly maturing, the researchers are able to report on challenges in the implementation of BRM capabilities. In this study, we identify the main challenges regarding the implementation of the elicitation, design, and specification of business rules in the Dutch governmental context. Building on the collection and the analysis of two three-round focus groups and two three-round Delphi studies we report on the 28 main challenges experienced and advance to provide directions for future research.

6.1 Introduction

Scholars agree on the evolution of information technology (IT) in both research and practice (Zoet, 2014). This evolution entails the separation of concerns and resulted in the separation of the 'data concern' from software in the seventies, the 'user interfacing concern' in the eighties, and the 'workflow/process concern' in the nineties (van der Aalst, 1998). More recent research (Boyer & Mili, 2011; Zoet, 2014) shows that the separation of business rules as a separate 'concern' is the next logical step in the evolution of IT. Related to the latter two, business process management and business rules management both study the management and execution of tasks (vans der Aalst, ter Hofstede, & Weske, 2003). However, both do so from different perspectives. Business process management (BPM) takes an activity/resources viewpoint while business rules management (BRM) approaches tasks from a guideline/knowledge viewpoint. Both management disciplines are growing closer towards each other (Gottesdiener, 1997; Zoet, 2014). This trend can be explained by the fact that a proper implementation of BPM as well as BRM may result in considerable rewards for or-

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ganizations, e.g. building compliance into the fabric of the organization while realizing flexibility for change.

Currently there is a broad body of literature on implementation challenges and critical success factors of BPM available. Bandara et al. (2007) and Sadiq et al. (2007) took a broad perspective on the topic and researched major challenges experienced by three different stakeholders: vendors, experts, and users. Furthermore, Vom Brocke et al., (2014) focus on the ten principles of good process management. In addition to this very broad perspective, research is also executed focusing on one specific target group, for example, government implementations (Lönn & Uppström, 2013) or the Australian situation (Indulska, Chong, Bandara, Sadiq, & Rosemann, 2006). Another category of research focuses on a particular perspective of a BPM implementation. For example, they focus on the role of process orientation regarding successful implementations (Reijers, 2006), on factors that influence acceptance and use of process modeling (Eikebrokk, Iden, Olsen, & Opdahl, 2011), or on the effect of proper governance on BPM implementations (Jeston & Nelis, 2014).

However, there has been little to no work on challenges in BRM implementations, despite the fact that a wrongful implementation of BRM can greatly affect organizational goals. Furthermore, when challenges are not (properly) identified and understood, the chance of success of an implementation decreases (Bandara et al., 2007). When analyzing the research that has been performed with regards to business rules (concern), we identify a predominant emphasis on technical and theoretical application of information technology with regards to BRM solutions. This is in line with the research of Nelson et al. (2008) which state: "*studies provide beginnings of a business rules research program, but collectively the research often overlooks major steps in BRM and fails to focus on business rules specific challenges and the larger context that rules play in organizations.*" Therefore, we identify that the BRM domain does not show a well-balanced mix of research, which is also stated in the work of (Kovacic, 2004; Nelson, Peterson, Rariden, & Sen, 2010) stating "*with so much emphasis towards the technological aspects, we can lose sight of the management of information systems considerations.*" Losing sight, in addition, is further strengthened by the research of Arnott and Pervan (2005) who conclude, after studying 1,020 papers, that the field has lost its connection with industry some time ago and research output with practical relevance is scarce.

In 2014, Arnott and Pervan (re-)analyzed a collection of 1466 papers to conclude that a transition is taking place towards a more practical-oriented approach, whilst a strong connection between theory and practice is still lacking (Arnott & Pervan, 2014). Additionally, this was also one of the conclusions in the work of Zoet (2014). We conclude that there is a need for BRM research from a broader perspective taking into account the application of BRM in practice. Additionally, Nelson (2008) and Zoet (2014) argue that BRM-related research should focus on the management perspective, featuring methods and techniques, rather than only focusing on the information technology perspective. Based on these premises provided in literature, we aim to conduct research that adds to the theoretical body of knowledge as well as focusing on the implementations of BRM solutions in practice. Furthermore, our research can be characterized by a broad focus due to the fact that we take into account the whole spectrum of information systems and information technology by applying the information systems framework originally proposed by Weber (1997) and extended by Strong and Volkoff (2010).

One type of organization in which an increasing number of BRM implementations occur are governmental institutions. Government institutions deliver public administration services which are specified in laws and regulations. Based on the laws and regulations, the business processes, and decisions (that are executed) and the data (that is registered to deliver a particular service) are restricted. As laws and regulations change constantly, for example due to societal developments, the public administration services also need to change. A solution to guide the design and implementation of public administration services is BRM. The key building blocks of BRM are business rules, which are translated from laws and regulations into computer-executable business rules, and serve as building blocks for legal products and/or services. To understand the challenges governmental institutions experience when implementing BRM, we intend to answer the following research question: "*Which implementation challenges do governmental institutions encounter while implementing the elicitation, design and specification capabilities of business rules management?"* Based on the propositions regarding the predominant technically-oriented research stream, we expect that the identified challenges will be more organizational-centered instead of technological-centered.

The remainder of this paper is structured as follows: First, we present an overview of the BRM problem space. This is followed by the research method used to identify the current BRM implementation challenges at Dutch governmental institutions. Next, the collection and analysis of our research data is described. Subsequently, our results are presented, providing an overview of challenges regarding the elicitation, design, and specification of business rules. Finally, we present our conclusions and discuss the utilized research methods and results of our study, as well as proposing possible directions for future research.

6.2 Contribution

Most current BRM solutions research emphasizes on technical and theoretical applications of information technology. Literature shows there is a lack of knowledge regarding practical insights and integrated, overall perspective in implementations of this specific type of IS solutions. This paper focuses on the implementation of BRM solutions in the Dutch governmental context, indicating that many challenges are experienced in practice in this particular sector. Our study is triggered by the Dutch government, who formulated goals with regard to improving their e-services by applying several mechanisms, one of which being the implementation of BRM (Commission rulepressure and ICT policies, 2017). From a theoretical perspective, our results build new knowledge on BRM solutions and provide a fundament for future research directions, showing that research as for the organizational and deep layer aspects is much needed. From a practical perspective, our study provides a collection of challenges regarding the design and implementation of a BRM solution at governmental institutions which could be taken into account by organizations to avoid common pitfalls in likewise projects. Furthermore, the practical potential of the identification and classification of challenges allows organizations to prioritize their resources and adjust their BRM implementation strategy.

6.3 Background and Related Work

With increasing investments in BRM, organizations are searching for ways to guide the design of BRM solutions. A business rule is defined as "a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behavior of the business" (Morgan, 2002). A BRM solution enables organizations to elicit, design, specify, verify, validate, deploy, execute, evaluate and govern business rules, see Figure 6-1 (Graham, 2007; Kovacic, 2004; Nelson et al., 2008; Schlosser, Baghi, Otto, & Oesterle, 2014; Zoet, 2014). When a BRM solution is designed, each of the nine mentioned capabilities need to be designed, implemented and governed. The manner in which way the capabilities are realized depends on the actual situation in a specific organization. This paper is part of a large research project in which all nine capabilities of five Dutch government institutions were evaluated. Earlier studies already focused on the verification and validation (Smit, Versendaal, et al., 2017), monitoring (Smit & Zoet, 2016b), and governance capabilities (Smit, Versendaal, et al., 2017). In this paper, the elicitation, design, and specification capabilities are investigated. By doing so, the focus lies on the major challenges experienced in practice regarding the implementation of these capabilities. A detailed explanation of each capability can be found in (Smit & Zoet, 2016b). However, to ground our research, a summary of the elicitation, design, and specification capabilities is provided below.

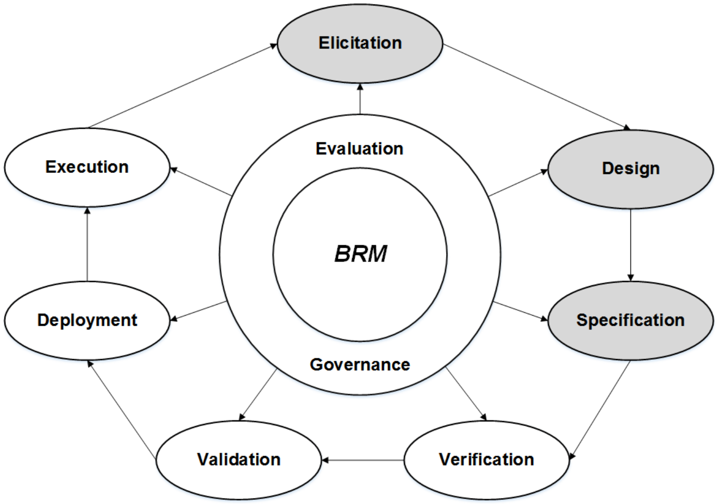

Figure 6-1: BRM Capabilities Overview

The purpose of the elicitation capability is to determine the knowledge that needs to be captured from various legal sources to realize an institute's value proposition. Different types of legal sources from which knowledge can be derived are: laws, regulations, policies, internal documentation and human experts. Depending on the type of knowledge source(s) and the current state of a BRM solution, different processes, techniques and tools to extract the knowledge are required. The output of the capability is the knowledge required to design the business rules architecture. If a business rules architecture is already in place, an impact analysis is performed. The actual business rules architecture is the output of the design capability. The business rules architecture consists of a combination of so-called design contexts and derivation structures. A design context is a set of business knowledge (in terms of business rules and fact types) with a maximum internal cohesion and a minimal external coherence. The relationship between different design contexts is depicted in a derivation structure. After the business rules architecture is designed the actual contents of each individual design context need to be specified. The purpose of the specification capability is to determine and describe the business rules and create the fact types needed to define or constrain some particular aspect of the business. The output of the specification capability is a specified context that contains business rules and fact types (Zoet, 2014).

6.4 Research Method

The goal of this research is to identify challenges that were experienced in the implementation of the capabilities to elicit, design and specify business rules. The maturity of the BRM research field, with regard to non-technological research, is nascent (Kovacic, 2004; Nelson, Peterson, Rariden, & Sen, 2010; Zoet, 2014). An appropriate focus of research in nascent research fields is on identifying new constructs and establishing relationships between identified constructs (e.g. Edmondson and McManus, 2007), characterized by explorative qualitative research methods. Therefore, this study is qualitative of nature and through grounded theory based data collection and analysis, we search for challenges regarding the elicitation, design and specification capabilities. Furthermore, grounded theory based data collection is selected, since to the knowledge of the authors no research on challenges in BRM implementations has been conducted. In this context, explorative research methods are more suitable as it allows for the development of context-based descriptions and explanations of a phenomenon (Myers, 1997).

For research methods related to exploring a broad range of possible solutions to a complex issue -and combining them into one view when a lack of empirical evidence exists, group based research techniques are adequate (Delbecq & Van de Ven, 1971; Okoli & Pawlowski, 2004; Ono & Wedemeyer, 1994). Examples of group based techniques are focus groups, Delphi studies, brainstorming and the nominal group technique. The main characteristic that differentiates these types of group-based research techniques from each other is the use of face-to-face versus non-face-to-face approaches. Both approaches have advantages and disadvantages; for example, in face-to-face meetings, provision of immediate feedback is possible. However, face-to-face meetings have restrictions with regard to the number of participants and the possible existence of group or peer pressure. To eliminate the disadvantages, we combined the face-to-face and non-face-to-face technique by means of applying the following two group based research techniques: the focus group and Delphi study. The focus group data collection technique was selected because it allows for broad interactions on a topic in a limited amount of time. Compared to participant observation in the form of interviews, the advantage of applying focus groups is the ability to compare a substantial set of observations with regards to the topic of interest (Morgan, 1996). This aligns with the limited amount of time the research team was provided to interview the participants face-to-face. The Delphi data collection technique, as a non-face-to-face technique, was selected because it allows for the inclusion of a larger sample size and validation of the challenges that were identified during the focus groups (Okoli and Pawlowski, 2004). By applying controlled opinion feedback during the Delphi study, the research team was able to gather data on the identified challenges anonymously. The anonymity of data collection, in an individual manner between the participant and the researcher, mitigates peer-pressure and allows for data collection in a more natural environment compared to a focus group approach (Morgan, 1996).

To structure our results and findings, we selected the information systems framework originally proposed by Weber (1997) and extended by Strong and Volkoff (2010). Specifically, this information systems framework was selected due to 1) it's general information systems perspective, which was applied to structure and categorize all possible challenges identified, 2) it's proven status within the IS/IT community as it is widely cited and used, and 3) it's structure that allows us to confirm the phenomena of a predominant view in current literature as it separates the technical and management perspectives. The framework is divided into four sections: 1) deep structure, 2) organizational structure 3) physical structure and, 4) surface structure. Deep structure elements are subjects that describe real-world systems, their properties, states and transformations (Weber, 1997). Organizational structures are the roles, control and organizational culture represented within organizations or within solutions (Strong & Volkoff, 2010). Physical structure elements describe the physical technology and software in which the deep structure is embedded (Weber, 1997). Lastly, surface structure elements describe the elements that are available in the information system to allow users to interact with the information system (Strong & Volkoff, 2010).

6.5 Data Collection and Analysis

The data for this study is collected over a period of three months, between January 2014 and March 2014. Data collection and analysis consisted of two series of a three-round focus group and a three-round Delphi study, see Figure 6-2.

This approach is applied for the challenges concerning the elicitation, design and specification capabilities. Since most of the participated organizations combined their design and specification capabilities, the design and specification capabilities are combined and their results are reported together. This was requested and agreed upon by all participants.

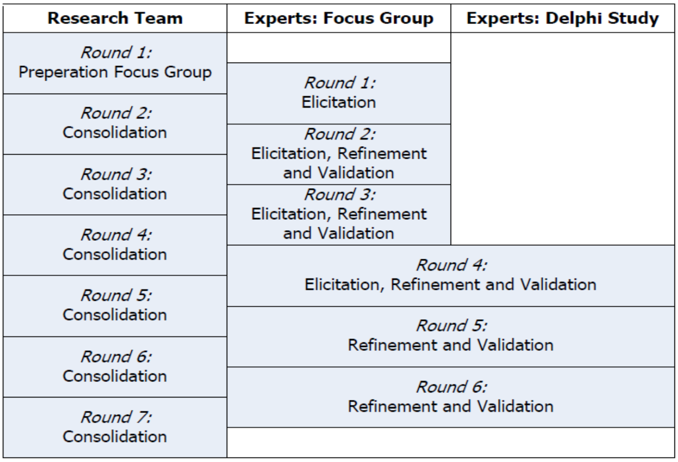

Figure 6-2: Data Collection Process Design

6.5.1 Focus Groups

Before a focus group is conducted, a number of topics need to be addressed: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities, and 6) the protocol of the focus group (Morgan, 1996). For this study, the goal of the focus group meetings was to identify implementation challenges of the elicitation, design, verification, and validation capabilities as part of BRM. The selection of participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In this study, organizations and individuals that deal with a lot of business rules represent the phenomenon studied; examples being financial and governmental institutions. Therefore, multiple Dutch governmental institutions were invited to provide input for this research. The organizations that agreed to co-operate with the focus group meetings were the: 1) Dutch Tax and Customs Administration, 2) Dutch Immigration and Naturalization Service, 3) Dutch Employee Insurance Agency, 4) Dutch Education Executive Agency, Ministry of Education, Culture and Science, and 5) Dutch Social Security Office. Based on the written description of the goal and consultation of employees of each governmental institution, participants were selected to take part in the three focus group rounds. In total, twelve participants took part in the focus groups regarding the elicitation capability. Moreover, nine participants took part in the focus groups regarding the design and specification capabilities. With regards to the elicitation capability, the following roles were included: two business rules architects, three business rule analysts, two policy advisors, three BRM project managers, one tax advisor, and one legislative author. With regards to the design and specification capability, the following roles were included: one business rules architect, two BRM project managers, and six business rule analysts. Each of the participants had at least five years of experience with business rules. Delbecq and van de Ven (1971) and Glaser (1978) state that the facilitator should be an expert on the topic and familiar with group meeting processes. The selected facilitator who is a Ph.D. in BRM, conducted eight years of research on the topic, and facilitated many (similar) focus group meetings in the past. In addition to the facilitator, five additional researchers were present during the focus group meetings. One researcher participated as 'back-up' facilitator who monitored whether each participant provided equal input, and if necessary, involved specific participants by asking for more in-depth elaboration on the subject. The remaining four researchers acted as secretaries. All focus groups were video and audio recorded. On average, the time spent on a focus group was three hours. Each focus group meeting followed the same protocol, each starting with an introduction and explanation of the purpose and procedures of the meeting. After the introduction, ideas were generated, shared, discussed and refined by the participants.

Prior to the first round, participants were informed about the purpose of the focus group meeting. Furthermore, the participants were invited to submit secondary data regarding known challenges during the implementation of the elicitation, design, and specification capabilities. When participants had submitted their secondary data, they had the opportunity to elaborate upon their documented challenges during the first focus group meeting. During this meeting, challenges that were not present in secondary data were also presented and discussed upon. For each challenge addressed, the name, description, origin (regarding which institutions experienced the same or similar challenges), and classification were discussed and noted. After the first focus group, the researchers analyzed and consolidated the results.

The results of the analysis and consolidation were sent to the participants of the focus group two weeks in advance for the second focus group meeting. During these two weeks, the participants assessed the consolidated results in relationship to three questions: 1) "Are all challenges described correctly?", 2) "Do we need to address additional challenges?", and 3) "How do the challenges affect the design and/or implementation of the BRM capability?" This process of conducting focus group meetings, consolidation by the researchers and assessment by the participants of the focus group was repeated two more times (round 2 and round 3). After the third focus group meeting (round 3), saturation within the group occurred. This resulted into a consolidated overview of challenges regarding the elicitation, design, and specification capabilities for BRM.

Data analysis was conducted in three cycles of coding, following Strauss and Corbin's (1990) process of 1) open coding, 2) axial coding, and 3) selective coding. After each focus group round, open coding was conducted, involving the analysis of significant participant quotes by the individual researchers. In this process, the researchers tried to identify what Boyatzis (1998) refers to as 'codable observations'. Here, the researchers coded the data by identifying sentences where challenges were discussed. The participants named and listed challenges that occurred. For example, one of the codable observations was as follows: "*We design and specify our contexts and business rules in Microsoft Word, which forced us to define guidelines as we usually work with five or more people on the same business case. However, these guidelines are not enforced by Microsoft Word.*"

The open coding was followed by axial coding during the analysis and consolidation phase between the focus group rounds to see what challenges can be identified and how the participants supported their challenges. The researchers employed the Toulmin's (2003) framework, which consists of three elements, claim-ground-warrant, to code the challenges addressed in the focus group rounds. For example, the following claim-ground-warrant relationship was coded: Claim - "*working with the tools we currently use is amateurish*"; Ground - "[Working with MS word] *which forced us to define guidelines as we usually work with five or more people on the same business case. However, these guidelines are not enforced by Microsoft Word*", Warrant - "*Authority, - the reliability and validity originated from a presumed expert source*".

Lastly, the selective coding was applied to categorize the identified challenges that were the output of the axial coding process. The coding family 'Unit' was adhered to during the selective coding rounds (Glaser, 1978) to categorize the identified challenges. This process required inductive as well as deductive reasoning. Inductive reasoning was applied to reason from concrete factors to general situational factors. For example, two participants reported using Microsoft Word to specify and manage business rules, while four other participants reported using Microsoft Excel for the specification and management of their business rules. In this case, both statements were coded to the maturity of tooling to support the design and specification capabilities. Deductive reasoning was applied to reason from general situational factors to specific cases. For example, one participant stated that the language they applied to formulate business rules was not sufficient enough. When elaborating on this topic more in-depth, the business rules language applied wasn't precise enough. Therefore the challenge was assigned to the precision of the business rules language.

6.5.2 Delphi Study

Before a Delphi study is conducted, a number of topics need to be addressed: 1) the goal of the Delphi study, 2) the selection of participants, 3) the number of participants, and 4) the protocol of the Delphi study (Okoli & Pawlowski, 2004). The goal of the Delphi study was two-fold. The first goal was to validate and refine the challenges identified in the focus group meetings, while the second goal was to identify additional challenges. Based on the written description of the goal and consultation of employees of each organization, participants were selected to take part in the Delphi study. In total, 44 participants participated. Twenty-three experts, in addition to the 21 experts that participated in the focus group meetings, were involved in the Delphi Studies. The reason for involving the 21 experts from the focus groups was to decrease the likelihood of peer-pressure amongst group members, which could have been the case during the focus group meetings. This is achieved by exploiting the advantage of a Delphi Study which is characterized by a non-face-to-face approach. The non-face-to-face approach was achieved by the use of online questionnaires that the participants had to return via mail. The additional 23 participants involved in the Delphi Study had the following positions: one software engineer, one project manager, four enterprise architects, three business rules analysts, four policy advisors, two IT-architects, three business rules architects, two business consultants, one functional designer, one legal advisor, and one knowledge management expert. Each of the 23 additional participants had at least two years of experience with business rules. Each round (4, 5, and 6) of the Delphi Study followed the same protocol, whereby each participant was asked to assess the identified challenges in relationship to three questions: 1) "Are all challenges described correctly?", 2) "Do we need to address additional challenges?", and 3) "How do the challenges affect the design and/or implementation of a BRM solution? Regarding the analysis of the collected data as a result of the Delphi study rounds, the same method of coding as elaborated in section 4.1 is adhered to.

6.6 Results

In this section, a summary of the challenges obtained from our data collection and analysis are presented. The order of the challenges presented do not reflect their relative importance, but refers to the paragraph and explanation in this section. Since it is our aim to solely identify challenges with regards to the elicitation, design, and specification capabilities, we did not explore solutions which address the identified challenges.

First, an overview of the identified challenges are presented in Figure 6-3. In this figure the challenges are mapped alongside the earlier mentioned information systems framework of Weber (1997) and Strong and Volkoff (2010). Next, the general implementation challenges that apply to all capabilities are described after which the specific challenges per capability are presented.

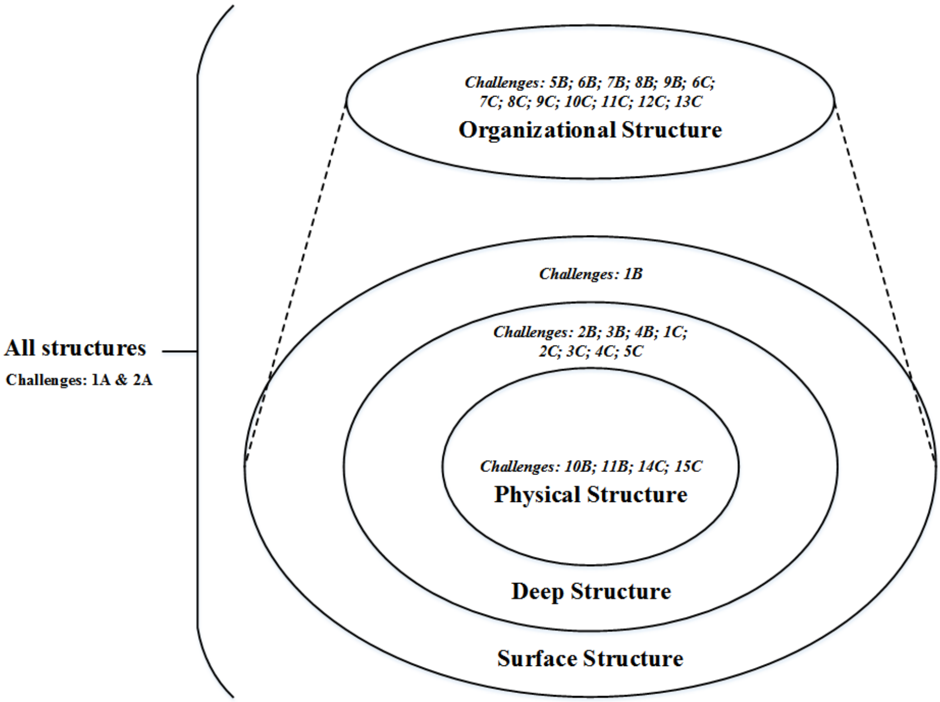

Figure 6-3: Mapping of Identified Challenges – An Overview

6.6.1 General Implementation Challenges

The first general implementation challenge (**1A**) concerns the lack of structured and repeatable processes for each BRM capability. The participants stated that activities were performed on an ad-hoc basis from which the output is unpredictable in terms of quality. According to the participants, this was due to the fact that current BRM practices mostly focuses on the implementation of software systems and not on the needed business processes.

The second general implementation challenge (**2A**) concerned the education and knowledge level of employees with respect to BRM. Currently, the knowledge level influences the effectiveness and efficiency of the governmental institutions. All participated organizations indicated having challenges with recruiting employees which have a combination of subject-matter knowledge, methodological knowledge and technological knowledge with respect to the elicitation, design, and specification capability.

Additionally, the participants addressed that new employees are costly in terms of organizational resources to educate in order to be utilized in the BRM processes.

6.6.2 Elicitation Implementation Challenges

Surface layer implementation challenges

Challenge 1B) The current value of the available languages, that support the efficient and effective annotation of business rules, is low. This is grounded by the fact that the laws and regulations are written in natural language and therefore are imprecise and ambiguous for easy translation into business rules. For example, the natural language in which laws and regulations are written may be capable of being understood in more ways than one due to the fact that individuals, i.e. different employees analyzing new or modified laws and regulations, may have different interpretations. One of the participants stated: "*Rule-speak contains too much specification freedom, that's why we started to design our own language, Regelspraak, which does not allow for different interpretations as we work with a set of patterns in which the laws and regulations must be captured.*"

Deep layer implementation challenges

Challenge 2B) The current value of the alignment between products and services on the one hand, and laws and regulations on the other is low. This is grounded by the fact that laws and regulations are not structured along the products and services the governmental institutions deliver. For example, to design and specify the service "grant benefits", business rules from multiple different laws and regulations must be elicited. Currently, the meta-models applied to describe both laws and products have not been adequately aligned. One of the participants stated the following: "*Laws and regulations are, on the higher abstraction level, easy to understand and thus to model. However, when modeling the details of lower abstraction levels of law, many exceptions exist, and even then, there are exceptions regarding these exceptions. To make it even worse, different groups are defined within those exceptions." Another participant added, "All forms of standardization used to align the law with the execution are not taken into account in these exceptions, and there are a lot of them.*"

Challenge 3B) The current value of the ability to effectively connect fact types with database entities of the existing databases is low. This is grounded by the fact that, ideally, when business rules are deployed, fact types used in those business rules are directly connected to database entities in an existing database. However, the participated organizations currently are unable to directly connect fact types with their corresponding database entities. This is caused by a meta-model design in which the relationship between a fact type and a database entity is not taken into account. As a result, the participated organizations all need to perform additional manual activities to ensure that the fact types, as part of deployed business rules, are connected with database entities in order to be executed.

Challenge 4B) The current value of the ability to design business rules that guide synthetic tasks is low; Current projects are focused on one specific type of task, namely decisions, which is a specific analytic task type (Breuker & Van de Velde, 1994). This is grounded by the fact that currently, only knowledge on business rules to specify analytic tasks is present within the organizations. Therefore, organizations are unable to specify business rules that guide synthetic tasks.

Organizational layer implementation challenges

Challenge 5B) The current value of the collaboration with staff from third parties is low. This is grounded by the fact that the participants all indicated that they experience the large amount of external staff in their organizations as a burden. There are situations where external staff elicits, designs, and specifies all business rules. For example, one of the participants stated the following: "*If we could go back in time I would ensure that people of our own organization participated in the definition of the elicitation, design, and specification processes as these are all fully defined by external employees.*" This is a challenge due to two reasons. The first reason is that external staff can more easily leave the organization, as they are not always contractually bound and often hired per hour. The second reason is that all participants experience difficulties with external staff as for documenting their accumulated knowledge at the case organizations, even when asked to do so.

Challenge 6B) The current value of the collaboration with ministries that provide laws and regulations which need to be implemented by the executive governmental institutions is low. This is grounded by the fact that the participants addressed that more extensive collaboration with ministries is essential to further improve their BRM processes. The ministries do not adequately take into account the practical aspects of the execution and enforcement of new or changed laws and regulations, while the participated organizations do need to take into account that the implementation does not distance itself from the specified laws and regulations (achieving the desired societal effect(s)) in combination with practical aspects (i.e. execution and enforcement). A participant stated: "*Five years ago we did not dare to say we could not execute the proposed changes by legislative institutions. This has changed a bit, but we still find it hard to do*" The gap in perspective between both the ministries and executive government institutions leads to frustration and decreased efficiency.

Challenge 7B) The current value of the governance of fact vocabularies is low. This is grounded by the fact that the participants indicated that a fact type vocabulary is a required artifact in the implementation of laws and regulations as it allows the central management of all fact types utilized in business rules for different products and services. However, the participants also indicated that, currently, the process of maintaining the fact type vocabulary is not adequately enforced, resulting in an increase in errors while eliciting, designing and specifying services and their business rules.

Challenge 8B) The current value of scenario coverage in the elicitation of legal requirements is low. This is grounded by the fact that three methods of elicitation for the development of public administration services are utilized; top-down, scenario-based, and a hybrid form of both. When adhering to a top-down approach, the services are designed while taking into account the laws and regulations provided. However, a bottom-up approach enables organizations to work from possible customer scenario's and is also referred to as scenario-based elicitation. The top-down approach is utilized by three of the five participated organizations. However, the participants indicated that the bottom-up approach covers all customer scenarios while the top-down approach could result in unsupported scenarios. Nonetheless, the participants stated that the scenario-based approach is more resource consuming and therefore often forces them to utilize the top-down approach.

Challenge 9B) The current value of elicitation quality is low. This is grounded by the fact that all participants experience time pressure in the elicitation processes. There are two main reasons time pressure occurs. First, this is caused by politics that cause shifting deadlines. Secondly, a government institution must execute a feasibility study to examine to what extend new or changing laws and regulations can be effectively and efficiently executed in practice. To make sure that both demands are met, less time is spent on the elicitation process. This results in a reduced fault-proof elicitation of legal requirements from legal sources. For example, one of the participants stated: "*Time pressure is playing an increasingly important role, therefore we sometimes are forced to only analyze on a high-level abstraction for potential impact. Available time determines the quality of the analysis.*" This can pose organizations with risks due to the fact that, as a consequence of inadequate elicitation of legal requirements, laws and regulations are inadequately designed and executed.

Physical layer implementation challenges

Challenge 10B) The current value of the supportive tooling for elicitation is low. This is grounded by the fact that the existing supportive tooling does not support the following activities: automatic importing of laws and regulations, annotate laws and regulations, and impact analysis. This is supported by two different participants that state: "*All activities to determine what legal requirements affect the current implementation are performed manually (i.e. letters, education material, work instructions, translations, IT codes). This is terrible to do manually and a lot of work.*" and "*Individuals all have different areas of expertise and they all individually check for the impact that proposed changes to a law result into. However, what happens with continuity of the analysis when such experts suddenly are unable to do their job (i.e. due to accident, disease, or death).*" Based on negative experiences with commercial tooling, three case organizations started development of their own annotation tool to support the elicitation process.

Challenge 11B) The current value of the support for the traceability of legal requirements to business rules and other software related building blocks is low. This is grounded by the fact that a large amount of different legal sources underlie a government service that utilizes business rules. According to the participants, insufficient traceability leads to an unwanted amount of manual activities when eliciting legal requirements from legal sources, as it makes it harder to identify modifications between versions and impact on existing implementations of the operational service. For example, one of the participants stated: "*Simulations for impact are performed manually – In my head -. However, all the information I need to know to be able to do so needs to be manually requested by specific colleagues, for example, how much time or money does it cost to change letters per impacted user group, or how much time does it take to change certain codes in a system.*"

6.6.3 Design and Specification Implementation Challenges

Deep layer implementation challenges

Challenge 1C) The current value of the expressiveness and precision of languages is low. This is grounded by the fact that the current languages utilized by the participants are not expressive and precise enough to design contexts and business rules in their design and specification processes. Also, they have experienced that software suppliers have this problem and these languages could benefit from further user-driven development so that all legal requirements can be formalized in business rules.

Challenge 2C) The current value of the ability to structure or group business rules is low. This is grounded by the fact that the modeling languages utilized by the participated organizations do not support an element to group and structure business rules. This is caused because of the fact that most languages are business rules-centric, for example, RuleSpeak, Declarative Process Modeling Notation (DMPN), and Semantics of Business Vocabulary and Rules (SBVR), resulting in a big bucket of business rules that cannot be related to each other by separate elements to apply cohesion. One of the participants stated: "*We use MS PowerPoint to structure groups of rules from our rule base as the current language does not structuring of rules adequately.*"

Challenge 3C) The current value of the quality criteria for the design and specification of products like decisions, derivation structures, business rules, and fact type vocabularies is low. This is grounded by the fact that, currently, the applied quality criteria at the participated organizations are often not present or validated adequately and are applied in an ad-hoc manner. This results in unpredictable outcomes in terms of the quality of the products designed and specified. For example, a set of business rules, that is not specified according to the quality criteria, but that is submitted to the verification process could result in an unnecessary waste of organizational resources. This can be the case when quality challenges are detected in the verification and validation processes, which triggers a re-design process of the product. Similarly to general software artifact development, adjustments to BRM-related artifacts are more resource consuming when processed later on in their development process (The Standish Group, 2014).

Challenge 4C) The current value of the inclusion of the input data method in design and specification processes is low. This is grounded in the fact that the participants addressed that their design and specification processes do not take into account the input method of data for the applied business rules. For example, the business rule set to determine whether a vehicle is a recreational vehicle is multiple pages long. However, this business rule set contains measurements a citizen is unable to collect themselves. Therefore the business rule set is translated to a boolean question: *is the vehicle a recreational vehicle?* This example demonstrates that the method of data collection influences the specification processes. Not determining upfront how data will be collected leads to situations where business rule analysts over or underspecify derivation-structures and business rules. This leads to the allocation of resources that should not have been allocated.

Challenge 5C) The current value of maintainable and extensible meta-models is low. This is grounded in the fact that the participants stated, due to time pressure, insufficient attention is spent on creating a maintainable and extensible meta-model. This causes problems when additional, or changes to laws and regulations are introduced. The participants urged that, if they could change one thing in a BRM project, more time was spend on designing maintenance-proof meta-models. For example, a lesson learned by the participants was that elements could best be separated from each other, which is also referred to as the 'single responsibility principle'. However, their meta-models did not allow for such a change to the structure as it would have too much impact on their existing products and services.

Organizational layer implementation challenges

Challenge 6C) The current value of activities and processes to specify implementation independent products is low. This is grounded by the fact that some participants indicated that their organizations currently do not have a process in place which structures the activities required to design and specify contexts and business rules in their implementation-independent form. It was indicated that such a process is required due to the fact that large organizations dealing with business rules often utilize a wide variety of software systems all retaining to their own language, in which business rules are referred to as implementation-dependent business rules. The utilization of implementation-independent business rules can be beneficial as these must be designed and specified in a uniform way, and therefore are a central point-of-truth for further transformation and implementation into specific software systems. One of the participants stated: "*The process to design contexts and business rules is important, but we don't have a process to do so. When we had a team meeting we said to each other: just get started with designing and specifying. However, we did this without any guidelines or process*"

Challenge 7C) The current value of the collaboration with staff from third parties is low. Similar to the reported challenges regarding elicitation, this is grounded by participants that stated that the amount of external staff involved in the design and specification processes is high, and therefore dependency from external parties poses the participated organizations with various risks. For a detailed explanation see challenge 5A.

Challenge 8C) The current value of communication with IT-departments regarding the specification of business rules is low. This is grounded by the fact that the participants addressed that, on the organizational level, many discussions are held with IT departments regarding how business rules are specified. The gap identified can also be referred to as the 'gray zone' in laws and regulations versus 'black-and-white' that needs to be implemented into computer systems. These discussions are considered not very problematic by the participants. However, it can slow down the implementation process of business rules, decreasing productivity of the organization as a whole. The participants indicated that either colleagues of the IT department should join the business rules designers in this particular process and directly influence the design of business rules by providing requirements from an IT-perspective, or that such discussions are held in the validation process(es).

Challenge 9C) The current value of knowledge loss risk reduction is low. This is grounded by the fact that the participants indicated that the BRM processes are convened with a handful of people. A possible risk that leads to problems in BRM processes is that internal staff that specialized in, for example, a specific jurisdiction, leaves the organization. The participants argue that the accumulated knowledge is not adequately documented as well. This results in a loss of knowledge, possibly influencing BRM processes in terms of efficiency and effectiveness. Lower effectiveness in the design and specification processes possibly result in noncompliance, and should, therefore, be mitigated.

Challenge 10C) The current value of trade-off determination as part of the design and specification processes regarding five dimensions: 1) *volume*, 2) *velocity*, 3) *veracity*, 4) *variance*, and 5) *value* is low. This is grounded by the fact that the participants find it difficult to determine the trade-off between the dimensions: 1) *volume*, 2) *velocity*, 3) *veracity*, 4) *variance*, and 5) *value*. To explain this challenge we first need to ground the five V's. Although the names of the five V's are similar to the five V's applied in Big Data (Kaisler, Armour, Espinosa, & Money, 2013), their definition is different. Volume (1) stands for the number of decisions made in a specific time unit. Velocity (2) stands for the amount of time in which a decision must be taken. Veracity (3) stands for the quality of the decision, in other words, does the decision needs to be 100% accurate or is 70% accuracy enough to take a proper decision. An example situation where decisions do not have to be 100% accurate are the recommender systems on the websites of retailers. Variance (4) indicates the variance in the decision made. This is based on two main variables: the a-prior definition of the possible execution paths and the change rate of the execution paths. For example, a doctor has many execution paths which cannot be all defined a-prior. On the other hand, the determination whether a specific case falls under the 'data-protection-law' is straightforward and each path can be a-prior defined. The second variable comprises the change rate of the possible execution paths. For example does the 'data-protection-law' changes every minute, month, six months on a yearly basis. Value (5) indicates the importance of the decision for the organization. For example, does the inadequate execution of a decision cost the organization one dollar, ten dollars, one thousand dollars or one million dollars.

Based on the trade-off for each of the five previously mentioned V's an organization can decide to fully elicit, design and specify the business rules or to not specify the business rules. For example, the cost to fully specify a decision that occurs once a year and must be made within 6 months may be higher than consulting an subject-matter-expert once a year. The challenge the organizations encounter is the fact that they do not define the value of the five V's or do so too late in the design and specification processes.

Challenge 11C) The current value of change management is low. This is grounded by the fact that the participants indicated that there are no change management processes in place or that existing are decentralized. Difficulties regarding the decentralized change processes are experienced as part of the BRM processes. All participated organizations except one employ decentralized change processes regarding decisions, business rules, fact types, and fact values. It was indicated that this particular approach hampers maintainability in general as, for example, changes to fact types usually also affect the business rules in which they are used. Therefore, the decentralized processing of changes does not take into account relations between elements in the design and specification processes that cause ripple effects. Moreover, as modifications to the same element can be initiated by different departments or teams simultaneously, modified elements could be in conflict with each other.

Challenge 12C) The current value of the knowledge level on business rules architectures is low. This is grounded by the fact that the participants addressed that, currently, a lack of process, guidelines, and best practices are experienced to support the creation of business rules architectures to guard cohesion between large amounts of business rules. When the subject matter experts individually create parts of business rules architectures, the combined total business rules architecture is not coherent. This results in unnecessary rework afterward.

Challenge 13C) The current value of processes to guide the creation of business rules architectures is low. This is grounded by the fact that, currently, the participated organizations do not have a process in place for the creation of business rules architectures. This results in an output that is unpredictable in terms of quality. The participants stated that the quality is dependent on the knowledge level of the individual employee. Moreover, the activities to create a business rules architecture are currently performed ad-hoc. The participants indicated that a standardized process to guide the creation of business rules architectures is much welcome, for example, one of the participants stated the following: "*When a method to create business rules architectures is utilized and adhered to by all the employees that structure the business rules I think that the quality of the outcome will be more stable.*"

Physical layer implementation challenges

Challenge 14C) The current value of the maturity of commercial tooling that should support the design and specification of business rules is low. This is grounded by the fact that almost all participants utilize regular spreadsheet software to design, specify, and maintain their contexts and business rules. This results in a decreased effectiveness and efficiency in these processes and should be supported by tooling that satisfies the requirements of experts that design, specify, and maintain contexts and business rules. The following was stated by participants: "*working with the tools we currently utilize is amateurish*" and "*We design and specify our contexts and business rules in Microsoft Word, which forced us to define guidelines as we usually work with five or more people on the same business case. However, these guidelines are not enforced by Microsoft Word.*"

Challenge 15C) The current value of the inclusion of the data availability aspect in the design of business rules is low. This is grounded by the fact that the participants argue that the design of business rules is dependent on the availability of data. For example, if a business rule uses the age of a patient as one of the conditions to derive a conclusion, but the age of the patient is not available but rather the birth date is available. In this case, an extra business rule must be specified to derive the age using the birth date. Currently, the participated organizations do not adequately take into account data availability when designing business rules, which could lead to redesign after the verification and validation processes.

6.7 Discussion and Conclusion

In this paper, we aimed to find an answer to the following research question: "*Which implementation challenges do governmental institutions encounter while implementing the elicitation, design and specification capabilities of business rules management?*" To accomplish this goal, we conducted a study combining two series of focus groups of three rounds each, and two series of Delphi studies of three rounds each. These research methods were applied to identify challenges regarding the implementation of the elicitation, design, and specification capabilities as part of a BRM project, with the input of 44 participants in total. Our rounds of data collection and analysis resulted in 28 main implementation challenges that should be taken into account when designing a BRM solution. When analyzing the challenges closely, we see that most challenges are mapped to either the deep or organizational layer. Analysis, with regards to deep layer challenges, shows that there are many languages available to represent business rules. However, the challenges in the deep layer illustrate that there is little integration possible and that there is a strong desire for a generic language that is able to support different meta-models from different organizational contexts. A solution could be seen in the recently published Decision Model and Notation standard (Object Management Group, 2015), which focuses on uniformity and portability of decisions and business rules. More evident is the amount of organizational challenges and the lack of technical and surface challenges. This is in line with the findings of Arnott and Pervan (2005), Nelson et al., (2008) and Nelson et al., (2010), which state that the maturity of BRM is divided by a relatively mature technical domain and the nascent organizational domain.

From a theoretical perspective our results are mapped on the information systems framework of Strong and Volkoff (2010), which is based on Weber (1997), see Figure 6-3. The insights derived from this study provides a better understanding of challenges in the context of the information systems framework with regards to BRM and will enable further exploration and identification of problem classes. Furthermore, our results underline the conclusions drawn from earlier literature with regards to technical versus organizational maturity of BRM implementation. From a practical perspective, our study provides a collection of challenges regarding the design and implementation of a BRM solution at governmental institutions which could be taken into account by organizations that wish to avoid common pitfalls in future projects. Currently, the participated organizations are implementing practices to mitigate the challenges identified. Furthermore, based on our results, clients and software vendors are able to develop best practices, concepts, and methods by software vendors as well as clients themselves.

While we provide an integrative overview of challenges, our study is not without limitations. The first limitation concerns the sampling and sample size. The sample group of participants is solely drawn from governmental institutions in the Netherlands. While we believe that government institutions are representative for organizations implementing BRM solutions, further generalization towards non-governmental organizations, amongst others, is recommended due to the fact that our results are limited to Dutch governmental institutions. Additionally, our results should be further validated in governmental contexts other than that of the Dutch context, i.e. other countries. With regards to research in this direction, the effect of cultural diversity should probably be taken into account. This is due to the fact that governmental institutions in, i.e. North America or Asia, apply different design solutions and therefore could experience different challenges with regards to the implementation of BRM solutions. Taking the sample size of 44 participants into account, this number can be increased in future research as well. Taking a closer look at our results presented in Figure 6-3, we identify an overrepresentation of deep and especially organizational-related challenges. This phenomena was also identified in literature (Arnott & Pervan, 2005; Arnott & Pervan, 2014; Boyer & Mili, 2011; Nelson et al., 2008), since most research has a focus on the technical perspective. Therefore, future research should also aim to investigate whether this was related to our data collection and analysis.

This study focused on identifying new constructs and establishing relationships provided by the current maturity of the BRM research field. Although the research approach chosen for this research type is appropriate, research focusing on further generalization should apply other research methods, such as quantitative research methods, which would allow for us to incorporate larger sample sizes to further validate our findings. Yet, provided the nascent nature of BRM research, this might be more appropriate in the years to come.

7 IDENTIFYING CHALLENGES IN BRM IMPLEMENTATIONS REGARDING THE VERIFICATION AND VALIDATION CAPABILITIES AT GOVERNMENTAL INSTITUTIONS

Since an increasing amount of business rules management solutions are utilized, organizations search for guidance to design such solutions. As the amount of BRMS-implementations increase, the amount of implementation challenges experienced in practice increase as well. Therefore, it is of importance to gain insights into these implementation challenges which can help guide future implementations of BRMS. Smit, Zoet and Versendaal (2017) described the challenges regarding elicitation, design and specification of business decisions and business logic; in this study, we identify the main challenges regarding 1) the verification and 2) validation of business decisions and business logic in the Dutch governmental context. Building on the collection and the analysis of two three-round focus groups and two three-round Delphi studies we report on the 17 challenges experienced by the participants. The presented results provide a grounded basis from which empirical and practical research on best practices can be further explored.

7.1 Introduction

Business decisions and business logic are an important part of an organization's daily activities. To increase grip on business decisions and business logic, organizations search for a systematic and controlled approach to support the elicitation, design, specification, verification, validation, deployment, execution, governance, and evaluation of business decisions and business logic. Such an approach can be defined as Business Rules Management (BRM), which is a combination of methods, techniques, and tools (Boyer & Mili, 2011; T. Morgan, 2002; R. G. Ross, 2003; Zoet, 2014). Many business services nowadays rely heavily on business decisions and business logic to express assessments, predictions and business decisions (Boyer & Mili, 2011; Nelson, Peterson, Rariden, & Sen, 2010). The very same holds for the management and use of business processes in Business Process Management (BPM) (van der Aalst et al., 2003). However, business decisions and logic approaches tasks from a guide-

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line/knowledge viewpoint, while the Business process management takes an activity/resources viewpoint.

In the current body of knowledge, a broad selection of literature on implementation challenges and critical success factors in the context of BPM is available. Reijers (2006) took a broad perspective on the topic of BPM and implementation of BPM in Systems (BPMS) and researched the major factors and challenges of such implementations at organizations. Moreover, Ravesteyn and Versendaal (2007) and Bandara, Alibabaei and Aghdasi (2009) target (critical) success factors for BPM (Systems) design and implementation. In addition to this very broad perspective, research is also executed focusing on one specific target group, for example, SME implementations (Chong, 2014) or government implementations (Lönn & Uppström, 2013). Another category of research focuses on a particular perspective of a BPM implementation. For example, they focus on the evaluation of critical success factors using a DEMATEL model specifically for project managers (Bai & Sarkis, 2013), risk mitigation strategies for BPM implementations (M. Zur Muehlen & Ho, 2005), or on the effect of proper governance on BPM implementations (Ernaus, Pejić Bach, & Bosilj Vukšić, 2012). In contrast to the available body of knowledge on implementation challenges regarding BPM, little to no work on challenges in BRM implementations that are experienced in practice is available. This is caused by several reasons; 1) studies often provide the beginnings of a business rules research program, but often do not focus on the specific challenges and the larger context that business logic plays in organizations (Nelson, Rariden, & Sen, 2008), 2) the body of knowledge regarding the BRM domain does not show a well-balanced mix of research, predominantly focusing on the technological aspects, while the non-technological aspects are rarely taken into account (Kovacic, 2004; Nelson et al., 2010). Additionally, 3) in 2005, Arnott and Pervan (2005) concluded, after studying more than one thousand papers, that that the field has lost its connection with industry some time ago and research output with practical relevance is scarce. This particular literature review has been revisited by the same authors, strengthening their conclusions from 2005 as follows: a transition is happening to a more practical-oriented approach; yet, still a strong connection between theory and practice is lacking (Arnott & Pervan, 2014). This was also one of the conclusions in the work of Zoet (2014). Therefore, we conclude that there is a need for BRM research from a broader perspective taking into account the implementation and application of BRM capabilities in practice.

In a previous study, Smit, Zoet and Versendaal (2017) described the challenges regarding the elicitation, design, and specification of business rules. In this study, we further extend this study by focusing on the two capabilities that focus on the quality control of business decisions and business logic. Quality control focuses on executability and compliance of the business decisions and business logic. Quality control is organized in two different capabilities within the spectrum of BRM; 1) verification and 2) validation. In this context, the purpose of verification is to determine whether the created artefacts adhere to predefined criteria and are logically consistent (Boyer & Mili, 2011). The purpose of validation is to determine whether the verified artefact delivers its intended behavior (Zoet & Versendaal, 2013). In this paper, we focus on understanding the challenges governmental institutions experience when implementing BRM, specifically concerning the verification and validation capabilities. Therefore, we intend to answer the following research question: "*Which implementation challenges do governmental institutions encounter while implementing the verification and validation capabilities of business rules management?*"

The remainder of this paper is structured as follows: First, we present an overview of the BRM problem space. This is followed by the research method used to identify the current BRM implementation challenges at Dutch governmental institutions. Next, the collection and analysis of our research data is described. Subsequently, our results are presented that provide an overview of challenges regarding the verification and validation of business decisions and business logic. Finally, we present our conclusions and discuss the utilized research methods and results of our study, and we propose possible directions for future research.

7.2 Background and Related Work

As an increasing amount of BRM solutions are being designed and implemented, organizations are searching for best practices, lessons learned, methods and other types of handles to guide the design and implementation of these solutions. A business rule is defined as "*a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behavior of the business*" (T. Morgan, 2002). A BRM solution enables organizations to elicit, design, specify, verify, validate, deploy, execute, evaluate and govern business rules. Each of the nine capabilities mentioned needs to be deployed, implemented and governed carefully. How a capability is realized by an organization depends on the situation in that specific organization, i.e. what technology or tooling is available, the maturity of the available technology, the available knowledge, and the available resources.

This paper is part of a large research project in which all nine capabilities of five Dutch government institutions were evaluated. In this paper, we investigate and elaborate upon the verification and validation capabilities and aim to identify the major challenges experienced in practice regarding the implementation of these capabilities. A detailed explanation of each capability can be found in (Smit & Zoet, 2016b). However, to ground our research, a summary of the verification and validation capabilities is provided here. Verification and validation as part of BRM comprise both business decisions and business logic. According to the Archimate 3.0 specification (Object Management Group, 2016a), a business decision can be defined as: "*A conclusion that a business arrives at through business logic and which the business is interested in managing.*" Furthermore, business logic can be defined as: "*a collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016b). Two parts of business logic are of relevance when performing the actual verification and validation; business rules and fact types (Von Halle & Goldberg, 2009). Business decisions and business logic can be designed, specified, verified and validated in both implementation-independent languages and implementation-dependent languages.

An implementation-independent language is defined as: "*a language that complies with a certain level of naturalness but has a delimited predefined expressiveness and is not tailored to be applicable to a specific automated information system*" (Zoet & Versendaal, 2013). In contrast, an implementation-dependent language is defined as: "*a language that complies with a specific software formalism, has a delimited predefined expressiveness and is tailored to be interpreted by a particular information system*" (Zoet & Versendaal, 2013). To illustrate the difference between both concepts, we first present the following implementation-independent business rule: '*Weight Loss Risk Points of the Patient must be equated to 1 IF Weight Loss of the Patient is >5% AND <10%*'. To be able to execute this particular business rule in, for example, a business rules management system, a decision table has to be created as this system cannot interpret the controlled natural language in which the implementation-independent business rule is formulated. Therefore, the implementation-dependent variant (decision table) of the business rule is formulated in Table 7-1, row 4:

Rule ID	**Input**	**Output**	**Annotation**
	Weight Loss of the Patient	*Weight Loss Risk Points of the Patient*	
xxx	xxx	Xxx	xxx
002	]5..10[	1	Weight Loss of the Patient is 1
xxx	xxx	xxx	xxx

Table 7-1: Implementation-dependent Business Rule (in a Decision Table Format)

Verification and validation usually take place after the design, specification, and deployment capabilities have been executed. After the design phase, the business Decision Requirements Diagram (DRD) is verified (to check for semantic / syntax errors) and validated (to check for errors in its intended behavior). After the DRD is designed the implementation-independent business rules are specified, verified and validated while after the deployment capability, the implementation-dependent business rules are, again, verified and validated. From this point on, both implementation-independent and implementation-dependent artifacts are referred to as artifacts. If an example only applies to implementation-independent or implementation-dependent we call artifacts by their specific name. The purpose of the verification capability is to determine if the artifacts adhere to predefined criteria and are logically consistent (Boyer & Mili, 2011). For example, a business decision could contain multiple verification errors, such as omitted conclusion errors, circularity errors, and atomic business decision errors (Von Halle & Goldberg, 2009). The same holds for business rules (Buchanan & Shortcliffe, 1984) and facts (Von Halle & Goldberg, 2009). Business rules can contain, for example, domain validation errors, omission errors, and overlapping condition key errors, and facts can contain, for example, atomic fact errors, domain violation errors, and fact value overlap errors. Verification errors not properly addressed could result in the improper execution of the value proposition in the execution capability later on in the BRM processes (Zoet, 2014). When no verification errors are identified, the created artifacts are reviewed in the validation capability. The purpose of the validation capability is to determine whether the verified artifacts delivers its intended behavior (Zoet & Versendaal, 2013). Validation errors not properly identified or addressed could lead to economic losses or loss of reputation (Zoet & Versendaal, 2013). When no validation errors are identified, the business decision and business logic are approved and marked for deployment.

Verification and validation of business decisions and business logic can be performed utilizing four possible techniques. To illustrate these techniques, we adopt and adapt the IT Controls Automation Strategy formulated by Tarantino (2008) which comprises detection and prevention of compliance errors, in a manual or automated manner. Within this spectrum, four archetypes exist: 1) manual detection, 2) automatic detection, 3) manual prevention, and 4) automatic prevention of verification and validation errors in business decisions and business logic.

Manual detection is often applied by utilizing collegial reviews where peers manually check for errors and report back upon the author of the business decision and corresponding business logic, which is applicable for both the verification and validation capability. Regarding the verification capability, the created business decisions and business logic are manually matched against the syntax and semantics of the language it is expressed in. Regarding the validation capability, the created business decision and business logic are manually tested by applying 1) source-based validation, 2) scenario-based validation, or 3) a hybrid of Source-based validation combined with scenario-based validation. Source-based validation focuses on validation based on the sources the artifacts are based on. However, this may result in a loss in validation accuracy as not all possible scenarios are embedded in legal sources like laws and regulations. Therefore, to ensure all possible scenarios are covered by the validation capability, scenario-based validation is applied. Scenario-based validation, in most cases, is conducted manually. Therefore, the downside of scenario-based validation is the added amount of resources it requires, in terms of man-hours. However, when conducted in an automated manner, cases and data are generated by the system to support the validation of scenarios, decreasing the amount of resources needed for validation. Automatic detection is defined as a software system that checks the business decisions and business logic after it has been created, and reports in the form of a list of identified errors. Regarding the verification capability, the created business decisions and business logic are automatically matched against the syntax and semantics of the language it is expressed in. Regarding the validation capability, the created business decisions and business logic are automatically tested with real-world scenario's containing all available data, processes and actors. However, detection only results in informing the author of the artifact after the error has been made. Contrary to detection, prevention focuses on the immediate response when an error is identified, thus the author is unable to implement the artifact containing the error. Therefore, manual prevention is unrealistic and impractical as this would mean that peers are always authoring business decisions and business logic together with the author of the business decisions and business logic and manually intervene when an error is made, forcing the author to correct the error, which holds for both the verification and validation capability. Lastly, automatic prevention is applied by the software system, suggesting or enforcing certain behavior regarding the authoring of artifacts to prevent errors. Regarding the verification capability, the business decisions and business logic are automatically corrected or the authoring of business decisions and business logic is stopped, and the author is only able to proceed when the error is resolved. Yet, the automatic prevention approach does not tolerate workarounds and is considered very strict. Regarding the validation capability, automatic prevention could be possible but is almost near impossible. Automatic prevention would entail the following process. First, all cases have to be defined after which each business decision or business logic specified must immediately be checked against cases. If none of the cases can be executed, the business decisions or business logic should not be allowed to be carried trough.

7.3 Research Method Justification

The method of data collection and analysis, as well as the research method justification, have been previously described in (Smit & Zoet, 2016b). For clarity and readability, we repeat the argumentation with regards to the research method justification in this section, and the method of data collection and analysis in the next section. The goal of this study is to identify challenges that were experienced in the implementation of the verification and validation capabilities. The maturity of the BRM research field, with regard to non-technological research, is nascent (Kovacic, 2004; Nelson et al., 2010; Zoet, 2014). An appropriate focus of research in nascent research fields is on identifying new constructs and establishing relationships between identified constructs (e.g. Edmondson & Mcmanus, 2007). Therefore, through grounded theory based data collection and analysis. In this study, we search and specifically report on challenges regarding the verification and validation capabilities.

For research methods related to exploring a broad range of possible solutions to a complex issue -and combine them into one view when a lack of empirical evidence exists- group based research techniques are adequate (Delbecq & Van de Ven, 1971; Okoli & Pawlowski, 2004; Ono & Wedemeyer, 1994). Examples of group based techniques are focus groups, delphi studies, brainstorming and the nominal group technique. The main characteristic that differentiates these types of group-based research techniques from each other is the use of face-to-face versus non-face-to-face approaches. Both approaches have advantages and disadvantages; for example, in face-to-face meetings, provision of immediate feedback is possible. However, face-to-face meetings have restrictions with regard to the number of participants and the possible existence of group or peer pressure. To eliminate the disadvantages, we combined the face-to-face and non-face-to-face technique by means of applying the following two group based research techniques: the focus group and delphi study. To further structure our results, we selected the information systems framework originally proposed by Weber (1997) and extended by Strong and Volkoff (2010). The framework is divided into four sections: 1) deep structure, 2) organizational structure 3) physical structure and, 4) surface structure. Deep structure elements are subjects that describe real-world systems, their properties, states and transformations (Weber, 1997). Organizational structures are the roles, control and organizational culture represented within organizations or within solutions (Strong & Volkoff, 2010). Physical structure elements describe the physical technology and software in which the deep structure is embedded (Weber, 1997). Lastly, surface structure elements describe the elements that are available in the information system to allow users to interact with the information system (Strong & Volkoff, 2010).

7.4 Data Collection and Analysis

The data for this study is collected over a period of three months, between January 2014 and March 2014, through two series of a three-round focus group and a three-round Delphi study. This approach is applied to the challenges concerning the verification and validation capabilities. Between each individual round of focus group and Delphi study, the researchers consolidated the results. Both methods of data collection and analysis are further discussed in the remainder of this section.

7.4.1 Focus Groups

Before a focus group is conducted, a number of topics need to be addressed: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities and 6) the protocol of the focus group (Morgan, 1996). For us, the goal of the focus group meetings was to identify implementation challenges of the verification and validation capabilities as part of BRM. The selection of participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In this study, organizations and individuals that deal with business decisions and business logic represent the phenomenon studied; examples are financial and governmental institutions. Therefore, multiple Dutch governmental institutions were invited to provide input for this research. The organizations that agreed to cooperate with the focus group meetings were the: 1) Dutch Tax and Customs Administration, 2) Dutch Immigration and Naturalization Service, 3) Dutch Employee Insurance Agency, 4) Dutch Education Executive Agency, Ministry of Education, Culture and Science, and 5) Dutch Social Security Office. Based on the written description of the goal and consultation with employees of each governmental institution, participants were selected to take part in the three focus group rounds. In total, ten participants took part in the focus groups regarding the verification capability. Moreover, fourteen participants took part in the focus groups regarding the validation capability. Regarding the verification capability, the following roles were included: One legal advisor, two BRM project managers, and seven business rule analysts. Regarding the validation capability, the following roles were included: one business rules architect, four business rules analysts, five policy advisors, two BRM project managers, one functional designer, and one enterprise architect. Each of the participants had at least five years of experience with business rules. Delbecq and van de Ven (1971) and Glaser (1978) state that the facilitator should be an expert on the topic and familiar with group meeting processes. The selected facilitator has a Ph.D. in BRM, has conducted eight years of research on the topic, and has facilitated many (similar) focus group meetings before. Besides the facilitator, five additional researchers were present during the focus group meetings. One researcher participated as 'back-up' facilitator. The remaining four researchers acted as a minute's secretary taking field notes. All focus groups were recorded. The duration of the first verification focus group was 192 minutes, the second 205 minutes and the third 207 minutes. The duration of the first validation focus group was 209 minutes, the second 242 minutes, and the third 176 minutes. Furthermore, each focus group meeting followed the same protocol, each starting with an introduction and explanation of the purpose and procedures of the meeting, after which ideas were generated, shared, discussed and refined by the participants.

Prior to the first round, participants were informed about the purpose of the focus group meeting and were invited to submit their secondary data regarding known challenges with regards to the implementation of the verification and validation capabilities. When participants had submitted their secondary data, they had the opportunity to elaborate upon their documented challenges during the first focus group meeting. Furthermore, during this meeting, challenges that were not present in secondary data were presented and discussed upon. For each challenge addressed, the name, description, origin, and classification were discussed and noted. After the first focus group, the researchers analyzed and consolidated the results.

The results of the analysis and consolidation were sent to the participants of the focus group two weeks in advance for the second focus group meeting. During these two weeks, the participants assessed the consolidated results in relationship to three questions: 1) "Are all challenges described correctly?", 2) "Do we need to address additional challenges?", and 3) "How do the challenges affect the design and/or implementation of the BRM capability?" This process of conducting focus group meetings, consolidation by the researchers and assessment by the participants of the focus group was repeated two more times (round 2 and round 3). After the third focus group meeting (round 3), saturation within the group occurred, leading to a consolidated overview of challenges regarding the verification and validation capabilities for BRM.

Data analysis was conducted in three cycles of coding: 1) open coding, 2) axial coding, and 3) selective coding (Strauss & Corbin, 1990). After each focus group round, open coding was conducted, involving the analysis of significant participant quotes by the individual researchers. In this process, the researchers tried to identify what Boyatzis (1998) refers to as 'codable observations'. Here, the researchers coded the data by identifying sentences where challenges were discussed. The participants named and listed challenges that occurred. For example, one of the codable observations was as follows: "*There is a project with business rules in it, but all the business rules are presented in one overview without any hierarchy, while you are responsible yourself on what business rules follow each other as part of the validation.*"

The open coding was followed by axial coding during the analysis and consolidation phase between the focus group rounds to see what challenges can be identified and how the participants supported their challenges. The researchers employed the Toulmin's (2003) framework, which consists of three elements, claim-ground-warrant, to code the challenges addressed in the focus group rounds. For example, the following claim-ground-warrant relationship was coded: Claim - "*the lack of cohesion in the language our business logic is represented in makes it unnecessarily difficult to validate projects*"; Ground - "*There is a project with business rules in it, but all the business rules are presented in one overview without any hierarchy, while you are responsible yourself on what business rules follow each other as part of the validation.*", Warrant - "*Authority, - the reliability and validity originated from a presumed expert source*".

Lastly, selective coding was applied to categorize the identified challenges that were the output of the axial coding process. The coding family 'Unit' (Glaser, 1978) was adhered to during the selective coding rounds to categorize the identified challenges. This process required inductive as well as deductive reasoning. The inductive reasoning was applied to reason from concrete factors to general situational factors. For example, multiple participants reported to use different (software) systems to verify and validate business decisions and business logic, for example, MS Word, MS Excel, MS Access, and on paper. In this case, all different statements were coded to the maturity of tooling to support the verification and validation capabilities. Deductive reasoning has been applied to reason from general situational factors to specific cases. For example, one participant stated that the language they applied to verify business decisions and business logic was not sufficient enough. When elaborating on this topic more in-depth, the language applied wasn't precise enough. Therefore the challenge was assigned to the prevention of adequate automatic verification due to the precision of the language in which the business decisions and business logic are formulated.

7.4.2 Delphi Study

Before a Delphi study is conducted, also a number of topics need to be addressed: 1) the goal of the Delphi study, 2) the selection of participants, 3) the number of participants, and 4) the protocol of the Delphi study (Okoli & Pawlowski, 2004). The goal of the Delphi study was twofold. The first goal was to validate and refine the challenges identified in the focus group meetings, while the second goal was to identify additional challenges. In total, 44 participants were involved. Twenty experts, next to the 24 experts that participated in the focus group meetings, were involved in the Delphi Studies. The reason for involving the 24 experts from the focus groups was to decrease the likelihood of peer-pressure amongst group members, which could have been the case during the focus group meetings. This is achieved by exploiting the advantage of a Delphi Study which is characterized by a non-face-to-face approach.

The non-face-to-face approach was achieved by the use of online questionnaires that the participants had to return via e-mail. The additional 20 participants involved in the Delphi Study had the following positions: one software engineer, three enterprise architects, two business rules analysts, one policy advisor, two IT-architects, six business rules architects, two business consultants, one tax advisor, one legislative author, and one knowledge management expert. Each of the 20 additional participants had at least two years of experience with business decisions and business logic. Each round (4, 5, and 6) of the Delphi Study followed the same protocol, whereby each participant was asked to assess the identified challenges in relationship to three questions: 1) "Are all challenges described correctly?", 2) "Do we need to address additional challenges?", and 3) "How do the challenges affect the design and/or implementation of a BRM solution? Regarding the analysis of the collected data as a result of the Delphi study rounds, the same method of analysis as elaborated in the focus groups section was adhered to.

7.5 Results

In this section, a summary of the challenges derived from our data collection and analysis are presented and structured for both the verification and validation capabilities. The order of the challenges presented does not reflect their relative importance. The challenges have been further structured along the dimensions of the ontological foundations of the information systems framework, see also the research method justification section. All challenges derived were based on the majority of agreement of the participants.

In this section, a summary of the challenges derived from our data collection and analysis are presented and structured for both the verification and validation capabilities. The order of the challenges presented does not reflect their relative importance. The challenges have been further structured along the dimensions of the ontological foundations of the information systems framework, see also the research method justification section. All challenges derived were based on the majority of agreement of the participants.

7.5.1 Verification Implementation Challenges

Surface layer implementation challenges

Challenge 1A) Trade-offs that organizations made regarding their business decisions and business logic languages prevents adequate verification. This is grounded by the fact that all organizations made a trade-off between precision, expressiveness, naturalness and simplicity and modified the use of their business decisions and business logic languages, which is in line with the work of Kuhn (2014) that states that a language cannot entirely comply with all four properties since they are frequently in conflict. The organizations made modifications to the representation of the applied languages, increasing, for example, its naturalness, to ensure all involved human stakeholders are able to work with the business decisions and business logic. However, these modifications also resulted into decoupling the representation of the language and the underlying meta-model, which decreases the possibilities for automatic detection and prevention of verification errors. One of the participants stated: "*We do not believe in the 100% utilization of patterns to specify business logic, as this decreases the naturalness of the language and the readability for the stakeholders in the BRM's processes.*"

Deep layer implementation challenges

Challenge 2A) The current value of the ability to verify syntactic tasks is low. Current projects are focused on one specific type of task, namely business decisions, which is a specific analytic task type (Breuker & Van de Velde, 1994). This is grounded by the fact that only knowledge on how to verify analytic tasks is present within the organizations. However, the organizations are increasingly experimenting with synthetic tasks, but lacking the knowledge to adequately verify these type of tasks. Therefore, organizations are unable to verify business decisions and business logic that guide synthetic tasks as such business decisions and business logic artifacts utilize concepts which differ from synthetic tasks (in terms of meta-models). The participants stated that this should be further investigated by their subject-matter experts.

Organizational layer implementation challenges

Challenge 3A) The current maturity of the verification capability is low. This is grounded by the fact that verification is often seen and implemented as an integral part of the design, specification and deployment capability and only a few of in total 33 capabilities (Smit, Zoet and Versendaal, 2017) are implemented. Therefore, the implementation of the verification capability and its sub-capabilities is often implicit and not properly controlled. This also harms the development of the verification capability as important knowledge (i.e. lessons learned, best practices) is not made explicit. One of the participants stated: "*When we identify new errors, we retain knowledge about how to test for those errors a few weeks implicitly. But, after a few weeks, the implicit knowledge is lost and we continue to verify our business logic like we always did.*"

Challenge 4A) Verification is applied too late in the business decision and business logic creation processes. This is grounded in the fact that most organizations elicitate, design and specify their implementation-independent business decisions and business logic in paper form or in wiki-style databases, which cannot be verified automatically. However, automatic verification is possible in implementation-dependent software systems. This results in the business decisions and business logic being verified when it is implemented in their corresponding implementation-depended systems, but also resulting in omitting the verification of the implementation-independent business decisions and business logic the implementation-dependent business decisions and business logic is based on. Another effect of only applying verification in the implementation-dependent systems is that no knowledge is gathered on how implementation-independent business decisions and business logic should be verified. The participants stated that the verification of implementation-independent business decisions and business logic is a must-have. One of the participants stated: *"We struggle with unambiguous and inconsistent implementation-independent artifacts which we are unable to verify."*

Challenge 5A) Automatic verification is not widely applied. This is grounded in the fact that most participants utilize different software systems to specify and verify their artifacts. An example of one of our participated organizations is the utilization of the Bizzdesign suite for the specification of their artifacts, while the verification is performed in Microsoft Excel. Regarding the discussion concerning the application of automatic verification, all participants agreed that, for example, the verification of the use of fact types in business rules, should be verified in an automatic preventive manner so that verification errors are avoided, supported by their system. One of the participants stated: *"If only it were true that, when specifying business decisions and business logic, verification is applied in an automatic preventive manner."*

Physical layer implementation challenges

Challenge 6A) In addition to challenge 5a that no automatic verification occurs, the current value of the maturity of commercial tooling to design and specify artifacts that support verification is low. This is grounded by the fact that almost all participated organizations employ systems that are unable to support verification adequately (i.e. do not cover the required verification capabilities/tests to analyze business decisions and business logic, such as circularity, interdeterminism, and transitive dependency). Most participants currently perform verification of their business decisions and business logic manually with no support from a specialized tool. One of the participants stated: *"A quality summary is available in our tooling, sometimes it gives a 10/10 when my business rules are really bad, while 100% sound business rules are given a 7/10 in the summary."*

7.5.2 Validation Implementation Challenges

Surface layer implementation challenges

Challenge 1B) Business logic that is communicated to end-users is not validated. This is grounded by the fact that readability requirements demand that the business logic is translated to natural language which does not allow for validation (Kuhn, 2014). Therefore, sufficient attention should be invested into the validation of the transformation of the artifacts back into a more natural language for end-users in products and services. One participant stated: "*It is important to validate the content of the instructions, web pages, and/or folders with the specified business decisions and business logic*"

Deep layer implementation challenges

Challenge 2B) The current value of the possibilities to structure business decisions and business logic in the available languages is low. This is grounded in the fact that most of the business rules languages are restricted by their meta-model that does not offer any or appropriate elements to structure business decisions, business rules, and fact types. Therefore, validation of individual business decisions or small sets of business decisions can be adequately managed in current languages. However, when moderate or large amounts of business decisions and underlying business logic need to be validated, the currently available representation languages do not offer appropriate expressiveness to support the structuring, resulting in the validation of a '*big bucket of business decisions and business logic.*' One of the participants stated the following: "*Because it's not possible to structure business rules in coherent business rule sets, validation becomes harder for the roles responsible for validation*."

Organizational layer implementation challenges

Challenge 3B) In addition to challenge 2B, the current value of the ability to validate the cohesion between business decisions and business logic by legal subject-matter experts is low. This is grounded in the fact that most of the legal experts are used to validate complete sets of business decisions and state they cannot validate individual parts of business decisions and business logic. This creates friction with the roles that elicitate, design and specify business decisions and business logic as these are used to create and validate business decisions and business logic as building blocks, lacking cohesion with the context around it as the current representation languages do not allow such relations to be created. Because of these different perspectives on validation by both roles, the efficiency of the validation processes is reduced.

Challenge 4B) The current value of the validation of business decisions and business logic in combination with business processes and data is low. This is grounded in the fact that the business decisions and business logic, business processes, and data domains are seen as separate areas of concern and therefore are the responsibility of different departments and subject-matter experts in an organization. However, the validation of business decisions and business logic should be combined with the relevant business processes and data to create added value. As these concerns are often validated separately, potential errors in the intended behavior of the business decisions and business logic are not detected, which leads to reduced effectiveness and efficiency of the BRM processes in general as the development of business decisions and business logic needs to re-iterate back to remove such errors in later stages (Dustin, 2002). One of the participants stated: "*Ideally, you want to validate the specified business logic together with the data (facts) it uses and the process it is utilized in, as this increases the speed and fault-tolerance of the validation processes*"

Challenge 5B) An unnecessary amount of validation re-iterations needs to be performed. This is grounded in the fact that the current validation processes often includes business decision and business logic design and specification experts in combination with subject-matter experts. However, the participants addressed that the validation processes do not include IT experts that focus on the implementation of the business decisions and business logic or do so too late in the validation processes. This often leads to more iterations with re-design than necessary as validation issues regarding the execution of the business decisions and business logic are not or too late identified by IT experts. More iteration(s) after the business decisions and business logic are delivered to be implemented lead to an increase in overall time required to develop business decisions and business logic. "*We do not include implementation experts while performing validation, which leads to the implementation teams rejecting and returning the business decisions and business logic back to us. This could be solved by including implementation experts in the validation processes to avoid too much re-iteration after the delivery of the business decisions and business logic to be deployed*."

Challenge 6B) The current value of the available resources for validation is low. This is grounded in the fact that the validation teams are consistently under pressure by management to perform validation processes in shorter timeframes or with less capacity. This leads to risks regarding the quality of the output of the validation capability as errors in the intended behavior are not always adequately detected or documented. Moreover, as less capacity is available for the validation processes, certain knowledge skill sets (i.e. legal experts on specific legal areas or IT experts specialized in the execution of business rules) are not always included, which also leads to risks regarding errors in the intended behavior of the specified business rules. Such risks potentially result in (severe) economic losses or loss of reputation (Smit & Zoet, 2016b). One of the participants stated: "*Performing validation with a shortage of resources is pretty much standard nowadays at our organization.*"

Challenge 7B) The current value of performing validation with relevant case data is low. This is grounded by the fact that, in most situations, scenario-based validation is performed using case data from previous implementations of the business decisions and business logic. However, the validation experts want to have case data which matches the changes in the business decisions and business logic. Essentially, the experts want to utilize simulation in their validation processes to search for errors in intended behavior before the new or changed business decisions and business logic goes live. However, this is not possible with the available case data the participated organizations collect and manage. Simulation is, therefore, impossible for the participants as manually imitating real-world case data for new or changed business decisions and business logic is deemed very time-consuming and therefore not always possible. One of the participants stated: "*We test our new business rules with case data from the previous year, which results in the detection of problems very late in the development process or even at execution. It's in the differences between old and new law that produces problems that we ideally want to filter out, but are unable to.*"

Challenge 8B) The current value of the alignment of business decisions and business logic between release schedules of the validation teams and implementation teams is low. This is grounded in the fact that the validation and implementation teams often comprise different subject-matter experts and are part of different departments. Both domains apply separate project management methods, which results in different release schedules which currently often conflict with each other. In the most situations, the implementation departments work with agile sprints, which badly allow for delay in the validation processes, caused by additional consultation with subject-matter experts for the (small) redesign of business decisions and business logic. When artifacts aren't re-designed to meet the deadline of the implementation teams, potential errors in the intended behavior are overlooked, possibly resulting in economic losses or loss of reputation (Zoet & Versendaal, 2013).

Challenge 9B) The current value of the adoption of available testing methods for validation specific towards business decisions and business logic is low. This is grounded in the fact that the validation processes and subject-matter experts do not employ testing methods that are tailored for the validation of business decisions and business logic. All participated organizations individually adopted various testing methods that are often utilized in an unstructured manner. However, the participants posed that these methods do not sufficiently cover the current validation needs of the subject-matter experts that need to validate the business decisions and business logic. According to the participants, a structured approach with clear activities and deliverables is essential for adequate validation of business decisions and business logic. One of the participants stated: "*I think we do not adequately take into account which scenarios are hit when something changes in legal sources. When we do such a thing we also need to evaluate afterward with the data from execution whether our estimation [on what was validated] was true or not. Currently, we do this in an unstructured and unmethodical manner*."

Physical layer implementation challenges

Challenge 10B) The current value of the maturity of commercial tooling that should support validation is low. This is grounded by the fact that almost all participants utilize regular spreadsheet software to support the validation of their business decisions and business logic. However, the participants utilize such tools parallel to their software to design and specify their artifacts, mainly because their specialized software is not able to adequately support the validation of business decisions and business logic (in terms of functionalities). The usage of low maturity tools for a capability that is critical for the quality of the created business decisions and business logic poses the organizations with several risks such as the lack of clarity, the lack of searchability and the lack of interconnectivity with specialized software that is used in the other capabilities or even within the validation capability processes. Therefore, the lack of available specialized tooling to support validation processes results in a decreased effectiveness and efficiency of validation processes. One of the participants stated: "*There is much to be gained by the use of a specialized too* -other than MS office software- *which could provide a clear overview of the business logic that has to be validated.*"

Challenge 11B) The current value of the support for impact assessment in the available tooling is low. This is grounded by the fact that, currently, all participated organizations are unable to perform impact assessment as part of their validation processes supported by tooling. However, all participants deemed this particular capability very important, as it allows them to analyze the exact impact of new and/or modified artifacts on the already implemented artifacts, significantly increasing the effectiveness of the validation process. One of the participants stated the following: "*We don't have support in our system for impact assessment when something changes in one of the legal sources, for example, that the system shows what implementation-independent rule model and which criteria are affected so the validator knows where to look for during the validation processes. Now, this process is performed in the minds of the people that validate.*

7.6 Discussion and Conclusion

In the current body of academic literature, challenges regarding the implementation of BPM capabilities are widely reported and discussed upon. However, the same does not hold for challenges regarding the implementation of BRM capabilities. In Smit, Zoet and Versendaal (2017) the challenges regarding the elicitation, design, and specification capabilities were identified. In this study, we continued with the identification of challenges, scoped to the verification and validation challenges. To be able to do so, we aimed to find an answer to the following research question: "*Which implementation challenges do governmental institutions encounter while implementing the verification and validation capabilities of business rules management?"*

These challenges should be taken into account when designing the verification and validation capabilities in a BRM solution. From a research perspective, this study's results provide a fundament for further research regarding challenges that possibly hamper the implementation of the verification and validation capabilities as part of a BRM solution. Furthermore, the results could spark the development of best practices, concepts, and methods by software vendors as well as clients themselves. From a practical perspective, this study's results provides a collection of challenges regarding the design and implementation of a BRM solution at governmental institutions which could be taken into account by similar organizations that wish to avoid common pitfalls in future projects.

In our study, we draw our conclusions based upon data collected solely from the Dutch governmental context, which limits, in terms of sampling, a broader generalization towards other industries. Related to the previous limitation is the sample size, which is limited as we utilized two series of focus groups of three rounds each and two series of Delphi studies of three rounds each. These research techniques are best suited for qualitative research methods and do not support the inclusion of large sample sizes. However, the current sample size of 44 participants should be increased in future research. Additionally, while we believe that our sample composition is representative for organizations designing and implementing BRM solutions in general, future research should focus on further generalization towards other industries (non-governmental). Taking into account the limitations of our study and its results we argue that studies with the goal to improve the generalizability of our findings should focus on employing quantitative research methods as well.

8 IDENTIFYING CHALLENGES IN BUSINESS RULES MANAGEMENT IMPLEMENTATIONS REGARDING THE GOVERNANCE CAPABILITY AT GOVERNMENTAL INSTITUTIONS

As the number of BRMS-implementations increases, more and more organizations search for guidance to design such solutions. Given these premises, more implementation challenges experienced from practice become evident. In this study, we identify the main challenges regarding the governance capability as part of BRM, in the Dutch governmental context. To be able to do so, we utilized a four-round focus group and a three-round Delphi study set-up to collect our data. The analysis resulted in eight implementation challenges experienced by the participants. The presented results provide a grounded basis from which empirical and practical research on best practices can be further explored.

8.1 Introduction

As an increasing number of Business Rules Management (BRM) solutions are being designed and implemented, organizations are searching for best practices, lessons learned, methods and other types of handles to guide the design and implementation of these solutions (Zoet, 2014), (Smit, Zoet, et al., 2017a). In this study, the concept of design represents the creation and planning of a solution, while the concept of implementation represents the technical integration and organizational embedding (Lehman, 1980). A BRM solution enables organizations to, in a systematic and controlled manner, elicitate, design, specify, verify, validate, deploy, execute, govern and evaluate business decisions and underlying business logic to create added value, see Figure 8-1 (Boyer & Mili, 2011; Graham, 2007; Schlosser et al., 2014). Each of the earlier mentioned nine capabilities mentioned need to be deployed, implemented and governed carefully. How a capability is realized by an organization depends on the situation in that specific organization, i.e. what technology or tooling is available, the maturity of the available technology, the available knowledge, and the available resources.

A business decision can be defined as: "*A conclusion that a business arrives at through business logic and which the business is interested in managing*" (Object

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Management Group, 2016a). Furthermore, business logic can be defined as "*a collection of business rules, business decision tables, or executable analytic models to make individual business decisions*" (Object Management Group, 2016b).

An important aspect of BRM is the governance of business decisions and business logic, which is essential for the continuity of the added value originally created by the implementation of the business decisions and business logic.

In the current body of knowledge, a broad selection of literature on implementation challenges and critical success factors in the context of Enterprise Resource Planning implementations, for example, (Gargeya & Brady, 2005; Xue, Liang, Boulton, & Snyder, 2005), Business Process Management implementations, for example, (Lönn & Uppström, 2013; Reijers, 2006) and Supply Chain Management implementations, for example, (Boddy, Cahill, Charles, Fraser-Kraus, & Macbeth, 1998; Lambert & Cooper, 2000) is available.

In contrast to the available body of knowledge on implementation challenges regarding domains such as ERP, BPM, and SCM, little to no work on challenges in BRM implementations that are experienced in practice is available. This is caused by several reasons; 1) studies often provide the beginnings of a business rules research program, but often do not focus on the specific challenges and the larger context that business logic plays in organizations (Nelson et al., 2008), 2) the body of knowledge regarding the BRM domain does not show a well-balanced mix of research, predominantly focusing on the technological aspects, while the non-technological aspects are rarely taken into account (Graham, 2007; Schlosser et al., 2014). Additionally, 3) in 2005, Arnott and Pervan (2005) concluded, after studying more than one thousand papers, that the field lost its connection with industry some time ago and research output with practical relevance is scarce. This particular literature review has been revisited by the same authors, strengthening their conclusions from 2005 as follows: a transition is happening to a more practical-oriented approach; yet, still, a strong connection between theory and practice is lacking (Arnott & Pervan, 2014). This was also one of the conclusions in the work of (Zoet, 2014). Therefore, we conclude that there is a need for BRM research from a broader perspective, taking into account the implementation and application of BRM capabilities in practice.

Organizations in which more and more BRM implementations are executed are governmental institutions. Government institutions deliver public administration (e-)services, which are specified in laws and regulations. Based on the laws and regulations, the business processes, procedures, decisions (that are executed) and the data (that is registered to deliver a particular service) are restricted. As laws and regulations change in an increasing pace, for example, due to societal developments, public administration (e-)services also need to change. A solution to guide the design and implementation of public administration (e-)services is BRM. The key building blocks of BRM are business rules, which are translated from laws and regulations into computer-executable business rules and serve as building blocks for legal digital products and/or services.

This paper is part of a large research project in which all nine capabilities of five Dutch government institutions were evaluated. In previous studies, the implementation challenges regarding the elicitation, design specification verification, validation, and monitoring capabilities were identified (Smit, Versendaal, et al., 2017; Smit & Zoet, 2016b). A full elaboration of all BRM capabilities can be found in (Smit & Zoet, 2016b). In this paper, we investigate and elaborate upon the governance capability and aim to identify the major challenges experienced in practice regarding the implementation of this capability. To be able to do so, we intend to answer the following research question: "*Which implementation challenges do governmental institutions encounter while implementing the governance capability of business rules management?*"

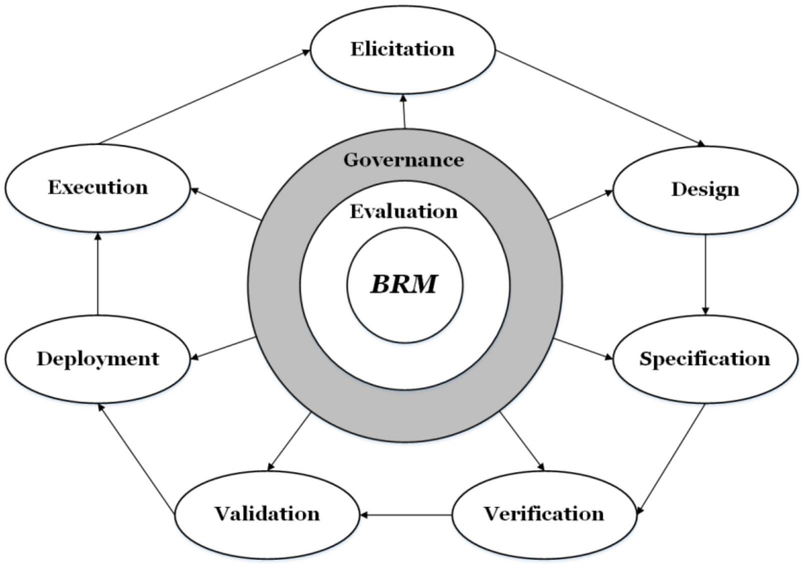

Figure 8-1: BRM Capabilities Overview

The remainder of this paper is structured as follows: First, we present an overview of the governance problem space. This is followed by the research method used to identify the current governance-related BRM implementation challenges at Dutch governmental institutions. Next, the collection and analysis of our research data is described. Subsequently, our results are presented that provide an overview of the implementation challenges regarding the governance of business decisions and business logic.

Finally, we present our conclusions and discuss the utilized research methods and results of our study, followed by possible directions for future research.

8.2 Background and Related Work

Governance in terms of BRM can be defined as the capability of the registration of meta-data with regards to version management, validity management, traceability management and the relationships between these sub-capabilities (Zoet, 2014). The previously mentioned activities concern the entire lifecycle and thereby the implementation-independent and implementation-dependent artefacts that are realized or are required for the elicitation, design, specification, verification, validation, deployment, execution, and evaluation capabilities. The governance capability comprises three separate sub-capabilities: 1) Traceability Management, 2) Validity Management, and 3) Version Management.

In specific industries, the level of maturity with regards to traceability management is mature, i.e. healthcare, food processing and systems and software development (requirements) (GS1, 2017). The goal of traceability management with regards to BRM is to make the relationships between specific versions of a specific set of artifacts visible, in two dimensions. The first dimension comprises vertical and horizontal relations. Horizontal relations refer to traceability relations that associate elements of the same type of artifact (i.e. relationships between facts) while vertical relations refer to associations from an artifact towards different types of artifacts (i.e. a relationship between a decision and its underlying business rule) (Lindvall, Tvedt, & Costa, 2003). The second dimension comprises pre and post-traceability, which is also referred to as forward and backward traceability (Gotel & Finkelstein, 1994). Pre-traceability refers to the relations between business decisions/business logic and the sources that have given rise to these specifications, i.e. the stakeholders that have expressed the views and needs which are reflected in them while post-traceability refers to the relations between business decisions/business logic and artifacts that are created in subsequent stages of the software development life cycle. The second goal of traceability management is to form a basis for impact assessments when existing business decisions or business logic need to be modified (Smit, Zoet, & Berkhout, 2016). Impact assessments are important as it allows organizations to provide feedback on the expected effect of a modification. Furthermore, impact assessment allows for the creation of a justified planning of resources to process the modifications. For example, in most countries, executive governmental branches execute the laws and regulations that are imposed by legislative governmental branches. When laws and regulations change, the executive governmental branches are expected to deliver insights beforehand on what the impact of the changed laws and regulations are with regards to executability, budgeting and whether the intended effect can be realized. This is usually referred to as the pilot phase. The current body of knowledge with regards to traceability of business decisions and business logic contains some solutions to realize traceability, these are; European Law Identifier (ELI), European Case Law Identifier (ECLI), and Juriconnect (van Kempen, 2017). However, these standards are defined for a specific context (for example, ECLI, which only traces case law) or with regards to a relationship between two specific artefacts.

Version Management aims to record changes in artifacts and to track and assign versions of the aforementioned changes in artifacts. To the knowledge of the authors, no standard that is specifically tailored to be utilized for business decisions and business logic exists. To our experience, organizations utilize generic methods, standards and processes developed for software engineering in general. Examples of such methods would be checking-out and checking-in artefacts via 1) Design on a trunk, fault recovery on a branch, 2) Design on a branch, fault recovery on a trunk, and 3) Design and fault recovery on a branch, deployment on a trunk (Chacon & Straub, 2014). Applying such methods, organizations often use applications, for example, Git (Loeliger & McCullough, 2012).

The purpose of validity management is to provide a specific version of a specific set of artifacts at any given moment in time (Jensen & Snodgrass, 1999). By realizing validity management, it is possible to see, at any moment in time, which instance is valid. This partly overlaps with the goal of version management. Similar to version management, no standard that is specifically tailored to be utilized for business decisions and business logic exists, to the knowledge of the authors. However, to the experience of the authors, organizations utilize validity management best practices borrowed from the data-management domain. For example, IBM, Microsoft, and Oracle utilize validity management of database entries, by using two possible methods: 1) temporal data management or 2) bi-temporal data management (Saracco, Nicola, & Gandhi, 2010). Temporal data management in relation to BRM focuses on the use of two-time dimensions represented by either system or transaction start and end-timestamps. The combination of both enables organizations to determine when an artefact is introduced in the system and when it is changed. Temporal data management can also utilize a different set of time stamps; validity start and validity end-timestamps. The combination of both enable organizations to determine the exact period an artefact, i.e. a specific version of a business decision or ruleset, is valid. Additionally, there is bi-temporal data management which utilizes both the previously described system and validity timestamps in order to time travel. Time travel with artefacts is possible due to the fact that the combination of both the system and validity time stamps allow querying for historical, current and future implementation of artefacts (Saracco et al., 2010).

The aforementioned sub-capabilities can be implemented in different domains, and thus must be managed accordingly. Also, multiple domains require multiple transformations as they are all part of the development process of business decisions and business logic. In literature, three domains are recognized, which influence the implementation of governance: 1) the source domain, 2) the implementation-independent domain, and 3) the implementation-dependent domain (Smit, Zoet, & Berkhout, 2016). The first domain comprises any source, for example, laws, regulations, EU agreements, policies, policies, internal documentation, guidance documents, Parliament documents, official disclosures, implementation instructions, and expert hearings that must be taken into account when designing the value proposition (i.e. service or product). The second domain comprises artifacts that are established without incorporating language or properties that are affiliated to the use of specific technology (i.e. from specific vendors) and are processed in an implementation-independent language (Zoet, 2014). An implementation-independent language is defined as: "*a language that complies with a certain level of naturalness but has a delimited predefined expressiveness and is not tailored to be applicable to a specific automated information system*" (Zoet & Versendaal, 2013). The third domain comprises implementation-dependent artefacts which are based on their implementation-independent counterparts created or modified in the previously elaborated domain and are implemented in an implementation-dependent language. An implementation-dependent language is defined as: "*a language that complies with a specific software formalism has a delimited predefined expressiveness and is tailored to be interpreted by a particular information system*" (Zoet & Versendaal, 2013). An example of an implementation-dependent artefact would be the use of knowledge models specifically created and used in the application BeInformed.

8.3 Research Method Justification

The goal of this study is to identify challenges that are experienced in the implementation of the governance capability. The maturity of the BRM research field, with regard to non-technological research, is nascent (Kovacic, 2004; Nelson et al., 2008; Zoet, 2014). An appropriate focus of research in nascent research fields is on identifying new constructs and establishing relationships between identified constructs (e.g. (Edmondson & Mcmanus, 2007)). Therefore, through grounded theory based data collection and analysis, in our research, we search for implementation challenges with regards to the governance capability.

For research methods related to exploring a broad range of possible solutions to a complex issue -and combine them into one view when a lack of empirical evidence exists- group based research techniques are adequate (Delbecq & Van de Ven, 1971; Okoli & Pawlowski, 2004; Ono & Wedemeyer, 1994). Examples of group based techniques are focus groups, Delphi studies, brainstorming and the nominal group technique. The main characteristic that differentiates these types of group-based research techniques from each other is the use of face-to-face versus non-face-to-face approaches. Both approaches have advantages and disadvantages; for example, in face-to-face meetings, provision of immediate feedback is possible. However, face-to-face meetings have restrictions regarding the number of participants and the possible existence of group or peer pressure. To eliminate the disadvantages, we combined the face-to-face and non-face-to-face technique by means of applying the following two group based research techniques: the focus group and Delphi study. To further structure our results, we selected the information systems framework originally proposed by Weber (Weber, 1997) and extended by Strong and Volkoff (Strong & Volkoff, 2010). The framework is divided into four sections: 1) deep structure, 2) organizational structure 3) physical structure and, 4) surface structure. Deep structure elements are subjects that describe real-world systems, their properties, states and transformations(Weber, 1997). Organizational structures are the roles, control and organizational culture represented within organizations or within solutions (Strong & Volkoff, 2010). Physical structure elements describe the physical technology and software in which the deep structure is embedded (Weber, 1997). Lastly, surface structure elements describe the elements that are available in the information system to allow users to interact with the information system (Strong & Volkoff, 2010).

8.4 Data Collection and Analysis

The data for this study is collected over a period of three months, between April 2015 and June 2015, through a three-round focus group and a three-round Delphi study, see Figure 8-2. Additionally, we conducted another round of data collection and validation in January 2017 to ensure the validity of our identified challenges.

This approach is applied to the implementation challenges with regards to the governance capability. Between each individual round of focus group and Delphi study, the researchers consolidated the results. Both methods of data collection and analysis are further discussed in the remainder of this section.

<table>
<tr><th>Research Team</th><th>Experts: Focus Group (FG)</th><th>Experts: Delphi Study (DS)</th></tr>
<tr><td>Round 1:
Preperation of focus groups</td><td></td><td></td></tr>
<tr><td>Round 2:
Consolidation</td><td>Round 1:
Elicitation</td><td></td></tr>
<tr><td>Round 3:
Consolidation</td><td>Round 2:
Elicitation, Refinement and Validation</td><td></td></tr>
<tr><td>Round 4:
Consolidation & Preperation DS</td><td>Round 3:
Elicitation, Refinement and Validation</td><td></td></tr>
<tr><td>Round 5:
Consolidation</td><td colspan="2">Round 4:
Elicitation, Refinement and Validation</td></tr>
<tr><td>Round 6:
Consolidation</td><td colspan="2">Round 5:
Elicitation, Refinement and Validation</td></tr>
<tr><td>Round 7:
Consolidation</td><td colspan="2">Round 6:
Elicitation, Refinement and Validation</td></tr>
<tr><td>Round 8:
Consolidation</td><td>Round 7:
Elicitation, Refinement and Validation</td><td></td></tr>
</table>

Figure 8-2: Data Collection Process Design

8.4.1 Focus Groups

Before a focus group is conducted, a number of topics need to be addressed: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities and 6) the protocol of the focus group (Morgan, 1996). For us, the goal of the focus group meetings was to identify implementation challenges of the governance capability as part of BRM. The selection of participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In this study, organizations and individuals that deal with business decisions and business logic represent the phenomenon studied; examples are financial and governmental institutions. Therefore, multiple Dutch governmental institutions were invited to provide input for this research. The organizations that agreed to cooperate with the focus group meetings were the: 1) Dutch Tax and Customs Administration, 2) Dutch Immigration and Naturalization Service, 3) Dutch Employee Insurance Agency, 4) Dutch Education Executive Agency, Ministry of Education, Culture and Science, and 5) Dutch Social Security Office. Based on the written description of the goal and consultation with employees of each governmental institution, participants were selected to take part in the four focus group rounds. In total, 21 participants took part in the focus groups. The following roles were included in the focus groups: One software engineer, three BRM project managers, one enterprise architect, eight business rule analysts, one IT-architect, five business rule architects, one business consultant, and one tax advisor. Each of the participants had at least five years of experience with BRM solutions. Delbecq and van de Ven (1971) and Glaser (1978) state that the facilitator should be an expert on the topic and familiar with group meeting processes. The selected facilitator has a Ph.D. in BRM, has conducted eight years of research on the topic, and has facilitated many (similar) focus group meetings before. Besides the facilitator, five additional researchers were present during the focus group meetings. One researcher participated as 'back-up' facilitator, who monitored whether each participant provided equal input, and if necessary, involved specific participants by asking for more in-depth elaboration on the subject. The remaining four researchers acted as a minute's secretary taking field notes. They did not intervene with the process. All focus groups except the last were video and audio recorded. The duration of the first focus group session was 191 minutes, the second 168 minutes, the third 157 minutes, and the fourth 120 minutes. Furthermore, each focus group meeting followed the same protocol, each starting with an introduction and explanation of the purpose and procedures of the meeting, after which ideas were generated, shared, discussed and refined by the participants.

Prior to the first round, participants were informed about the purpose of the focus group meeting and were invited to submit their secondary data regarding known challenges with regards to the implementation of the governance capability. When participants had submitted their secondary data, they had the opportunity to elaborate upon their documented challenges during the first focus group meeting. Furthermore, during this meeting, challenges that were not present in secondary data were presented and discussed upon. For each challenge addressed, the name, description, origin (regarding which institutions experienced the same or similar challenges), and classification were discussed and noted. After the first focus group, the researchers analyzed and consolidated the results.

The results of the analysis and consolidation were sent to the participants of the focus group two weeks in advance for the second focus group meeting. During these two weeks, the participants assessed the consolidated results in relationship to three questions: 1) "Are all challenges described correctly?", 2) "Do we need to address additional challenges?", and 3) "How do the challenges affect the design and implementation of the BRM capability?" This process of conducting focus group meetings, consolidation by the researchers and assessment by the participants of the focus group was repeated two more times (round 2 and round 3). After the third focus group meeting (round 3), saturation within the group occurred, leading to a consolidated overview of challenges regarding the governance capability as part of BRM.

Data analysis was conducted in three cycles of coding, following Strauss and Corbin's process of 1) open coding, 2) axial coding, and 3) selective coding (Strauss & Corbin, 1990). After each focus group round, open coding was conducted, involving the analysis of significant participant quotes by the individual researchers. In this process, the researchers tried to identify what Boyatzis (Boyatzis, 1998) refers to as 'codable observations'. Here, the researchers coded the data by identifying sentences where challenges were discussed. The participants named and listed challenges that occurred. For example, one of the codable observations was as follows: "*Version management is complex to implement at our organization. This is due to the fact that all involved departments either adhere to different version management schemes or do not apply version management at all.*"

The open coding was followed by axial coding during the analysis and consolidation phase between the focus group rounds to see what challenges can be identified and how the participants supported their challenges. The researchers employed the Toulmin's (Toulmin, 2003) framework, which consists of three elements, claim-ground-warrant, to code the challenges addressed in the focus group rounds. For example, the following claim-ground-warrant relationship was coded: Claim - "The collaboration between the designing and implementation teams within the organisations is low"; Ground - "*We –the business logic design team- do not have the authority to change certain processes to ensure the design and implementation teams work the same way and with the same methods. They have different agenda's and different preferences with regards to governance methods.*", Warrant - "Authority, - the reliability and validity originated from a presumed expert source".

Lastly, selective coding was applied to categorize the identified challenges that were the output of the axial coding process. The coding family 'Unit' (Glaser, 1978) was adhered to during the selective coding rounds to categorize the identified challenges. This process required inductive as well as deductive reasoning. The inductive reasoning was applied to reason from concrete factors to general situational factors. For example, multiple participants reported to use different (software) systems to govern their business decisions and business logic, for example, MS Word, MS Excel, and on paper. In this case, all different statements were coded to the maturity of tooling to support the governance capability. Deductive reasoning has been applied to reason from general situational factors to specific cases. For example, one participant stated that MS word was applied to manage versions of business rules. When elaborating on this topic more in-depth, the specialized BRM tooling they own does not support version management at all, so they identified MS word to be the best workaround. Therefore the challenge was assigned to the maturity of the available tooling to support the governance of business decisions and business logic.

8.4.2 Delphi Study

Before a Delphi study is conducted, also a number of topics need to be addressed: 1) the goal of the Delphi study, 2) the selection of participants, 3) the number of participants, and 4) the protocol of the Delphi study (Okoli & Pawlowski, 2004). The goal of the Delphi study was twofold. The first goal was to validate and refine the challenges identified in the focus group meetings, while the second goal was to identify additional challenges. Based on the written description of the goal and consultation of employees of each organization, participants were selected to take part in the Delphi study. In total, 45 participants were involved. 24, next to the 21 experts that participated in the focus group meetings, were involved in the Delphi Studies. The reason for involving the 21 experts from the focus groups was to decrease the likelihood of peer-pressure amongst group members, which could have been the case during the focus group meetings. This is achieved by exploiting the advantage of a Delphi Study which is characterized by a non-face-to-face approach. The non-face-to-face approach was achieved by the use of online questionnaires that the participants had to return via mail. The additional 24 participants involved in the Delphi Study had the following positions: one project manager, three enterprise architects, five business rules analysts, six policy advisors, one IT-architect, two business rules architects, one business consultant, one functional designer, one legal advisor, one legislative author, one knowledge management expert, and one operational auditor. Each of the 24 additional participants had at least two years of experience with BRM. Each round (4, 5, and 6) of the Delphi Study followed the same protocol, whereby each participant was asked to assess the identified challenges in relation to three questions: 1) "Are all challenges described correctly?", 2) "Do we need to address additional challenges?", and 3) "How do the challenges affect the design and implementation of a BRM solution? Regarding the analysis of the collected data as a result of the Delphi study rounds, the same method of analysis as elaborated in the focus groups section was adhered to.

8.5 Results

In this section, a summary of the governance-related challenges derived from our data collection and analysis are presented and structured. The order of the challenges presented does not reflect their relative importance. Note that, as our aim is to solely identify challenges with regards to the governance capability, we did not explore solutions which address the identified challenges. All challenges derived were based on the majority of agreement of the participants.

The challenges have been further structured along the dimensions of the ontological foundations of the information systems framework (Weber, 1997) & (Strong & Volkoff, 2010), see also the research method justification section.

Governance Maturity Implementation Challenges

Challenge 1) Governance process maturity: The overall maturity of governance is low. This is grounded by the fact that the participants do not or barely utilize processes, educated specialists and to ensure governance of their business decisions and business logic. The processes for governance are often not formally defined and most of the mechanisms to ensure legitimacy and transparency of the executed business decisions are grounded by manual labor of experts studded across multiple silos in the participating organizations. The number one concern is the legitimacy of the outcome of the business decisions executed. One of the participants stated: "*as we started to utilize some samples with regards to the validity of the different versions of business rule sets that were used we found out that 30% of the business rule sets that were executed were from a version that were not allowed to be executed due to changes in law.*" This could lead to situations where citizens or organizations could complain or appeal more, which results in additional resources that need to be reserved to handle such influxes due to improper governance. On the other hand, organizations and citizens could positively benefit from errors in the execution due to older versions of business rule sets such as illustrated in the previous quote. However, such errors could result in loss of tax money. For example, one of the participants stated the following: "*The worst case scenario is that our mistakes will make the headlines of the national newspapers. When this happens, politics will start to get involved, and we will be investigated and monitored closely.*"

Challenge 2) Maturity of tooling supporting governance: The current level of maturity of available commercial tooling with regards to governance is low. This is grounded by the fact that the participants experience that vendors only focus on the implementation of business decisions and business logic, but lack to invest in the development of functionality to properly support the governance capability. For example, with regards to version management, the participants currently have to manually add version metadata to their artefacts as the tooling they utilize do not support the automatic generation of versioning-related metadata. Another example was given with regards to the need for applying version management to decision tables, which is simply not possible in their current tooling, while the participants believe this should be possible and do not require a lot of resources to realize by the tool vendors. One of the participants stated: "*It surprises us that a specialized tool like RuleXpress does not support such functionality by default.*", another participant added: "*To my knowledge,* *all the tools available focus on executing the decisions and logic, while the functionalities with regards to governance are simply omitted. Tools are very immature when talking about governance.*"

Additionally, the participants addressed that they experience the tool vendors to ignore improvements with regards to governance, as the tool vendors develop their own methods and standards for their clients to adjust to, while the participated organizations expect the opposite. Therefore, based on this, we can also identify a possible gap between the expectations of both clients and tool vendors. An example of this is the need for validity management, where the validity start/end date and system registration date needs to be registered. This was not possible in the system that two of the participated organizations utilize, and the tool vendor admitted that they would not include functionality to support the registration of such data. Therefore, one participating organization built a tool to support validity management themselves that automatically checks the validity of different versions of business rule sets. One of the participants stated: "*We sometimes feel not taken seriously by tool vendors, with regards to our demands.*"

On the other hand, the participated organizations utilize tooling which is not intended to support adequate governance, while some of the tooling in their portfolio does support some basic functionality for governance. Three out of five participated organizations manage their business rules in MS Word and MS Excel, while they own licenses for specialized tooling such as RuleXpress, Bizzdesign-TDM, FICO Blaze Advisor, Drools, and Oracle Policy Automation. One of the participants stated: "*Working with tools like MS Word as a repository for our business rules greatly reduces the effectiveness and efficiency of version management."*

Organizational Layer Implementation Challenges

Challenge 3) Feedback loop: Additionally, in relation to the first challenge, the current maturity level influences the feedback loop with regards to the effectiveness and efficiency towards legislative bodies. This is grounded by the fact that the participants find it hard to make a business case for improving governance. As also stated in challenge 6 and 7, the responsibilities of stakeholders related to the governance processes are vague or not defined at all and the stakeholders themselves are spread over multiple silos in the organization. Therefore, it is difficult to provide insights into how much time and effort it costs to perform the manual labor by those stakeholders. One of the participants stated: "*We do not and cannot measure how much resources we currently spend on realizing manual traceability, version management and validity management because we do almost everything manually. When researching how much time it costs to answer a, for example, traceability-related question, they don't* *know as they do not measure it. Additionally, they don't want to get bothered with such questions."*

Challenge 4) Governance standards: The amount of knowledge with regards to standards for governance is low. This is grounded by the fact that all organisations claim that there are no standards with regards to validity management, versioning management and traceability management. However, in current practice, standards with regards to these three governance capabilities are available and widely applied, such as GS1, Juriconnect and ECLI (traceability management) (GS1, 2017), temporality versus non-temporality (validity management) (Saracco et al., 2010) and development on branches and stem in different compositions (version management) (Chacon & Straub, 2014). For example, one of the participated organizations is now able to trace three out of eleven implementation-dependent artefacts that they adhere to, to their source(s). The other four organizations admitted that they are not even able to trace their implementation-dependent artefacts to their sources adequately. Therefore, this challenge is more related to a knowledge problem, where the organizations are not adequately aware of the existing standards to support all three capabilities. Moreover, the participants addressed that knowledge to implement the standards known to them is absent. This knowledge is needed due to the fact that standards for traceability, version, and validity management often need to be adopted and adapted from other, neighboring fields, i.e. process management and data management.

Challenge 5) Partial governance: Not all abstraction levels/artefacts are covered by current governance practices. This is grounded by the fact that multiple stakeholders addressed that they find it very helpful to be able to trace to, assign validity data to, and manage the versions of fact types in the fact abstraction level. One of the participants stated: "*We all know why this is important, as, currently, everyone is adding fact types to be used by different artefacts. Currently, no governance metadata is captured when adding a fact type, so it is hard to find, for example, a definition of a fact type in a given period of time."*

Challenge 6) Data quality: The quality of data needed for adequate governance is overlooked. This is grounded by the fact that all participants admit that the quality of the data needed for traceability, version and validity management must have a certain quality by being complete, available and consistent. For example, traceability metadata must be complete in order to follow the trace successfully when required. However, the organizations see less in investing into enforcing or governing the quality of the data as it requires more resources, so the participants stated. Furthermore, the benefits of the investment are not always directly relevant or visible for all stakeholders. This is caused by the fluctuations in demand for transparency of decision making, i.e.

when an appeal is made against a decision regarding tax returns. When this happens, the organization that made the decision must be able to prove that the decision is based on valid sources and that their business logic can be traced to these sources. For example, one of the participants stated: "*It depends on how much trouble our organization is in when we are unable to prove our decisions outcome with the help of governance. It is hard to measure the benefits of quality data, as we do not even measure the current effort we invest into solving appeals by manually tracing back decision making. Therefore, it is hard to express benefits of capturing and enforcing data for governance*"

Challenge 7) Governance responsibilities: The responsibilities of the different roles with regards to governance are not adequately defined. This is grounded by the fact that the participants are unable to point out who is responsible for the repository where the business logic and their versions is managed. For example, one of the organizations has appointed information management the ownership of the business logic repository, while they have no experience with managing business logic. In the cases of the other participated organizations, it is vague who is responsible or isn't defined at all. Therefore, when problems need to be addressed or improvements are identified, it costs a significant amount of effort to find or appoint responsible roles or individuals.

Furthermore, because of the separation of design by business rule architects and analysists and implementation by IT specialists, collaboration with regards to responsibilities is more difficult according to the participants. With regards to the implementation of improvements in governance, the design teams deliver several proposals to persuade IT specialists into implementing the identified improvements, i.e. capturing governance data so that designed implementation-dependent artefacts can be traced to their implementation-independent artefacts. One of the participants stated: "*We currently can only employ a facilitating attitude towards IT specialists as we have no authority to force them to capture data according to a specific format to improve governance.*" Another participant added: "*For example, people that build our web sites for the e-services just do their thing and do not care about our preferences to improve traceability management.*"

Challenge 8) Design and implementation teams: The collaboration between the designing and implementation teams within the organisations is low. This is grounded by the fact that the design team delivers the business decisions and business logic for implementation, after which they lost all track of the status of the actual implementation. The participants addressed that this is a serious gap between both teams and does decrease effective and efficient collaboration, as the organisations are organized in silos. One of the participants stated: "*It is important for the design team to know in what phase the implementation of the business decisions and business logic is located. In certain phases, when we identify a small error, processing a quick fix is still possible. But because we simply have no insights into statuses after handing it over to the implementation team, we find it difficult collaborate."*

8.6 Discussion and Conclusion

In this paper, we aimed to find an answer to the following research question: "*Which implementation challenges do governmental institutions encounter while implementing the governance capability of business rules management?*" To answer this question, three focus groups sessions and three Delphi study rounds were conducted in a study that, to the knowledge of the authors, has not been conducted before in this research domain (concerning governmental and non-governmental context). By including 45 subject-matter experts in total over both qualitative data collection techniques, we managed to identify eight implementation challenges with regards to the governance capability as part of BRM projects at Dutch governmental institutions. The eight implementation challenges identified should be taken into account when designing a BRM solution. From a theoretical perspective, our results are mapped on the information systems framework of Weber (Weber, 1997) and Strong and Volkoff (Strong & Volkoff, 2010). The gained insights provide knowledge to better understand the implementation challenges in the context of the information systems framework with regards to BRM. Furthermore, it will enable further exploration and identification of problem classes. From a practical perspective, our study's results provide insights into what governance-related challenges are experienced in the Dutch governmental context. Organizations of any type, even non-governmental organizations, should take into account the common pitfalls to ensure future projects avoid the need to deal with such implementation challenges. Additionally, BRM solutions-software vendors and customers themselves should learn from the insights presented and start developing best practices, concepts, and methods as this could guide them in avoiding these pitfalls in future projects. Lastly, the now explicit challenges could trigger vendors and client organizations to enter the discussion and formulate future collaboration to tackle these challenges.

Our study and its results have several limitations. Considering our sampling and sample size, the current sample is solely drawn from governmental institutions in the Netherlands. We argue that governmental institutions are representative for organizations that implement BRM solutions, for example in other industries. However, it is important that future research focuses on further generalization towards non-governmental organizations, i.e. other industries like healthcare and financial services, due to the fact that our results are limited to Dutch governmental institutions. This same argument also holds as a basis for future research into implementation challenges experienced in other countries. Such research could identify differences in the implementation challenges experienced due to a different cultural composition, especially with regards to the organizational layer related challenges. With regards to the sample size, while we believe that 45 subject-matter experts is a sufficient sample to conduct explorative research on the current implementation challenges in the Dutch governmental context, future research should also focus on including more participants, preferably in conjunction with the aforementioned future research directions. Taking into account the identified challenges presented in section five, we see an overrepresentation of implementation challenges in the organizational layer compared to the other layers. This is in line with the literature (Arnott & Pervan, 2005; Arnott & Pervan, 2014; Boyer & Mili, 2011; Nelson et al., 2008), since most research has a focus on the technical and theoretical perspective while lacking management-related solutions in the context of BRM. Therefore, future research should aim to investigate whether this was related to our data collection and analysis. We believe that the use of the BRM capabilities defined in earlier research and the framework by Wand and Weber is appropriate to structure our findings to identify and cluster challenges. However, this results in the fact that our findings are also limited to this particular viewpoint, which should be taken into account in future research as well.

Lastly, the focus of this study was on identifying new constructs and establishing relationships, provided the current maturity of the BRM research field. While we believe that the research approach selected for this research type and study is appropriate, research focusing on further generalization as identified previously in this section should apply other research methods, such as quantitative research methods. Quantitative research methods allow for the incorporation of larger sample sizes to further validate our findings. Yet, provided the nascent nature of BRM research, this might be more appropriate in the years to come.

Part 3: Business Rules Management Governance

9 MANAGEMENT CONTROL SYSTEM FOR BUSINESS RULES MANAGEMENT

With increasing investments in business rules management (BRM), organizations are searching for ways to value and benchmark their processes to elicitate, design, specify, verify, validate, deploy, execute and govern business rules. To realize valuation and benchmarking of previously mentioned processes, organizations must be aware that performance measurement is essential, and of equal importance, which performance indicators to apply as part of performance measurement processes. However, scientific research on BRM, in general, is limited and research that focuses on BRM in combination with performance indicators is nascent. The purpose of this paper is to define performance indicators for previously mentioned BRM processes. We conducted a three round focus group and three round Delphi Study, which led to the identification of 14 performance indicators. In this paper, we re-address and - present our earlier work (Zoet et al., 2016)*, yet we extended the previous research with more detailed descriptions of the related literature, findings, and results, which provide a grounded basis from which further, empirical, research on performance indicators for BRM can be explored.*

9.1 Introduction

Business rules are an important part of an organization's daily activities. Many business services nowadays rely heavily on business rules to express assessments, predictions and decisions (Boyer & Mili, 2011; Nelson et al., 2010). A business rule is (Morgan, 2002) "*a statement that defines or constrains some aspect of the business intending to assert business structure or to control the behavior of the business.*" Most organizations experience three challenges when dealing with business rules management: 1) consistency challenges, 2) impact analysis challenges, and 3) transparency of business rule execution (Arnott & Pervan, 2005). A consistent interpretation of business rules ensures that different actors apply the same business rules, and apply them consistently. This is a challenge since business rules are often not centralized, but they are embedded in various elements of an organization's information system instead. For example, business rules are embedded in minds of employees, part of textual procedures, manuals, tables, schemes, business process models, and hard-coded as software applications. Impact assessment determines the impact of changes made to business rules and the effect on an existing implementation. Currently, im-

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pact assessments can take significant time, which results in situations where the business rules already have changed again while the impact assessment is still ongoing (Alles, Brennan, Kogan, & Vasarhelyi, 2006). Transparency, or business rules transparency, indicates that organizations should establish a system to prove what business rules are applied at a specific moment in time. To tackle the previously mentioned challenges and to improve grip on business rules, organizations search for a systematic and controlled approach to support the discovery, design, validation and deployment of business rules (Boyer & Mili, 2011; Ross, 2009). To be able to manage or even address these challenges, insight has to be created concerning business rule management processes at organizations. This can be achieved using performance management, which can provide insight into an organization's current situation, but can also point towards where and how to improve. However, research on performance management concerning BRM is nascent.

The measurement of performance has always been important in the field of enterprise management and, therefore, has been of interest for both practitioners and researchers (Cokins, 2009). Performance measurement systems are applied to provide useful information to manage, control and improve business processes. One of the most important tasks of performance management is to identify (and properly) evaluate suitable Performance Indicators (PI's) (Ferreira & Otley, 2009). The increase of interest and research towards identifying the right set of indicators has led to 'standard' frameworks and PI's tailored to a specific industry or purpose. Examples of such frameworks are the balanced scorecard, the total quality management framework, and the seven-S model (Kerklaan, 2007; Owhoso & Vasudevan, 2005). Moreover, research on standard indicators is increasingly performed for sales and manufacturing processes. To the knowledge of the authors, research, which focuses on performance measures for BRM is absent. This article extends the understanding of performance measurement with regard to the BRM processes. To be able to do so, the following research question is addressed: "*Which performance indicators are useful to measure the BRM processes?"*

This paper is organized as follows: In section two we provide insights into performance management and performance measurement. This is followed by the exploration of performance measurement Systems in section three. In section four, we provide an overview of the BRM capabilities and their goals. In section five, we report upon the research method utilized to construct our set of PI's. Next, the data collection and analysis of our study is described in section six. In section seven, our results, which led to our PI's for BRM are presented. This is followed by a critical view of the research method and results of our study and how future research could be conducted in section eight. Lastly, in section nine, we discuss what conclusions can be drawn from our results.

9.2 Performance Management and Performance Measurement

When examining PI's and what role it plays in the performance measurement and performance management domains, the first essential question is what is meant by these terms. In theory and practice, multiple different acronyms are adhered to when trying to define the concept of performance management (Cokins, 2009). In our research we adhere to the popular definition provided by Amaratunga & Baldry (2002): "*Performance Management is the use of Performance Measurement information to effect positive change in organizational culture, systems and processes, by helping to set agreed-upon performance goals, allocating and prioritizing resources, informing managers to either confirm or change current policy or programme directions to meet these goals, and sharing results of performance in pursuing those goals.*" This definition instantly elaborates upon the relationship between performance measurement (utilizing PI's) and performance management. Additionally, the definition includes multiple domains (culture, systems, and processes) and takes into account the overall goal of performance management. Performance Measurement plays an important role in the Performance Management Processes, and is defined as (Neely, Richards, Mills, Platts, & Bourne, 1997): "*The process by which the efficiency and effectiveness of an action can be quantified.*" To visualize the relationship between both concepts, Kerklaan (2007) created a basis for the performance feedback loop that could be utilized when a performance management and performance measurement solution need to be designed, see Figure 9-1.

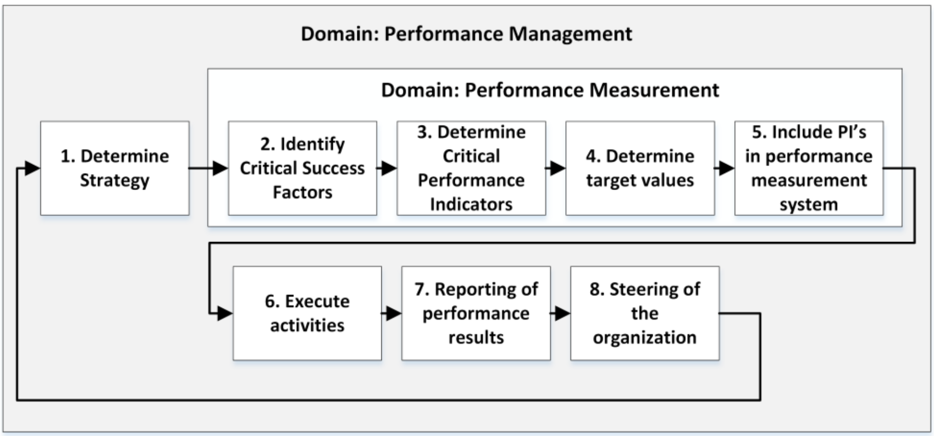

Figure 9-1: Performance Measurement within Performance Management

9.3 Performance Measurement Systems

Taking into account possible research avenues in the light of Performance Management and Performance Measurement, Ferreira and Otley (2009) identified the demand for a holistic view for researching and designing Performance Management solutions. In their work, a selection of 12 key aspects are highlighted that make up the core of the Performance Management Systems Framework. The framework consists of 8 aspects that are the building blocks of a Performance Management System; 1. Vision and mission 2. Key success factors, 3. Organization structure, 4. Strategies and plans, 5. Key performance measures, 6. Target setting, 7. Performance evaluation, and 8. Reward systems. Furthermore, the remaining four key aspects comprise; 9. Information flows, systems, and networks, 10. Use of the Performance Management System, 11. Performance Management System change, and 12. Strength and coherence, which represent the contextual and cultural factors of an organization. As the first four key aspects are relevant, but already being explored by researchers in the field of BRM, our focus in this study lies on the exploration and development of the fifth key aspect; key performance measures. As performance measures are operationalized in performance measurement systems we first analyze more in depth what a performance measurement system entails and what types of performance measurement systems are utilized for what goals.

The aim of using a performance measurement system is to provide a closed loop control system in line with predefined business objectives. In scientific literature and industry, an abundance of performance management systems exists (Franco-Santos, Lucianetti, & Bourne, 2012). Although a lot of performance systems exist, in general, they can be grouped into four base types (Kerklaan, 2007): 1) consolidate and simulate, 2) consolidate and manage, 3) innovate and stimulate, and 4) innovate and manage. The predefined business objectives, and, therefore, the creation of the closed loop control system, differ per base-type. In the remainder of this section, first, the four performance measurement system base-types will be discussed, after which the registration of a single performance measure will be presented. Subsequently, the processes will be discussed for which the performance management system is created. The last paragraph will focus on bringing all elements together.

Performance measurement systems of the first base-type, *consolidate and stimulate,* are utilized to measure and stimulate the current system performance. The formulation process of PI's is usually performed with employees that work with the system, possibly in combination with direct management, and is, therefore, a bottom-up approach. Examples of this type of performance measurement system are the "control loop system" or "business process management system". Performance measurement systems, that focus purely on measuring and maintaining the current performance level, are classified as the second base-type c*onsolidate and manage.* Consolidate and manage is a purely top-down approach in which PI's are formulated by top management based on the current strategy. Each PI defined by the top-management is translated into multiple different underlying PI's by each lower management level. Two examples of performance measurement systems of this type are "management by objectives" and "quality policy development". The third base-type, *innovate and stimulate*, focuses on the customer and the product or service delivered to the customer by the organization. To define the PI's, first, the quality attributes of the product or service delivered to the customer need to be defined. Based on these quality attributes, PI's for each business process that contributes to the product or service is defined. An example of a performance measurement system of this type is Quality Function Deployment (QFD). The fourth base-type, *innovate and manage*, focuses on the future of the organization while managing the present. It is a top-down approach in which PI's are formulated, based on the strategy of the organization. Furthermore, these PI's are then translated to the lower echelons of the organization. Moreover, PI's that are used to manage the current state of the organization are specified. The combination of both measures is used to make sure that the company is performing well while at the same time steering it into the future. An example of this performance measurement system type is the Balanced Score Card.

In addition to choosing the (combination of) performance measurement system(s), the individual performance indicators (PI's) of which the performance measurement system is composed have to be defined. A PI is defined as (Kerklaan, 2007): "*an authoritative measure, often in quantitative form, of one or multiple aspects of the organizational system."* Scholars as well as practitioners debate on which characteristics must be registered with respect to PI's (Hudson, Smart, & Bourne, 2001; Neely, 2005). Comparative research executed by (Neely et al., 1997) identified a set of five characteristics each scholar applies: 1) the PI must be derived from objectives, 2) the PI must be clearly defined with an explicit purpose, 3) the PI must be relevant and easy to maintain, 4) the PI must be simple to understand, and 5) the PI must provide fast and accurate feedback.

9.4 Business Rules Management

The performance measurement system in this paper is developed for the elicitation, design, specification, verification, validation, deployment, and execution process of BRM. To ground our research a summary of BRM is provided here.

BRM is a process that deals with the elicitation, design, specification, verification, validation, deployment, execution, evaluation and governance of business rules for analytic or syntactic tasks within an organization to support and improve its business performance (Breuker & Van de Velde, 1994), see Figure 9-2.

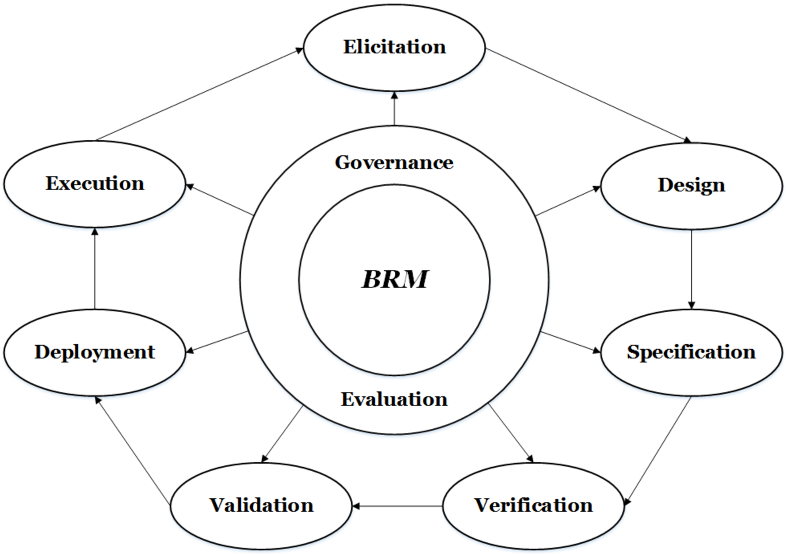

Figure 9-2: BRM Capability Overview

The purpose of the elicitation capability is twofold. First, the purpose is to determine the knowledge that needs to be captured from various legal sources to realize the value proposition of the business rules. Different types of legal sources from which knowledge can be derived are, for example, laws, regulations, policies, internal documentation, guidance documents, parliament documents, official disclosures, implementation instructions, and experts. Depending on the type of knowledge source(s), for example documentation versus experts, different methods, processes, techniques and tools to extract the knowledge are applied (Liao, 2004). The output of the elicitation capability is the knowledge required to design the business rule architecture. The second purpose is to conduct an impact analysis is if a business rule architecture is already in place. The business rule architecture itself is the output to be realized by the design capability. The business rule architecture consists of a combination of context designs and derivation structures. A context design is a set of business knowledge (in terms of business rules and fact types) with a maximum internal cohesion and a minimal external coherence, which adheres to the single responsibility principle (Martin, 2003). The relationship between different context designs is depicted in a derivation structure. After the business rule architecture is designed, the contents of each individual context design need to be specified in the specification capability. The purpose of the specification capability is to write the business rules and create the fact types needed to define or constrain some particular aspect of the business. The output of the specification capability is a specified context that contains business rules and fact types. After the business rule architecture is created it is verified (to check for semantic / syntax errors) and validated (to check for errors in its intended behavior). The first happens in the verification capability of which the purpose is to determine if the business rules adhere to predefined criteria and are logically consistent. For example, a business rule could contain multiple verification errors, such as domain violation errors, omission errors, and overlapping condition key errors. If errors are identified, two scenarios can occur. First, the business rules can be specified based on the current elicitated, designed and specified knowledge. Secondly, the design or specification could be altered. Verification errors not properly addressed could result in the improper execution of the value proposition in the execution capability later on in the BRM processes (Zoet, 2014). When no verification errors are identified, the created value proposition is reviewed in the validation capability. The purpose of the validation capability is to determine whether the verified value proposition holds to its intended behavior (Zoet & Versendaal, 2013). To be able to do so, two processes can be applied. First, scenario-based testing can be applied. The scenario-based testing applies pre-defined test sets to check the behavior. Secondly, colleague-based testing can be applied. In this case, a colleague checks if the context is in concurrence with law. When validation errors are identified the created element (i.e. decision, business rule, fact type) is rejected and an additional cycle of the elicitation, design, specification, and verification capabilities must be initiated to resolve the validation error. Validation errors not properly identified or addressed could lead to economic losses or loss of reputation (Zoet & Versendaal, 2013). When no validation errors are identified the context is approved and marked for deployment. The purpose of the deployment capability is to transform the verified and validated value proposition to implementation-dependent executable business rules. However, this does not necessarily imply that the actor that utilizes the value proposition is a system, as the value proposition could also be used by subject-matter experts (Zoet, 2014). An implementation-dependent value proposition can be source code, handbooks or procedures (Morgan, 2002). The output of the deployment capability is then executed in the execution capability, which delivers the actual value proposition. To realize the added value, human or information system actors execute the business rules. Overall, covering the full range of capabilities described earlier, two more capabilities are of importance; governance and monitoring. The governance capability consists of three sub-capabilities; version management, traceability, and validity management (Morgan, 2002). The goal of the versioning capability is to capture and keep track of version data regarding the elements created or modified in the elicitation, design, specification, verification, validation, deployment and execution capabilities. Proper version control as part of the BRM processes allows organizations to keep track what elements are utilized in the execution and deliverance of their added value. For example, the governmental domain needs to support several versions of a regulation as it takes into account different target groups under different conditions. The traceability capability is utilized to create relationships between specific versions of elements used in the value proposition. The goal of the traceability capability is to make it possible to trace created elements, as parts of the value proposition, to the corresponding laws and regulations on which they are based. Another goal of the traceability capability is the foundation it forms for impact analysis when new or existing laws and regulations need to be processed into the value proposition. The third sub-capability comprises validity management. The goal of validity management is to be able to provide, at any given time, a specific version of a value proposition. Validity management is utilized to increase transparency. Transparency is achieved as validity management enables organizations to provide when a specific value proposition was, is or will be valid. Lastly, the monitoring capability observes, checks and keeps record of not only the execution of the value proposition but also the full range of activities in the previously explained BRM capabilities that are conducted to realize the value proposition. The goal of the monitoring capability is to provide insights into how the BRM capabilities perform and, additionally, suggest improvements (Bajec & Krisper, 2005).

To further ground our research a summary of artefacts that are utilized in the BRM processes by the Dutch government are provided here, see also a schematic overview of the concepts in Figure 9-3.

Overall, a difference is made between implementation-independent design and implementation-dependent design of artefacts (these are: scope, context, business rule, fact type model, and facts). An implementation-independent artefact is always designed in a notation that is not adjusted to accommodate a specific system.

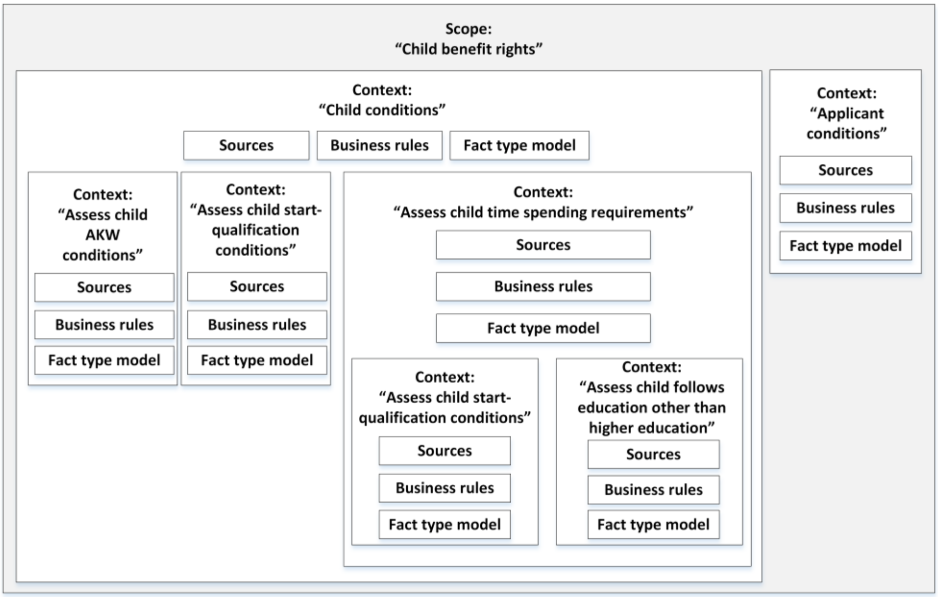

Figure 9-3: Overview of the Relationship Between a Scope and Multiple Contexts

On the other hand, an implementation-dependent artefact is adjusted to a specific system, and thus can only be utilized in relation to that specific system. The highest level abstraction artefact is referred to as a scope. The scope is dynamic in size as it represents the established limits of the value proposition that must be realized in the elicitation, design, specification, verification and validation processes. A scope could be further divided into one or multiple collections of knowledge, containing sources, business rules, and fact type models (Graham, 2007). This is also referred to as a context. A context is characterized by a maximum internal coherence and a minimal external coherence. The goal of a context is the identification of artefacts that can be independently developed within the defined scope. A context contains one or more sources, a fact type model, and business rules. A source can be defined as an authority that imposes requirements to the value proposition that has to be realized, for example, published laws and regulations from the parliament, court decisions, regulations promulgated by executive governmental branches, and international treaties. A fact type model provides an overview of terms and the relationship between these terms, which represent facts. For example, a country (term) has a province (term) or state (state), which contains a city (term). In the elicitation, design and specification processes the collection of a scope containing all underlying artefacts is defined as a scope design. Consequently, the same holds for a context containing source(s), a fact type model, and business rules, which is defined as a context design. Each of the BRM capabilities described can be measured and should be measured to continuously improve the process and stay competitive and innovative. The actual measurements applied depends on the base-type(s) the organization chooses to apply. The four base types are based on two main axes. The first axis described the current focus of the organization: consolidating versus innovating. On the other hand, the management style is described by the second axis: stimulate versus control, which leads to the question for which base type performance measurements are most needed?

The current trend in business rules management is a shift from an information technology perspective towards a broader information systems perspective. Therefore, researchers and scientist are interested in measuring the current state of business rules management implementations and capabilities (Kovacic, 2004; Nelson et al., 2008; Zoet, 2014). An important question when measuring the current state is that organizations want to compare and benchmark their implementations, processes, and capabilities. For this purpose, multiple initiatives are started, for example, expert group BRM (Handvestgroep Publiek Verantwoorden, 2013) and the blue chamber (Blauwe kamer, 2015). This trend of comparing different parts of a BRM implementation also concerns the comparison of different rule sets built for the same solutions. An example of this are the challenges released by the decision management community (Decision Management Community, 2016). Every month they release a problem for which different vendors provide their solutions such that they can be compared to each other. To manage and improve the different BRM capabilities/processes insight has to be created regarding the current situation of these processes. Thus, on the current focus of the organization axis we adopt the consolidating perspective over the innovating perspective for this study.

The selection of the participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In this study, we want to measure the current practice of the work of the employees that perform the capabilities. This implies that we will apply a bottom-up approach and will involve employees working on business rules and their direct management. Therefore, on the second axis we focus on the stimulating over controlling, thereby adopting the perspective of the first base-type, consolidate and stimulate, as described in detail in section three.

Our focus per PI will be on the characteristics as defined by (Hudson et al., 2001): 1) derived from objectives, 2) clearly defined with an explicit purpose, 3) relevant and easy to maintain, 4) simple to understand, and 5) provide fast and accurate feedback. These PI's form the basis to build a framework that organizations can utilize to design their BRM evaluation process focused on evaluating and improving its business performance.

9.5 Research Method

The goal of this research is to identify performance measurements that provide relevant insight into the performance of the elicitation, design, specification, verification, validation, deployment, execution, and governance processes of BRM. In addition to the goal of the research, also, the maturity of the research field is a factor in determining the appropriate research method and technique. The maturity of the BRM research field, with regard to non-technological research, is nascent (Kovacic, 2004; Nelson et al., 2010; Zoet, 2014). Focus of research in nascent research fields should lie on identifying new constructs and establishing relationships between identified constructs (Edmondson & Mcmanus, 2007). Summarized, to accomplish our research goal, a research approach is needed in which a broad range of possible performance measurements are explored and combined into one view in order to contribute to an incomplete state of knowledge.

Adequate research methods to explore a broad range of possible ideas / solutions to a complex issue and combine them into one view when a lack of empirical evidence exists consist of group-based research techniques (Delbecq & Van de Ven, 1971; Murphy et al., 1998; Okoli & Pawlowski, 2004; Ono & Wedemeyer, 1994). Examples of group based techniques are Focus Groups, Delphi Studies, Brainstorming and the Nominal Group Technique. The main characteristic that differentiates these types of group-based research techniques from each other is the use of face-to-face versus non-face-to-face approaches. Both approaches have advantages and disadvantages, for example, in face-to-face meetings, provision of immediate feedback is possible. However, face-to-face meetings have restrictions with regard to the number of participants and the possible existence of group or peer pressure. To eliminate the disadvantages, we combined the face-to-face and non-face-to-face technique by means of applying the following two group based research approaches: the Focus Group and Delphi Study.

9.6 Data Collection and Analysis

Data for this study is collected over a period of six months, through three rounds of focus groups (rounds 1, 2 and 3: experts focus group) and a three-round Delphi study (rounds 4, 5 and 6 Delphi study), see Figure 9-4. Between each individual round of focus group and Delphi Study, the researchers consolidated the results (rounds 1, 2, 3, 4, 5, 6 and 7: research team). Both methods of data collection and analysis are further discussed in the remainder of this section.

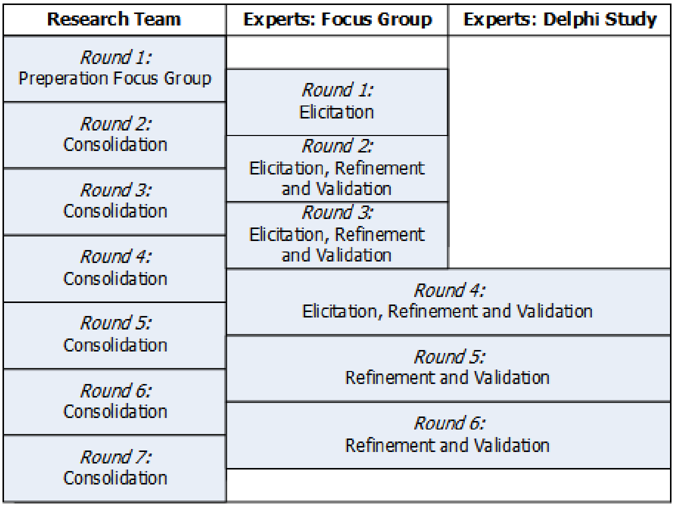

Figure 9-4: Data Collection Process Design

9.6.1 Focus Groups

Before a focus group is conducted, a number of key issues need to be considered: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities, and 6) the protocol of the focus group. The goal of the focus group was to identify performance measurements for the performance of the elicitation, design, specification, verification, validation, deployment, execution, and governance capabilities of BRM. The selection of the participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). In this study, organizations and individuals that deal with a large amount of business rules represent the phenomenon studied. Such organizations are often financial and government institutions. During this research, which was conducted from September 2014 to December 2014, five large Dutch government institutions participated. Based on the written description of the goal and consultation with employees of each government institution, participants were selected to take part in the three focus group meetings. In total, ten participants took part, which fulfilled the following positions: two enterprise architects, two business rules architects, three business rules analysts, one project manager, and two policy advisors. Each of the participants had, at least, five years of experience with business rules. Delbecq and van de Ven (1971) and Glaser (1978) state that the facilitator should be an expert on the topic and familiar with group meeting processes. The selected facilitator has a Ph.D. in BRM, has conducted 7 years of research on the topic, and has facilitated many (similar) focus group meetings before. Besides the facilitator, five additional researchers were present during the focus group meetings. One researcher participated as 'back-up' facilitator, who monitored if each participant provided equal input, and if necessary, involved specific participants by asking for more in-depth elaboration on the subject. The remaining four researchers acted as a minute's secretary taking field notes. They did not intervene in the process; they operated from the sideline. All focus groups were video and audio recorded. A focus group meeting took on average three and a half hour. Each focus group meeting followed the same overall protocol, each starting with an introduction and explanation of the purpose and procedures of the meeting, after which ideas were generated, shared, discussed and/or refined.

Prior to the first round, participants were informed about the purpose of the focus group meeting and were invited to submit their current PI's applied in the BRM process. When participants had submitted PI's, they had the opportunity to elaborate upon their PI's during the first focus group meeting. During this meeting, also, additional PI's were proposed. For each proposed PI, the name, goal, specification and measurements were discussed and noted. For some PI's, the participants did not know what specifications or measurements to use. These elements were left blank and agreed to deal with during the second focus group meeting. After the first focus group, the researchers consolidated the results. Consolidation comprised the detection of double PI's, incomplete PI's, conflicting goals and measurements. Double PI's exist in two forms: 1) identical PI's and 2) PI's, which are textually different, but similar on the conceptual level. The results of the consolidation were sent to the participants of the focus group two weeks in advance for the second focus group meeting. During these two weeks, the participants assessed the consolidated results in relationship to four questions: 1) "Are all PI's described correctly?", "2) Do I want to remove a PI?" 3) "Do we need additional PI's?", and 4) "How do the PI's affect the design of a business rule management solution?". This process of conducting focus group meetings, consolidation by the researchers and assessment by the participants of the focus group was repeated two more times (round 2 and round 3). After the third focus group meeting (round 3), saturation within the group occurred leading to a consolidated set of PI's.

9.6.2 Delphi Study

Before a Delphi study is conducted, also a number of key issues need to be considered: 1) the goal of the Delphi study, 2) the selection of participants, 3) the number of participants, and 4) the protocol of the Delphi study. The goal of the Delphi study was twofold. The first goal was to validate and refine existing PI's identified in the focus group meetings, and the second goal was to identify new PI's. Based on the written description of the goal and consultation with employees of each organization, participants were selected to take part in the Delphi study. In total, 36 participants took part. Twenty-six experts, in addition to the ten experts that participated in the focus group meetings, of the large Dutch government institutions were involved in the Delphi Study, which was conducted from November 2014 to December 2014. The reason for involving the ten experts from the focus groups was to decrease the likelihood of peer-pressure amongst group members. This is achieved by exploiting the advantage of a Delphi Study, which is characterized by a non-face-to-face approach. The non-face-to-face approach was achieved by the use of online questionnaires that the participants had to return via mail. Combined with the ten participants from the focus groups, the twenty-six additional participants involved in the Delphi Study had the following positions: three project managers, four enterprise architects, ten business rules analyst, five policy advisors, two IT-architects, six business rules architects, two business consultants, one functional designer, one tax advisor, one legal advisor, and one legislative author. Each of the participants had, at least, two years of experience with business rules. Each round (4, 5, and 6) of the Delphi Study followed the same overall protocol, whereby each participant was asked to assess the PI's in relationship to four questions: 1) "Are all PI's described correctly?", "2) Do I want to remove a PI?" 3) "Do we need additional PI's?", and 4) "How do the PI's affect the design of a BRM solution?"

9.7 Results

In this section, the overall results of this study are presented. Furthermore, the final PI's are listed. Each PI is specified using a specific format to convey their characteristics in a unified way. Before the first focus group was conducted, participants were invited to submit the PI's they currently use. This resulted in the submission of zero PI's, which is in conformance with the literature described in section four. Since this result can imply a multitude of things (e.g., total absence of the phenomena researched or unmotivated participants), further inquiry was conducted. The reason that no participants submitted PI's was because none of the participants had a formal performance measurement system in place. Some measured BRM processes, but did so in an ad-hoc and unstructured manner.

PI 09: The amount of time units needed to define, verify, and validate a single business rule. **Goal**: Shortening the time needed to deliver defined, verified, and validated business rules.	
S	The number of time units per selected single business rule: • Measured over the entire collection of context designs;

	• During the design process; • (Sorted by selected context design); • (Sorted by selected complexity level of a business rule); • (Sorted by selected scope design); • (Sorted by selected time unit).
M	• Context design • Business rule • Complexity level of a business rule • Scope design • Time unit

Table 9-1: Example of PI Results: Time Measurement to Define, Verify and Validate a Business Rule

First Focus Group

The first focus group meeting resulted in 24 PI's. As stated in the previous section, for each PI the name, goal, specification, and measurements were discussed and noted. This led to two discussions: 1) different levels of abstraction and 2) person-based measurements. The discussion with regards to the abstraction level of sorting indicates that a specific organization chooses for a different level of detail when exploring the KPI. For example, in PI09, '*the number of time units per selected single business rule*' can be sorted by scope design or by context design. The first is a higher abstraction level then the latter. Because the goal of the research is to formulate a set of PI's that can be widely applied, the choice has been made to add sorting possibilities. In Table 9-1, dimensions are displayed between brackets, for example, sorted by selected context design. Therefore, each organization can choose to implement the PI specific to their needs. The second discussion was if PI's are allowed to be configured to monitor a specific individual. For example, '*the number of incorrectly written business rules per business rule analyst.*' The difference in opinion between the participants could not be bridged during this session. Since the discussion became quite heated during the meeting, it was decided that each expert would think about and reflect on this question outside the group and that this discussion would be continued in the next focus group meeting. After the first focus group, the results have been analyzed and sent to the participants.

Second Focus Group

During the second focus group, the participants started to discuss the usefulness of the PI's. This resulted in the removal of ten conceptual PI's. The ten PI's were discarded because they did not add value to the performance measurement process concerning BRM. This resulted into 14 remaining PI's, which had to be further analyzed by the researchers. Also, the discussion about the PI's formulated to measure specific individuals was continued. At the end, only three participants thought this was reasonable. The other seven disagreed and found it against their organization's ethics. Therefore, the group reached a consensus that this dimension should be added as optional.

Dimensions

The respondents discussed per PI the dimensions they should be measured by. In total, this resulted into five new dimensions. The first dimension is *the business rule complexity level*. The business rule complexity describes the effort it takes to formulate one business rule. The participants did state that, currently, no widely supported hierarchy to express the dimension level complexity exists. Two examples were provided by different respondents. The first example came from a respondent which indicated that business rule complexity can be determined by the amount of existing versus non-existing facts in the fact model that are utilized in a business rule, the impact a business rule has on other business rules when modified or removed, and the type of business rule. The second example came from a respondent which indicated that they use two languages to write business rules in. The complexity, in this case, is influenced by the language in which the business rule is written.

The second dimension represents the time unit that is used in the PI statement. The participated organizations all indicated different time units as part of their PI's due to differences in release schedules or reporting requirements. For example, one of the participated organizations currently adheres to a standard period of three months, while another adheres to a standard period of six months due to agreements with their parent ministry that publishes new or modified laws and regulations in the same cycle of six months. For example, the PI (09): '*The number of time units required to define, verify, and validate a single business rule*', is sorted by the dimension time unit.

The third dimension represents the roles and individuals. One observation regarding the third dimension, focusing on the utilization of roles in PI's, are the different labels for very similar or equivalent roles the participated organizations utilize in their BRM processes. For example, the PI (02): '*The frequency of corrections per selected context design, emerging from the verification process, per business analyst and per type of verification error*' can be sorted by the measure '*business analyst*.' The business analyst role is a generic role, which each organization can replace by a specific role. Examples of roles other respondents applied are: "*business rules writer*", "*business rules analyst*" or "*business rule expert.*"

The fourth dimension represents the error type, which describes the specific errors that can occur. Error types are applied as measures in two PI's: PI 07 (validation errors) and PI 08 (verification errors). With respect to verification errors three types can be recognized: 1) context error types, 2) business rules errors, and 3) fact type errors. Examples of specific errors are: circularity error, consequent error, unnecessary condition fact type error, interdeterminism error, overlapping condition key coverage error, unused fact type error and domain violation error. Not every organization can measure every error type, as this depends on the language and tool they apply. Therefore, the dimension can vary per organization.

The fifth dimension represents the implementation of the business rules: implementation-independent versus implementation-dependent. In this first case, an organization elicits, designs, specifies, verifies and validates the business rules in an implementation-independent way. Therefore, the PI also focuses on the implementation-independent part. However, one of the participated organizations already designs, specifies, verifies and validates the business rules in an implementation-dependent environment. In this case the PI's focus on the implementation-dependent part.

Third Focus Group

During the third focus group, the participants discussed the remaining 14 final PI's, which led to the further refinement of goals, specifications, and measurements. Additionally, the subject-matter experts expressed a certain need to categorize PI's into well-known phases within the development process of business rules at the case organizations. From the 14 remaining PI's, nine PI's were categorized as business rule design PI's, two PI's were categorized as business rule deployment PI's, and three PI's were categorized as business rules execution PI's.

Delphi Study

After the third focus group, the 14 PI's were subjected to the Delphi Study participants. In each of the three rounds, no additional PI's were formulated by the 26 experts. However, during the first two rounds, the specification and measurement elements of multiple PI's were refined. During the third round, which was also the last round, no further refinements were proposed and participants all agreed to the 14 formulated PI's, which are presented in Table 9-2.

PI 01: The frequency of corrections per selected context design emerging from the verification process.
Goal: Improve upon the design process of business rules.
PI 02: The frequency of corrections per selected context design, emerging

from the verification process, per business analyst and per type of verification error.

Goal: Improving the context design.

PI 03: The frequency of corrections per selected context design emerging from the validation process per complexity level of a business rule.

Goal: Improve upon the design process of business rules.

PI 04: The frequency of corrections per selected context design emerging from the validation process per type of validation error.

Goal: Improve upon the validation process for the benefit of improving the context design.

PI 05: The frequency of corrections per selected context architecture emerging from the design process per scope design.

Goal: Improve upon the design process for the benefit of improving the context architecture.

PI 06: The frequency of instantiations per selected context design

Goal: Provide insight into the possible instances of a context design.

PI 07: The frequency per selected type of validation error.

Goal: Improve upon the design process for the benefit of improving the context design.

PI 08: The frequency per selected type of verification error

Goal: Improve upon the design process for the benefit of improving the context design.

PI 09: The number of time units required to define, verify, and validate a single business rule.

Goal: Shortening the lead time of a business rule with regard to the design process.

PI 10: The frequency of deviations between an implementation dependent context design and an implementation independent context design.

Goal: Improve upon the deployment process.

PI 11: The frequency of executions of an implementation dependent business rule.

Goal: Gaining insight into what business rules are executed.

PI 12: The frequency of execution variants of a scope design.

Goal: Gaining insight into what decision paths are traversed to establish different decisions.

PI 13: The number of time units required for the execution per execution variant.

Goal: Shortening the lead time of an execution process with regard to enhancing an execution variant.

PI 14: The amount of business rules that cannot be automated. **Goal**: Provide insight into what business rules cannot be automated.

Table 9-2: PI's for BRM

Analyzing the defined PI's showed that three out of fourteen (PI 11, 12, and 14) are PI's that can be classified as *'innovate and manage'* PI's. PI number eleven and twelve focus on the number of times a business rule is executed, thereby providing insight on which business rules are most applied. PI twelve goes beyond that and shows which variants of business rules are executed. In other words, it shows the characteristics of the decision based on which citizens or organizations get services. This insight can be used to determine how many and which citizens or organizations are affected by changing specific laws (and, therefore, business rules). In other words, this can be used to further support the development of law. PI fourteen indicated the amount of business rules that cannot be automated, in other words, that need to be executed manually. This can also provide an indication of the amount of workload that organizations encounter due to the manual execution of these specific business rules. This PI can be used to decide if these business rules should be executed manually or that they should be reformulated in such a manner that they can be executed mechanically.

9.8 Discussion and Future Work

From a research perspective, our study provides a fundament for PI measurement and benchmarking of the elicitation, design, specification, verification, validation, deployment, execution, and governance capabilities of BRM. In addition to the PI's, one of the biggest discussion has been the question whether a PI should be measured per individual person. Regarding this discussion most respondents in our research agreed that PI's should not measure the performance of an individual person. This could be related to the fact that the sample group didn't contain respondents from a commercial organization where it might be more accepted that the performance of an individual person is measured. From the perspective of performance management systems we focused on the base type 1) consolidate and simulate. When BRM implementations become more mature, innovation should be encouraged and PI's for the base types 3) innovate and stimulate, and 4) innovate and manage should be measured. From an economic perspective, our research results contribute to the design of a proper performance measurement design for the BRM capabilities in order to provide insights about how organizational resources are utilized and how they could be utilized more effectively.

Another discussion focused on the terminology applied to formulate the PI's. The discussion started because the organizations that employ the participants applied different terms and definitions to describe the same elements. This is mainly caused by the different business rule management methods used, business rule management systems applied, business rule language(s) used or business rule engines implemented by the participating organizations. Most of the proprietary systems apply their own language, thereby decreasing interoperability. For example, one organization has implemented Be Informed, which applies the Declarative Process Modeling Notation while another organization implemented The Annotation Environment, which applies Structured Dutch. Therefore, the terminology chosen to formulate the PI's is neutral. However, the terms of the PI's can be adapted to the specific organization.

Several limitations may affect our results. The first limitation is the sampling and sample size. The sample group of participants is solely drawn from government institutions in the Netherlands. While we believe that government institutions are representative for organizations implementing business rules, further generalization towards non-governmental organizations, amongst others, is a recommended direction for future research. Taken the sample size of 36 participants into account, this number needs to be increased in future research as well. Another observation is the lack of PI's regarding some BRM capabilities described in section four. This could have been caused due to participants focusing on a specific BRM capability in practice, limiting the input of PI's regarding other BRM capabilities. Future research should focus on including participants, which are responsible for one capability (taking into account to cover all capabilities) a combination of BRM capabilities, or all BRM capabilities (higher level management).

This research focused on identifying new constructs and establishing relationships given the current maturity of the BRM research field. Although the research approach chosen for this research type is appropriate given the present maturity of the research field, research focusing on further generalization should apply different research methods such as qualitative research methods, which also allow incorporating a larger sample size in future research regarding PI's for BRM.

9.9 Conclusion

This research investigated PI's for the elicitation, design, acceptance, deployment and execution of business rules with the purpose of answering the following research question: "*Which performance measurements are useful to measure the BRM processes?*" To accomplish this goal, we conducted a study combining a three round focus group and three round Delphi Study. Both were applied to retrieve PI's from participants, 36 in total, employed by five governmental institutions. This analysis revealed fourteen PI's. We believe that this work represents a further step in research on PI's for BRM and maturing the BRM field as a whole.

10 A FRAMEWORK FOR TRACEABILITY OF LEGAL REQUIREMENTS IN THE DUTCH GOVERNMENTAL CONTEXT

In the past decades, research and practice focused a lot of attention towards traceability in the context of software requirements, food supply chains, manufacturing, and aviation industry. As legislation and regulations in software systems become increasingly relevant, traceability of legal requirements is of great importance. In this study, we aimed to create a framework in which the basis for traceability of legal requirements is addressed. To be able to do so we conducted five case studies at five Dutch governmental institutions, which was followed by a three-round focus group. The resulting framework comprises 22 (layered) traceability elements in relation to three domains that offers a reference model to determine how traceability can be applied in software system design, in the context of the Dutch government.

10.1 Introduction

An industry that is influenced by changes in laws and regulations comprises the governmental institutions that deliver public administration services. As more and more public administration services are offered digitally, the need to trace the delivered services to their legal sources, laws and regulations, becomes more complex. This type of traceability is absent in most of the current public administration services (Van Engers & Nijssen, 2014).

To be able to create new or change existing public administration services that adhere to laws and regulations, these legal sources need to be interpreted and transformed from natural language into specifications for computer-executable business rules (van Engers & van Doesburg, 2015). These activities are often defined in a specific process to guide and structure the transformation of legal requirements into software systems. An example of this is the '*agile execution of law*', developed and employed by the Dutch Tax and Customs Administration (Boer & Van Engers, 2013). In these processes, traceability is a core capability.

However, currently, traceability is often of secondary importance when a public administration service is designed. This influences the transparency governmental insti-

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tutions can provide when a service is delivered to a customer. The importance of traceability usually changes when errors are made providing the services (Van Engers & Nijssen, 2014). The main reason for this delay is that the implementation of adequate design and management of traceability often costs a significant amount of organizational resources, which should be justified by a proper business case (Cleland-Huang et al., 2014). In this paper, we propose a traceability framework which enables governmental institutions to select what form of traceability and to what extend traceability should be implemented. Moreover, our traceability framework enables governmental institutions to choose what elements to utilize in software systems design, based on what elements are usual when addressing traceability of legal requirements. To be able to do so, we addressed the following research question: "*Which elements are useful to trace with regards to legal requirements in the context of the Dutch government*"

The remainder of this paper is organized as follows: First, we provide insights into how traceability is intertwined with software systems design and how it affects decision making as part of public administration (e-)services. This is followed by the research method used to construct the traceability framework. Furthermore, the collection and analysis of our research data are described. Subsequently, our results which led to our traceability framework are presented. Finally, we discuss which conclusions can be drawn from our results, followed by a critical view of the research methods utilized and results of our study and propose possible directions for future research.

10.2 Background and Related Work

In the previous decades, much research focused on traceability. For example, traceability in food supply chains (Opara, 2003) and manufacturing chains in the aviation industry (Ngai et al., 2007). Furthermore, traceability is utilized in the context of requirements (Gotel & Finkelstein, 1994), software artifacts (Gao et al., 2000), model-engineering (Jouault, 2005), jurisprudence (ECLI) (van Harten & Jansen, 2013), and the protection of copyrighted material (Staddon et al., 2001). As laws and regulations need to be transformed and processed into software systems of governmental institutions, we focus on traceability of legal requirements in the context of software artifact traceability.

Software artifact traceability is defined as: "*Software artifact traceability is the ability to describe and follow the life of an artifact (requirements, code, tests, models, reports, plans, etc.) developed during the software lifecycle in both forward and backward directions*" (Gotel & Finkelstein, 1994). A proper implementation of software artifact traceability can provide insights into system development and evolution, assisting in both top-down and bottom-up program comprehension, impact analysis, and reuse of existing software artifacts, and is therefore defined as a critical success factor in software development (Domges & Pohl, 1998). In this context, traceability knows two dimensions. The first dimension comprises vertical and horizontal relations. Horizontal relations refer to traceability relations that associate elements of the same type of artifact (i.e. relationships between facts) while vertical relations refer to associations from an artifact towards different type of artifacts (i.e. a relationship between a decision and its underlying business rule) (Lindvall et al., 2003). The second dimension comprises pre and post-traceability, which is also referred to as forward and backward traceability (Gotel & Finkelstein, 1994). Pre-traceability refers to the relations between requirement specifications and the sources that have given rise to these specifications, i.e. the stakeholders that have expressed the views and needs which are reflected in them while post-traceability refers to the relations between requirement specifications and artifacts that are created in subsequent stages of the software development life cycle.

A lot of research is performed on software artifact traceability (Lucia, Marcus, Oliveto, & Poshyvanyk, 2012; Lucia, Fasano, Oliveto, & Tortora, 2007; Sundaram, Hayes, Dekhtyar, & Holbrook, 2010). However, a recent study by Cleland-Huang et al. (2014), who analyzed the knowledge base regarding software artifact traceability, still uncovered research directions that are not adequately covered by current research effort. For example, traceability strategizing, creation of intuitive forms of query mechanisms, and visualization of trace data. Their study resulted in a collection of research directions that are defined as useful for both complementations of the body of knowledge and applicability in practice. One of those research directions is that of the development of traceability reference models to guide the design of traceability solutions. Cleland-Huang et al. (2014) state that, to date, most research on traceability reference models focused on the creation of a reference model for standard (generalized) projects. According to (Ramesh & Jarke, 2001), a traceability reference model can be defined as: "*A traceability reference model specifies the permissible artifact types and permissible link types that can form a trace on a project, and is derived from an analysis of the queries that the resulting traceability is intended to answer.*" The problem with most of the currently proposed traceability reference models is that none of them are universally accepted of widely used in industry, due to the fact that most of them are too general of nature (Cleland-Huang et al., 2014). An example of a traceability reference model which is tailored for application in a specific domain is the work of Katta (2012), which proposed a traceability reference model for use in the highly-regulated nuclear domain. One of the key factors of its acceptance by the industry was that the creation and tailoring of the traceability reference model were driven by the industry itself.

This particular study was initiated and driven by five executive governmental institutions. These institutions are responsible for delivering public administration services. Due to this, traceability between software systems and legal sources is an important component in their software development lifecycle. An example of a Dutch public administration service which is offered as an e-service would be, on a yearly basis, the declaration of taxes. For this e-service, it is essential that the decision-making is transparent and thus, all components that are part of the e-service are linked to legal sources. This ensures a legally valid execution of decision-making that is supported by software systems and/or executed in a fully automated manner. In this study, we define a legal source as a source of law or regulation, stated by supranational, national, regional or local stakeholders within the legal rights to do so (Tarantino, 2008). Examples of legal sources are 1) international treaties on human rights, 2) the European Community Law, 3) national laws and regulations, 4) civil rights, and 5) internal policies. Moreover, we also utilize the concept of a legal requirement, which we define as a requirement that is extracted from a legal source which influences software system design. Legal requirements are different from conventional software requirements in three distinct ways (Breaux, 2009): 1) legal requirements govern multiple industries, goods, and services, whereas traditional practice focuses on software requirements target specific systems, 2) Legal requirements are not elicited by engineers from stakeholders, they are codified in legal language and interpreted therefrom, and 3) Ambiguity cannot be removed from legal requirements by software engineers, it can only be classified and interpreted in the context of organizational practices, goods, and services. An example of a method that is tailored to the definition of legal requirements based on legal sources is the Frame-Based Requirements Analysis Method (FBRAM), see (Breaux & Antón, 2007) and (Breaux, 2009).

10.3 Research Method

The goal of this research is to propose a validated traceability framework which can guide the design of the traceability capability at governmental institutions. In addition to the goal of the research, also, the maturity of the research field is a factor in determining the appropriate research method and technique(s). In this study, traceability is considered in combination with the research field of legal requirements. The maturity of the traceability research field, in general, is very mature. Still, research on traceability reference models is less mature (Cleland-Huang et al., 2014). The research areas of legal requirements and business rules management, in general, is less mature to nascent (Kovacic, 2004; Nelson, Peterson, Rariden, & Sen, 2010; Anonymous, 2014). Focus of research in nascent research fields should lie on identifying new constructs and establishing relationships between identified constructs (Edmondson & Mcmanus, 2007). Summarized, to accomplish our research goal, a research approach is needed in which elements that should be traced and the actual traces are explored and combined into one traceability framework. To achieve our goal, we analyze traceability demands regarding legal requirements in five case studies at five governmental institutions. Based on this round of data collection a traceability framework is constructed and proposed. Then, to increase the generalizability of the traceability framework, three rounds of validation are conducted in the form of a focus group where experts of all five case study organizations participated.

Case study research is selected so that the researchers were able to gather data on how traceability is implemented. Therefore, the case studies are exploratory of nature. The organizations are selected from a pool of Dutch governmental institutions that provide public administration services based on laws and regulations that are provided by the Dutch legislative governmental branches. Our study comprised a holistic case study approach, featuring one context, traceability of legal requirements, and five cases within this context. The unit of analysis are the traceability demands of the individual case organizations. As the case study approach is exploratory of nature, the data collection and analysis consisted of secondary data and semi-structured interviews, which is a combination of first and third-degree data collection. This approach has several advantages and is thoroughly discussed in (Runeson & Höst, 2009).

Adequate research methods to explore a broad range of possible ideas and/or solutions to a complex issue and combine them into one view when a lack of empirical evidence exists consist of group-based research techniques (Delbecq & Van de Ven, 1971; Okoli & Pawlowski, 2004; Ono & Wedemeyer, 1994). Examples of group based techniques are Focus Groups, Delphi Studies, Brainstorming and the Nominal Group Technique. The main characteristic that differentiates these types of group-based research techniques from each other is the use of face-to-face versus non-face-to-face approaches. Both approaches have advantages and disadvantages, for example, in face-to-face meetings, provision of immediate feedback is possible. However, face-to-face meetings have restrictions with regard to the number of participants and the possible existence of group or peer pressure. To eliminate the disadvantages, we combined the face-to-face and non-face-to-face technique by means of applying case studies and three focus group meetings.

10.4 Data Collection and Analysis

Data for this study is collected over a period of six months, between August 2014 to February 2015, through five case studies and three rounds of focus groups. Between each round of the focus group, researchers consolidated the results. Both methods of data collection are further discussed in the remainder of this section.

10.4.1 Case Studies

Over a period of three months, between August 2014 and November 2014, five case studies were conducted by a group of seven researchers. The case studies were performed in two phases. The first phase comprised the collection and analysis of secondary data. The second phase comprised the semi-structured interviews. The selection of the participants should be based on the group of individuals, organizations, information technology, or community that best represents the phenomenon studied (Strauss & Corbin, 1990). For this study, the phenomenon studied is represented by organizations and individuals that deal with traceability of legal requirements. Such organizations are often financial and government institutions. The organizations that agreed to cooperate with the focus group meetings were the: 1) Dutch Tax and Customs Administration, 2) Dutch Immigration and Naturalization Service, 3) Dutch Employee Insurance Agency, 4) Dutch Education Executive Agency, Ministry of Education, Culture and Science, and 5) Dutch Social Security Office.

First, the experts of the case study organizations were prompted to gather and send all relevant and available documentation to the research team to analyze in advance of the semi-structured interviews. As this yielded a large amount of secondary data, the researchers needed a month to structure the data so that it was understood by the researchers and that it could serve as a basis for the semi-structured interviews, in terms of topics to be discussed.

Second, we conducted two semi-structured interviews with subject-matter experts at each case organization. The subject-matter experts were in all cases responsible for the traceability capability at the case organization and had more than five years of experience. Based on our findings from the first phase, an interview protocol was followed, comprising the following questions: 1) "Are all elements and traces described correctly?", "2) Do I want to remove an element or a trace?" 3) "Do we need additional elements or traces?", and 4) "Does the element or trace contribute to the traceability of legal requirements throughout software systems design?" The interviews were all audio-taped and were protocolled and consolidated on the same day.

10.4.2 Focus Groups

Subsequently to the case studies, the focus groups were prepared and conducted between November 2014 to February 2015. Before a focus group is conducted, first, a number of key issues need to be considered: 1) the goal of the focus group, 2) the selection of participants, 3) the number of participants, 4) the selection of the facilitator, 5) the information recording facilities, and 6) the protocol of the focus group.

The goal of the focus group was to assemble and validate a traceability framework. We utilized the same selection of Dutch governmental institutions which collaborated in the case study phase, also to increase generalizability. Based on the written description of the goal and consultation with employees of each government institution, participants were selected to take part in the three focus group meetings. In total, thirteen participants took part who fulfilled the following positions: four business rule architects, three business rule analysts, two project managers, one IT architect, one enterprise architect, one software engineer, and one tax advisor. Each of the participants had, at least, five years of experience with traceability and traceability issues in practice. Each focus group was chaired by one experienced facilitator. Besides the facilitator, five additional researchers were present during the focus group meetings. One researcher participated as 'back-up' facilitator, who monitored if each participant provided equal input, and if necessary, involved specific participants by asking for more in-depth elaboration on the subject. The remaining four researchers acted as a minute's secretary taking field notes. They did not intervene in the process. All focus groups were video and audio recorded. A focus group meeting took on average one and a half hours. Each focus group meeting followed the same overall protocol, each starting with an introduction and explanation of the purpose and procedures of the meeting, after which ideas were generated, shared, discussed and/or refined.

Prior to the first round, participants were informed about the purpose of the focus group meeting and were invited to study the traceability model of their corresponding organization, derived from the case study results. In addition, the first version of the traceability framework that was constructed from the results of the case studies was also included. All participants were asked to bring any comments, which came up while studying the results, with them to the first focus group meeting. The first round started with the presentations of the individual traceability models derived from the case study results. After the individual presentations, participants discussed the usefulness of each traceability element. Also, additional traceability elements were proposed. For each proposed traceability element, the name, description, rationale, domain, and organization-specific examples were discussed and noted. After the first focus group, the researchers consolidated the results. Consolidation comprised the construction of the first version of the traceability framework and detection of double traceability elements (conceptually equal). The results of the consolidation were sent to the participants of the focus group two weeks in advance for the second focus group meeting. During these two weeks, the participants assessed the consolidated results in relationship to four questions: 1) "Are all elements and traces described correctly?", "2) Do I want to remove an element or a trace?" 3) "Do we need additional elements or traces?", and 4) "Does the element or trace contribute to the traceability of legal requirements throughout software systems design"?" This process of conducting focus group meetings, consolidation by the researchers and assessment by the participants of the focus group was repeated two more times (round 2 and round 3). After the third focus group meeting (round 3), saturation within the group occurred, leading to a consolidated traceability framework.

10.5 Results

In this section, the results of the case studies and the focus group are presented. First, we report on the results of the case studies conducted. This is followed by the results from the comparative analysis in which the case study results are compared. Lastly, we report on the results of the focus group meeting, which had the goal to validate our findings and come to a traceability framework a basis for traceability of legal requirements in software systems.

10.5.1 Case Study Results

As mentioned in section three, five case studies were conducted. Based on the analysis of both the secondary data and interview results a traceability map is created that visualizes the traceability elements deemed important per case study, see for example figure 10-1. To improve the readability of this section, we label the Dutch Tax and Customs Administration as case A, the Dutch Immigration and Naturalization Service as case B, the Dutch Employee Insurance Agency as case C, the Dutch Education Executive Agency as case D, and the Dutch Social Security Office as case E. In our results we refer to elements and traces as a singular form, while, in practice, it is possible that elements are referred to in the plural form.

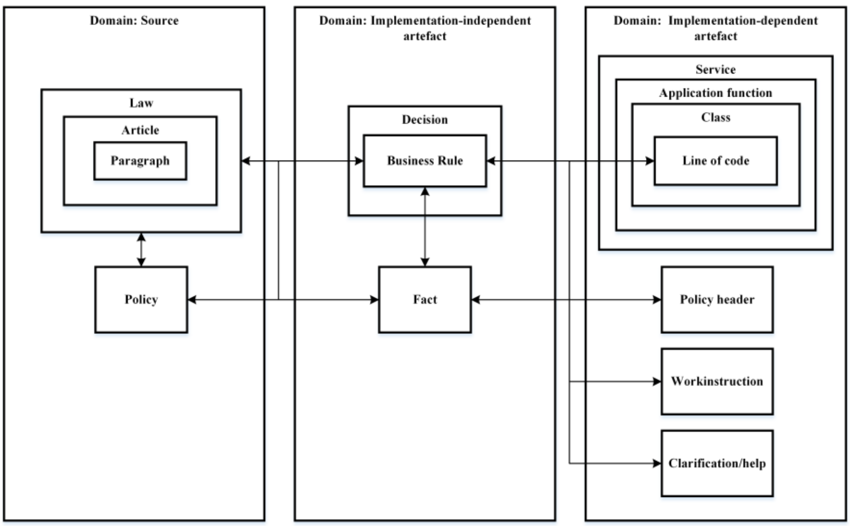

Figure 10-1: Example Traceability Model of the Dutch Education Executive Agency

A similarity that we identified was that all five cases utilize three domains in which elements are managed and traces are implemented. Additionally, all five case organizations utilize those domains to trace between as well. The first domain is the source domain. This domain comprises the laws and regulations as defined by the legal writers of the house of representatives of the Netherlands. The second domain is defined as the implementation-independent artifact domain. This domain comprises artifacts that are established without incorporating language or properties that are affiliated to the use of specific technology (i.e. from specific vendors). The third domain comprises the implementation-dependent artifacts domain. This domain utilizes, for example, vendor specific instantiations of artifacts. An example of this would be the use of knowledge models specifically created and used in the application BeInformed.

In total, the results of the case studies identified multiple similarities and differences between the involved case organizations. However, due to space limitations, we do not cover each individual difference but summarize the differences. In summary, there were seven elements that were included by all case organizations, four elements that were included by all but one case organization, two elements that were included by all but two case organizations, and four elements were included by two of five case organizations.

Further summarized, our findings show some noteworthy design decisions by the case organizations regarding traceability demands. First, we identified a difference in the traceability towards laws and regulations in the source domain. Case A and B reported to trace to the lowest level possible; individual words, whilst case C, D and E report to trace on the level of paragraphs. Case A and B indicate to require these extra levels of traceability due to the fact that both organizations need process less structured laws and regulations compared to case C, D, and E (i.e. often lacking structuring in articles or paragraphs). Moreover, case A also required lower levels of traceability to be able to compare words as concepts in laws and regulations.

Case A and C trace business rules, while case B, D and E utilize decisions as parent elements for business rules which are also traced. Case A indicates to do so because it allows them to execute a more precise form of traceability. Case C motivation for this design decision is that they are still designing their solution and experimenting with the required precision of traceability. Case B, D, and E utilize decisions as parent level of business rules because it enables them to build business rule architectures with the purpose to structure a large amount of business rules as part of a decision.

Moreover, case C and E include a data-model in addition to the common vocabulary-model (i.e. an Entity Relationship Diagram). Case E needs to trace this element due to the fact that their software systems require a data-model in processing legal requirements and providing their public administration services.

Similarly, both case C and E include implementation-dependent data models, whilst case A, B, and D did not want to trace data related models in the implementation-dependent domain. Case E reported utilizing implementation-dependent data models for the execution of their public administration services, bound to a specific software system supplier.

Lastly, case B reported to not trace to either software systems, services, components, classes or a line of code, while case A, C, D, and E did express the necessity to trace to these elements. This is due to the fact that the chosen software system of case B is built upon design principles that do not adhere to layers as, for example, software systems, services, components. Also, case E was the only organization which reported to also trace towards process activities as part of their Business Process Management System due to their integration with a specific software system supplier.

10.5.2 Focus Group Results

Based on the case study results the researchers prepared the first focus group session. The goal of these focus group sessions was to, based on the participant's input and feedback, assemble the traceability framework. Also, as described in section 4, the participants focused on further refinement of the elements to trace in terms of label and description and vertical traceability demands regarding the traceability framework.

The participants agreed in the first focus group round on the consolidated source domain. For this domain two traceability elements were split into different levels of elements to trace; delegated legislation and jurisprudence. Delegated legislation is added due to the fact that the executive organizations of the government are also able to extend or further define constraints for the implementation of laws and regulations. As this kind of regulation can influence how software systems are designed the executive organizations should be able to trace it. Jurisprudence is in this case defined as judgments or decisions by judges from various legislative levels. As these judgments or decisions can influence how the executive organizations should execute laws and regulations (i.e. by constraining them to judge negatively in specific situations which were previously allowed by law), jurisprudence should be traced as well.

Furthermore, little variety was identified regarding the elements in the implementation-independent domain. The participants agreed to split a traceability element into two elements; object model and use-case. An object model is utilized as an Entity

Relationship Diagram, serving as a frame of reference how data is used in decision services by the executive organizations. The way the data is structured and used in decision making affects software systems design, and thus should be traced. Furthermore, use cases are important to trace due to the fact that these contain specific end-user scenario's coupled with certain laws and regulations.

Moreover, the participants had the most discussion regarding the implementation-dependent domain. This was due to the fact that the software systems are very diverse (i.e. most suppliers impose self-developed languages or solutions). However, although most consensus amongst the participants was required for the traceability elements in this domain, no additional element was included op top of the elements deducted from the case studies.

10.5.3 Traceability Framework

To select the elements to be included in the final traceability framework, multiple methods of agreement can be applied, for example, nominal comparison, ordinal comparison or narrative appraisal. In our research, we applied the method of agreement to compare the different cases and to be traced elements. However, a traceable element was added to the framework even it occurred only once. The reason for this is that the framework provides organizations all possibilities to choose from. Therefore also situations that occur only once in the selected organizations can be applicable to other organizations. The final traceability framework derived from the focus groups is built out of three domains, which are elaborated upon in section 5.1. Summarized, each of the domains comprises three or more high-level traceability elements which we will elaborate in this subsection if not already addressed in the previous subsections. Regarding the source domain, a policy refers to internal procedures or protocols inherent to the specific organization.

Regarding the implementation-independent domain, the high-level traceability elements are a scope, fact type model, object model, and use-case. A scope is defined as any unit of analysis, stated by the organization. Examples of this are a selection of business rules part of a specific decision service or one decision with all its underlying business rules. The number of contexts in a scope can vary but consists of a minimum of one context. A decision is built from one or more business rules. The fact type model serves as a domain model containing all possible terms that are utilized in decision making, which are labeled as facts.

Regarding the implementation-dependent domain, the high-level traceability elements are a software system, work instruction, and specification. The software system is built from one, but usually multiple (shared) services. Services are built from (shared) components. A component can be further dissected into classes, and on the lowest possible level, a Line of Code (LoC) that can be traced. The relationships between the different elements are all identical: many to many relationships. Summarized, the consolidated traceability framework is presented in Figure 10-2.

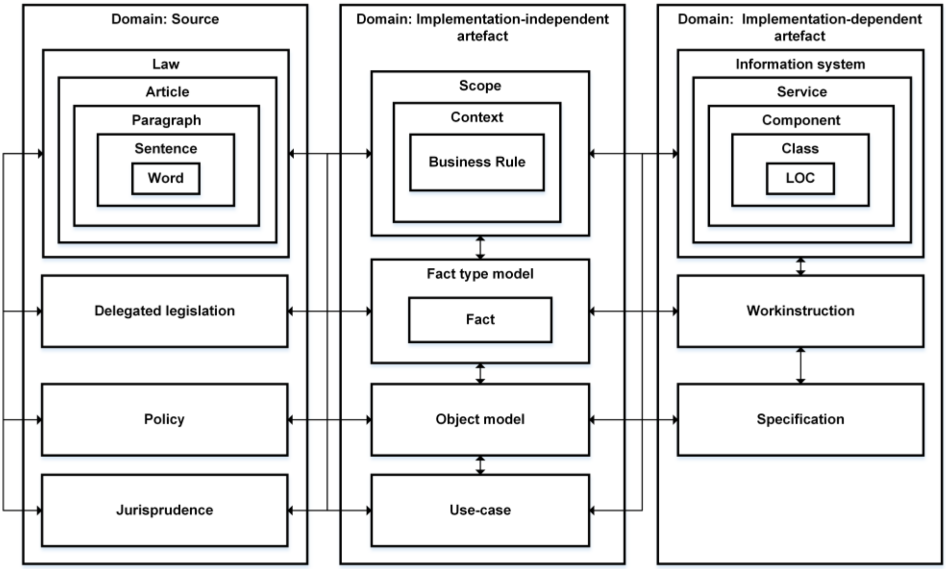

Figure 10-2: Final Traceability Framework

10.6 Discussion and Conclusion

In this paper, we aimed to find an answer to the following question: "*Which elements are useful to trace with regards to legal requirements in the context of the Dutch government*". To accomplish this goal, we conducted a study conducting five case studies and a three round focus group. Both were applied to retrieve traceability elements from participants, 41 in total, employed by five executive governmental agencies. Our rounds of data collection and analysis resulted in a traceability framework which can be utilized when designing or improving the traceability capability of governmental organizations that execute laws and regulations. From a research perspective, our study provides a fundament for traceability principles and traceability elements focused on the implementation of laws and regulations in software systems design. From a practical perspective, executive governmental organizations could utilize the results of this study to guide the (re)design of traceability of legal requirements in software systems. With this in place organizations can ensure the adequate level of transparency towards legislative branches of the government, judges and judicial systems, and no less significant, towards citizens and businesses. Furthermore, another practical implication of our results could be that the governmental organizations now have a common frame of reference to communicate when addressing traceability. Therefore, our proposed traceability framework can be useful when executive governmental branches need to collaborate in a single chain of services.

Several limitations may affect our results. The first limitation concerns the sampling and sample size. The sample group of case organizations and participants is solely drawn from government institutions in the Netherlands. While we believe that government institutions are representative for organizations implementing traceability of legal requirements to implementation systems design, further generalization towards non-governmental organizations, amongst others, is recommended. Taken the sample size of five case studies and 41 participants into account, this number needs to be increased in future research. This research focused on identifying new constructs and establishing relationships given the current maturity of the traceability research field. Although the research approach chosen for this research type is appropriate, research focusing on further generalization should apply different research methods, such as quantitative research methods, which also allow us to incorporate larger sample sizes to validate our findings.

11 CONCLUSIONS AND OUTLOOK

As described in the introduction of this thesis, the main question of this research is:

MRQ: ***How can business rules management be organized and governed?***

In this summary chapter, an overview of the results is provided, and the conclusions and contributions per research question are presented. We contributed to practice and science through the following deliverables: 1) BRM reference process description; 2) list of BRM compliance principles; 3) BRM verification capability framework; 4) list of BRM functional requirement themes; 5) list of BRM implementation challenges; 6) BRM management control system; and 7) BRM traceability framework. All together, these deliverables provide an answer to the overall research question in this thesis. The summary is followed by the conclusions and implications, limitations and future research for this thesis.

11.1 Stepwise summary

RQ-1: ***What are the compliance and functional requirements for Business Rules Management implementations?***

When implementing BRM we suggest to take into account the identification of business processes, BRM-related artifacts, compliance principles, and functional requirements. To analyze these aspects, a multimethod approach consisting of secondary data analysis, literature reviews, focus groups, Delphi studies, and case study research was applied. This research question was subdivided into four related sub-questions:

SQ-1: *Which (sub-)processes constitute a Business Rules Management Reference process for Dutch governmental agencies?*

The body of knowledge regarding neighboring research fields, i.e. data management and business process management, contains reference processes that are adequately grounded in theory and practice. However, limited research is conducted on reference processes for BRM implementations, especially in the context of governmental implementations. By analyzing the current BRM processes of five large Dutch governmental agencies a BRM reference process for Dutch governmental agencies was proposed and validated. The resulting BRM reference process contains a set of seven main processes, see Figure 11-1, and 20 underlying subprocesses. For each (sub-)process, the input, transformation, and output is defined.

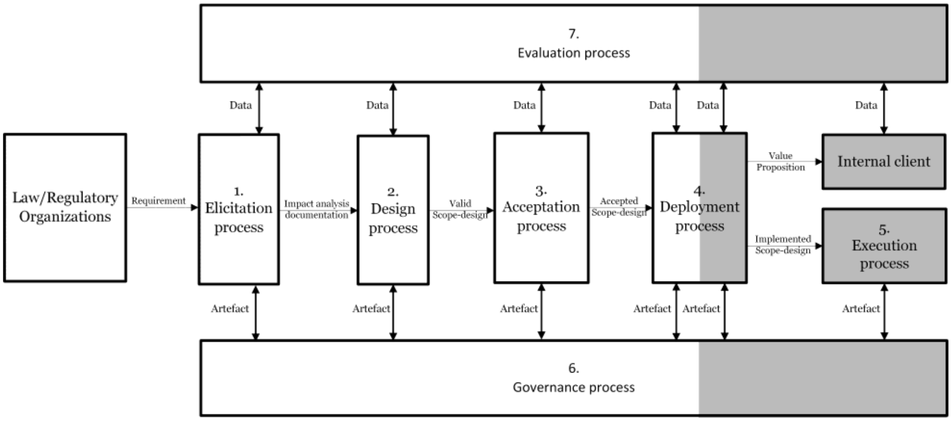

Figure 11-1: BRM reference process

The participants from the Dutch governmental agencies indicated that a BRM reference process benefits collaboration between the agencies as it allows for communication using shared processes and artifacts. The BRM reference process shows a strong similarity with the service systems proposed by Zoet (2014) and the BRM capabilities described in (Smit & Zoet, 2016a). Details are described in chapter two.

SQ-2: *Which principles are essential in designing a compliant business rules management solution?*

Compliance is one aspect of BRM. As the current knowledge base is limited with regards to design principles that guide BRM implementations, five large Dutch governmental agencies participated by presenting and discussing their applied principles for further analysis. With the input of 44 participants, 11 compliance principles were formulated, see Table 11-1 (adjusted from the original paper to represent an indicative form). The resulting set of compliance principles offer organizations a framework that can structure the design process of the BRM solution that needs to be implemented. Additionally, the compliance principles were mapped to the four structures of the OF-IS Framework. This shows the following categorization: one principle affects all four structures; four principles affect the organizational structure; three principles affect the surface structure; five principles affect the deep structure; and two principles affect the physical structure. The results are described in detail in chapter three.

Principle ID and label	OF-IS Structure
• **Principle 1:** IT does not formulate business rules	Deep
• **Principle 2:** Authorize for decision-making	Physical and Organizational
• **Principle 3:** Define decision ownership	Deep and Organizational
• **Principle 4:** Trace a decision and related data	Deep
• **Principle 5:** Communicate with the same standards wherever possible, communicate with different standards where desirable	Surface, Organizational and Physical
• **Principle 6:** Record decisions, business rules, and data according to two time dimensions	Deep
• **Principle 7:** Assign sources for business rules	Deep
• **Principle 8:** Allow gaming only by 'gamers'	Organizational
• **Principle 9:** Ground transparency concerning decision-making for clients and users	Surface
• **Principle 10:** Share knowledge concerning the execution of laws, regulations and policies with employees, partners, and clients	Surface
• **Principle 11:** Utilize government-wide standards	All

Table 11-1: Compliance Principles for BRM

SQ-3: *Which verification capabilities are useful to take into account when designing a business rules management solution?*

One of the benefits of a proper implementation of BRM capabilities is the ability to execute (semi-)automated decision-making. To be able to do so, the business logic designed and specified cannot contain verification errors. A framework of 28 types of verification has been defined. This has been done using existing literature, secondary data, consisting of verification documentation from five large Dutch governmental agencies and a three-round focus group approach, see Figure 11-2. Subsequently, the results have been evaluated against the Decision Model and Notation standard that is increasingly being used in practice (Object Management Group, 2016b). This process resulted in: eight *Decision Requirements Diagram* level types of verification; eight *Decision Logic* level types of verification; eight *Fact* level types of verification; and four *Generic* level types of verification. These can be taken into account when designing and implementing the verification capability in an organization and its information systems. Details are described in chapter four.

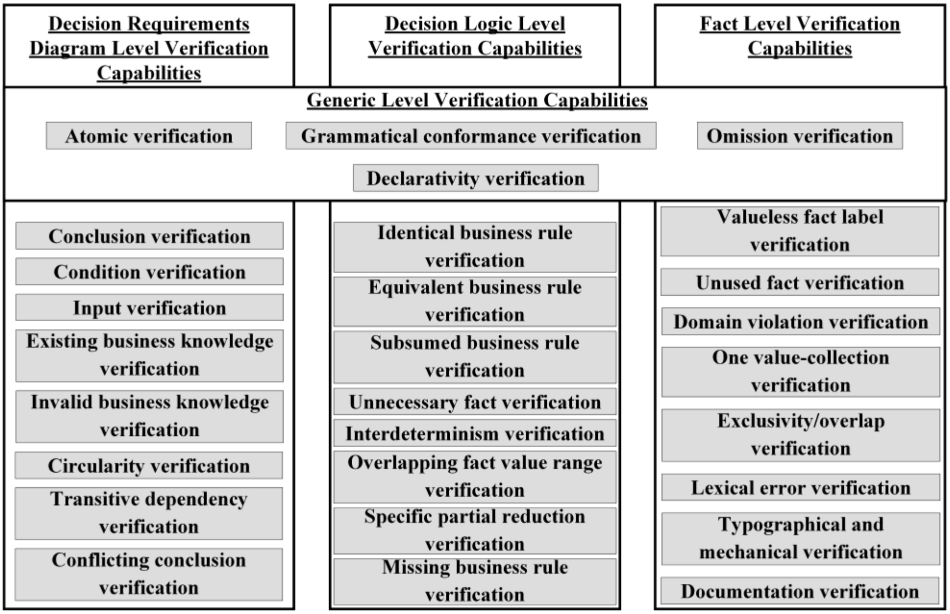

Figure 11-2: BRM Verification Capabilities Framework (corresponding to the levels of DMN (Object Management Group, 2016b))

SQ-4: ***Which functional requirements should be taken into account with regards to the different capabilities as part of BRM?***

The BRM capabilities are often supported by (a combination of) software systems and BRMS. Proper implementation of BRM in organizations is therefore dependent on the proper functional support that these software systems can realize. The current body of knowledge does not contain any contributions to guide organizations in determining functional requirements that should be taken into account when selecting or developing software that has an appropriate fit. A set of 759 functional requirements from four Dutch governmental agencies was identified and analyzed. The analysis identified 34 functional requirement themes distributed over the nine BRM capabilities presented in Figure 1-1, see Figure 11-3. On the one hand, this contribution guides organizations in selecting the appropriate set of functional requirements that should be taken into account when implementing BRM. On the other hand, this contribution aims to help voice the demands of organizations towards BRMS vendors; one of the current observations is that there is a misalignment regarding functional requirements between both. The results are described in detail in chapter five.

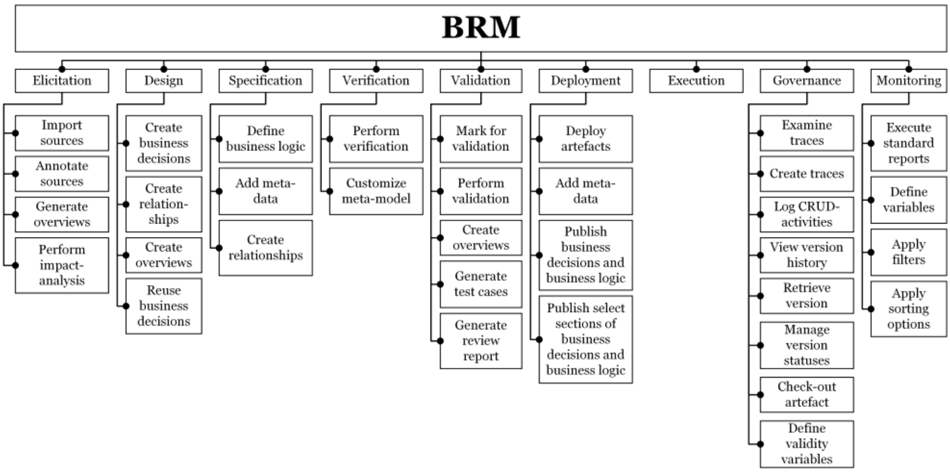

Figure 11-3: Functional Requirement Themes for BRM

RQ-2: ***What are the BRM implementation challenges for governmental institutions?***

For the proper organization and governance of BRM an organization should also take into account the challenges of BRM implementations. The identification of challenges in this part resulted in 53 challenges, see Figure 11-4.

		OF-IS Structures			
		Surface Structure	Deep Structure	Organizational Structure	Physical Structure
BRM Capabilities	Elicitation	1	3	5	2
	Design*		5	8	2
	Specification*		5	8	2
	Verification	1	1	3	1
	Validation	1	1	7	2
	Deployment				
	Execution				
	Monitoring				
	Governance			6	

Figure 11-4: Heat-mapping of BRM challenges per capability to the OF-IS Structures

The *Design* and *Specification* challenges have been reported identically because the participants addressed both capabilities as one integrated capability in their context. As this differs slightly with practices in other industries and literature on BRM capabilities, we retained the separate notion of both capabilities. To identify all challenges, a combination of focus groups and Delphi study rounds have been conducted. In general, based on the results of RQ-2, clients, users and software and BRMS vendors are able to develop best practices, concepts and methods. This research question was subdivided into three related sub-questions:

SQ-5: ***Which implementation challenges do governmental institutions encounter while implementing the elicitation, design and specification capabilities of business rules management?***

Building on the collection and analysis of two separate three-round focus groups and two separate three-round Delphi studies, this study identifies 28 main challenges with regards to the elicitation, design, and specification BRM capabilities. The challenges were mapped on to the four structures of the OF-IS Framework. This resulted in the following categorization: two challenges affect all structures; one challenge affects the surface structure; eight challenges affect the deep structure; four challenges affect the physical structure; and 13 challenges affect the organizational structure. One of the conclusions that can be drawn from this categorization is the difference in the amount of surface and physical structure challenges compared to the amount of deep and, especially, organizational structure challenges. Furthermore, the participants formulated two general BRM implementation challenges that are applicable for all capabilities across all structures: 1) the lack of structured and repeatable processes for each BRM capability; and 2) education and knowledge level with respect to BRM. Both overall challenges show that BRM challenges are complex as they do not only affect one or some BRM capabilities but can span all structures of the OF-IS. The challenges identified have triggered the participating organizations to evaluate how these challenges can best be mitigated. Some are being mitigated, or have already been mitigated, at the time of writing. Details are described in chapter six.

SQ-6: ***Which implementation challenges do governmental institutions encounter while implementing the verification and validation capabilities of business rules management?***

Building on the collection and analysis of two separate three-round focus groups and two separate three-round Delphi studies, this study reports on 17 main challenges with regards to the verification and validation capabilities. The challenges were mapped on to the four structures of the OF-IS Framework. This resulted in the following categorization: two challenges affect the surface structure; two challenges affect the deep structure; three challenges affect the physical structure; and ten challenges affect the organizational structure. Similar to the results of SQ-5, there are more organizational-structure challenges experienced by the participants compared to the other structures. Details are described in chapter seven.

SQ-7: ***Which implementation challenges do governmental institutions encounter while implementing the governance capability of business rules management?***

Building on the collection and analysis of a four-round focus group and a three-round Delphi study, this study reports on eight main challenges with regards to the governance capability. The challenges were mapped on to the four structures of the OF-IS Framework. This resulted in the following categorization: two challenges affect all structures; no challenges affect the surface, deep and physical structures; and six challenges affect the organizational structure. Similar to the results of SQ-5 and SQ-6, there are more organizational-structure challenges experienced by the participants compared to the other structures. The two general governance implementation challenges that apply to all structures were: 1) governance process maturity; and 2) maturity of tooling supporting governance. Both overall governance challenges underline the importance of proper embedding of governance as part of BRM in an organization. They also underline the phenomenon that is described in the introduction of this thesis: currently available tooling lacks proper functionality to support governance. Details are described in chapter eight.

RQ-3: ***How can a BRM implementation be evaluated?***

How to organize for the evaluation and governance of BRM implementations is a knowledge gap in the current body of knowledge. Because of this, two studies were conducted, using a multimethod consisting of literature reviews, focus groups, Delphi study rounds, and case study research. This research question was addressed by two related sub-questions:

SQ-8: ***Which performance indicators are useful to measure the BRM processes?***

Evaluation entails a management control system in which Performance Indicators (PI) measurement and benchmarking is conducted for the BRM capabilities 'elicitation', 'design', 'specification', 'verification', 'validation', 'deployment', 'execution', and 'governance'. The current knowledge base on the evaluation of BRM capabilities lacks contributions that can guide an organization to develop an adequate management control system. Based on a three-round focus group and a three-round Delphi study, 14 validated key performance indicators were identified, see Table 11-2. As it is expected that a management control system with key PI is defined differently per organization, four situational factors were identified and addressed: 1) business rule complexity level; 2) time unit; 3) scope; and 4) implementation type. The results enable organizations to measure performance and improve their BRM processes. These results are described in detail in chapter nine.

- **PI 01**: The frequency of corrections per selected context design emerging from the verification process.
- **PI 02:** The frequency of corrections per selected context design emerging from the verification process per business analyst and per type of verification error.
- **PI 03:** The frequency of corrections per selected context design emerging from the validation process per complexity level of a business rule.
- **PI 04:** The frequency of corrections per selected context design emerging from the validation process per type of validation error.
- **PI 05:** The frequency of corrections per selected context architecture emerging from the design process per scope design.
- **PI 06:** The frequency of instantiations per selected context design
- **PI 07:** The frequency per selected type of validation error.
- **PI 08:** The frequency per selected type of verification error.
- **PI 09:** The number of time units required to define, verify, and validate a single business rule.
- **PI 10:** The frequency of deviations between an implementation dependent context design and an implementation independent context design.
- **PI 11:** The frequency of executions of an implementation dependent business rule.
- **PI 12:** The frequency of execution variants of a scope design.
- **PI 13:** The number of time units required for the execution per execution variant.
- **PI 14:** The amount of business rules that cannot be automated.

Table 11-2: Performance Indicators for BRM

SQ-9: ***Which elements are useful to trace with regards to legal requirements in the context of the Dutch government?***

The degree of traceability of business rules is an important aspect for a successful BRM implementation. The translation of legal sources to business decisions and underlying business logic with the aim to (semi-)automatically execute them requires several (software) artifacts that need to be traceable. Traceability allows for the justification of compliance. In neighboring fields, like requirements management, process management, and data management, compliance is a mature mechanism and described in detail. However, this is not the case for BRM. By conducting five case studies at large Dutch governmental agencies, the traceability of (software) artifacts in the translation process is made explicit, which formed a basis for the developed traceability framework, see Figure 11-5. The results are described in detail in chapter ten.

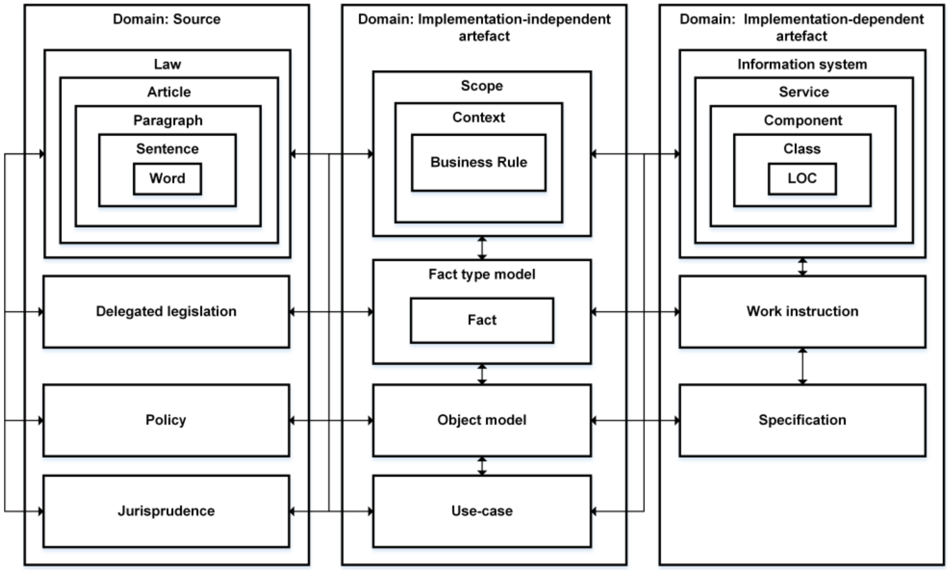

Figure 11-5: Traceability framework for BRM

With the help of 13 participants, three focus group rounds were conducted to refine and validate the traceability framework. The framework consists of 22 (layered) traceability elements distributed over three domains: 1) legal sources; 2) implementation-independent artifacts; and 3) implementations-dependent artifacts.

The framework offers organizations a reference model to determine how traceability can be designed as part of the implementation of BRM. This is done by presenting commonly used artifacts in the different domains. The framework also enables organizations to structure discussion and decision-making regarding the degree of traceability that is required for a specific context.

11.2 Contributions and Implications

The research in this thesis follows principles and guidelines from Design Science Research (Hevner et al, 2004). Design science research contributes in two ways: new knowledge that is added to the existing knowledge base on the subject; and artifacts that are proposed to the environment to be used in practice with the goal to solve the identified problems (Hevner et al, 2004). In this sub-section, the scientific contributions as well as the contributions to practice are discussed for each part in this thesis.

Compliance and functional requirements

The first part (part one) of this thesis presents four contributions: 1) a BRM reference process for Dutch governmental agencies; 2) a set of compliance principles for BRM; 3) different types of verification to ground the quality of business decisions and business logic; and 4) a set of functional requirement themes for BRM systems.

From a theoretical perspective, the BRM reference process presented in chapter two provides a fundament for BRM processes in general and also provides a knowledge base for a governmental context.

The set of compliance principles presented in chapter three provides a fundament for design principles related to compliance, which can be applied to create or implement a BRM solution. The identified principles can be applied in practice and their impact can be measured and further evaluated upon in future studies.

The types of verification presented in chapter four provide a framework that can guide future research into the quality mechanisms of business decisions and business logic, also in relation to the DMN standard.

Lastly, the functional requirement themes presented in chapter five provide a first exploration into requirements for the BRM capabilities presented in Figure 1-1. This contribution could structure further research regarding the development of situational sets of requirement themes, which can be related to organizational goals or specific organizational characteristics.

From a practical perspective, the BRM reference process presented in chapter two provides a process architecture that can be used as a point of reference when (re)designing BRM implementations. The reference process can also help in normalizing BRM processes (and thus, in the case of executive governmental institutions, the service providing processes) and BRM-related artefacts so that alignment of BRM capabilities between governmental institutions can increase. Using the reference process description promotes commonality. Eventually, more alignment between governmental institutions could result in higher quality products and services for citizens and businesses in the Netherlands. Our results are already applied in projects at Dutch governmental institutions, but they could also inspire other organizations or researchers to determine BRM processes in other industries. The set of compliance principles presented in chapter three provides organizations and (enterprise) architects within organizations with a set of principles that can be applied to guide regulatory compliancy and the design of decision management solutions. It offers a framework that can structure thinking about the solution that needs to be implemented. Furthermore, the types of verification presented in chapter four provide a framework that organizations can utilize to (re)address how the quality of their business decisions and business logic should be controlled. An increasing number of organizations are embracing the DMN standard: for example, some of the Dutch governmental institutions label adherence to the DMN standard as a 'must have' in software selection. Our contribution could also trigger the development of products that support organizations with, in a consistent way, achieving a certain level of quality; our observation is that, currently, many available products like BRMS and business rules engines only support some (not all) types of verification. Lastly, the functional requirement themes presented in chapter five provide organizations with a frame of reference that can guide the process of selection and development of BRM solutions. This is beneficial as the process of requirement discovery and formulation can be difficult and resource demanding, when performed profoundly. Additionally, BRMS vendors could take note of the functional requirement themes to develop products and services that better fit the demands of organizations implementing BRM solutions.

Challenges in BRM implementations

The second part (part two) of this thesis presents three contributions: 1) a set of challenges with regards to the implementation of the elicitation, design and specification BRM capabilities; 2) a set of challenges with regards to the implementation of the verification and validation BRM capabilities; and 3) a set of challenges with regards to the implementation of the governance BRM capability.

From a theoretical perspective, all three contributions presented in chapters six, seven, and eight provide a better understanding as they are mapped to the different OF-IS structures of Strong and Volkoff (2010) and Weber (1997). This enables the identification of relevant research directions. Furthermore, the mapping will enable further exploration and identification of problem classes. The results presented in all three contributions underline the conclusions drawn from earlier literature with regards to technical versus organizational maturity of the implementation of BRM; most challenges identified are mapped to the organizational structure. This emphasizes the importance of organizational structure implementation of BRM and reveals future research directions.

From a practical perspective, the challenges identified and presented in chapters six, seven, and eight provide insights into which governance related challenges are experienced in the Dutch governmental context when implementing BRM capabilities. Organizations of any type, even non-governmental organizations, can learn from these implementation challenges. However, future research still needs to validate the extent to which the results of these studies are relevant to other industries both in a national as well as an international context. Governmental institutions should use the knowledge gained on the challenges presented to guide the design of their BRM capabilities (e.g. to avoid using mainly third party staff for critical processes such as the management of their business logic or the importance of a central fact vocabulary).

Additionally, BRMS vendors could learn from the insights presented and start developing best practices, concepts and methods as this could guide them in avoiding or mitigating pitfalls in implementation projects.

Evaluation and governance of BRM implementations

The third part (part three) of this thesis presents two contributions: 1) a management control system for BRM; and 2) a traceability framework for BRM.

From a theoretical perspective, the management control system presented in chapter nine provides a fundament for measurement of performance and benchmarking of the BRM capabilities 'elicitation', 'design', 'specification', 'verification', 'validation', 'deployment', 'execution', and 'governance'. Knowledge on monitoring and evaluation of BRM implementations and the execution of business decisions and business rules is scarce. Benchmarking BRM implementations results in insights that can be used to identify best practices that can guide future BRM implementations. The traceability framework presented in chapter ten provides a fundament for traceability principles and traceability elements as for the implementation of laws and regulations in an organization. The available knowledge on the traceability of business decisions and business logic is limited. Therefore, our contribution could help in articulating the need for future research in similar or other contexts or industries.

From a practical perspective, the management control system presented in chapter nine provides, first of all, a set of rigorously validated Performance Indicators (PI) that organizations can apply to measure the performance of BRM processes. Overall, this contribution provides guidelines that can be taken into account when designing and implementing the monitoring BRM capability: many organizations nowadays lack proper BRM-related PI that could indicate areas of improvement. The traceability framework presented in chapter ten provides organizations, especially Dutch governmental institutions, with a framework that can guide the (re)design of the traceability of legal requirements in information systems or other forms of deployment, like processes and procedures. With this in place, organizations can address transparency towards legislative branches of the government, judges and judicial systems, and towards citizens and businesses. Another practical implication could be that the governmental organizations have a common frame of reference for communicating when addressing traceability. Therefore, the proposed traceability framework can be applied when executive governmental agencies need to collaborate in a single chain of services.

Contributions of this thesis as a whole

To conclude with the contributions of this thesis we revisit the research triggers, both scientific and practical, identified in chapter one. These were:

- Scientific triggers
    - The current body of knowledge does not show a well-balanced mix of research with regards to technical versus organizational research;
    - The current body of knowledge does not show a well-balanced mix of research with regards to theoretical versus practical research;
- Practical triggers
    - BRM-tooling is immature;
    - Collaboration between vendors is lacking;
    - There is insufficient knowledge on how to apply BRM;

    As a consequence:

    - Organizations do not strategically and structurally embed BRM;
    - Rather few successful implementations of BRM-Systems (BRMS) are known.

From a scientific point of view, multiple research triggers were identified. Based on the lack of organizational focused research on BRM we took into account the OF-IS framework of Strong and Volkoff (2010), which is based on Weber (1997). This framework includes four structures, consisting of the technical (physical) as well as the organizational (surface, deep and organizational) structures. The research presented in this thesis concerned especially the organizational levels (of the OS-IF framework) of BRM implementations. Additionally, the artifacts proposed in this thesis are constructed and presented as implementation independent organizational levers, for example, (sub-)processes, design principles, capabilities, and frameworks. These levers can help organizations in organizing and governing BRM implementations. Summarizing, the contributions presented in this thesis are adding to the nascent body of knowledge on BRM (especially the surface, deep, and organizational levels of

OS-IF). They also focus on practical utility as organizations are able to apply them in the (re)design of BRM capabilities. The contributions presented in this thesis focus on how to implement as well as how to govern BRM capabilities. The latter is not available in the current body of knowledge.

Based on the BRM capabilities and underlying concepts presented in this thesis, organizations that implement and utilize BRM, as well as organizations that develop and market BRMS, can leverage the results. Additionally, organizations could learn from the approach utilized in this thesis (among others focus groups and Delphi studies): it shows that collaboration on this topic contributes to knowledge sharing, from which all participants can benefit. A proper understanding of BRM begins with adequately educating professionals. The contributions presented in this thesis provide a basis for education on the different BRM capabilities.

11.3 Discussion and Future Research

The contributions discussed in this thesis have their limitations. The maturity of the BRM research field with regards to non-technological research is nascent. This resulted in the selection and application of solely qualitative research methods. Qualitative research is appropriate for conducting research where the focus is to "provide provisional explanations of phenomena, often introducing a new construct and proposing relationships between it and established constructs" (Edmondson and McManus, 2007: p. 1158). However, applying qualitative research methods limits the amount of cases or participants as the focus is on exploration of the rich data that in-depth interviews or case study approaches generate. Most artifacts in this study are based on the collection of data using groups of subject matter experts and case studies of limited sample sizes. Although each contribution in this thesis is characterized by a multi-iteration approach with the goal to construct as well as validate an artifact, validation of the artifacts is conducted for a specific context and therefore could not always be generalized for other contexts. Future research can therefore address the application of the artifacts proposed in industries other than the government, for example, highly regulated industries like healthcare, pharmaceutical, financial, utility, legal, and transportation as well as less regulated industries. An additional research direction is the application of the artifacts proposed in this thesis in other countries. Applying and validating the artifacts proposed could provide valuable insights into how other industries within and outside the Netherlands implement BRM capabilities and deal with business logic.

Moreover, as many challenges were identified and described in an explorative setting, one important future research direction would be the identification of solutions that mitigate these challenges.

As the maturity of the BRM research field will mature over time, future research should employ research methods that support the inclusion of larger sample sizes. This can be achieved with quantitative data collection and analysis approaches. Using larger sample sizes that characterize quantitative research approaches helps in establishing more generalizable artifacts that can support organizations across different industries in different countries in implementing BRM capabilities.

The artifacts presented in this thesis all contribute towards the understanding and application of BRM capabilities. However, their interrelationships and influence on each other should be taken into account in future research. Although we believe that the use of the OF-IS was appropriate in this research, taking, for example, a systems theory lens (cf. Adams, Hester, Bradley, Meyers, & Keating, 2014; Matook & Brown, 2017) will undoubtedly help in increasing knowledge on such interrelationships.

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14 SUMMARY

Properly managed business decisions and business logic are important assets for organizations. Organizations in general, and government agencies in particular, increasingly utilize (semi-)automated decision making in products and services delivery. Organizations obtain grip on regulatory compliance by well managing decision making processes. Organizations must secure adequate translation of legal sources into their products and services delivery. An approach to do so is through Business Rules Management (BRM).

Most research performed on BRM can be classified as technical (taking an information *technology* perspective), while research on the organizational implementation (taking an information *systems* perspective), considering organizational topics, is mainly unaccounted for. Furthermore, current research into BRM does not always adequately take into account the practical application of research results. Can an organization actually use the theory or artefact proposed?

The above may well explain why professional practice experiences challenges when adopting BRM in their organizations. We see that 1) BRM-tooling is immature, 2) collaboration between vendors is lacking, and 3) there is insufficient knowledge on how to apply BRM. As a consequence 4) organizations do not strategically and structurally embed BRM, and 5) rather few successful BRM-Systems (BRMS) are known.

With the aim to seize these observations and to add to the scientific body of knowledge on BRM's information *systems* perspective this thesis focuses on so called BRM *capabilities*[10] by proposing theory and delivering artefacts that could guide organizations adopting BRM. The following main research question is addressed in this thesis:

- *How can business rules management be organized and governed?*

To answer this question, multiple subquestions are posed and addressed, utilizing a multimethod approach, taking into account the limited body of knowledge on the organizational aspects of BRM. The thesis describes the application of literature reviews, grounded theory coding, focus groups, Delphi studies and case studies. This research mainly focuses on the Dutch government, including several large Dutch government agencies. The results of the research are presented in three interrelated parts: 1)

[10] An ability that an organization, person, or system, possesses. It therefore defines what an organization, person or system does or can do but not how it accomplishes it (Object Management Group, 2016a).

concepts and principles for business rules management, 2) business rules management implementation challenges, and 3) business rules management governance.

Regarding the first part: in the second chapter of this thesis, a BRM reference process is presented with seven main processes: 'elicitation', 'design', 'acceptation', 'deployment', 'execution', 'governance' and 'evaluation', together with underlying subprocesses. In the third chapter, 11 compliance principles are identified and described. Examples are 'all business rules refer to a (legal) source', and 'transparency concerning decision-making for clients and users'. In the fourth chapter, a verification framework is presented that comprises 28 types of verification that organizations could implement to ensure proper (automated) execution of their business decisions and business logic. Examples are 'circularity verification' (checking whether a conclusion fact of a parent business rule is used as a condition fact in the underlying business rule, while at the same time the conclusion fact of the underlying decision is used as a condition fact in the parent business rule), 'equivalence verification' (checking for business rules which are expressed differently, yet with the same outcome), and 'conflict conclusion verification' (checking whether conclusions exist that are established using different business rules and facts). This part closes with the fifth chapter, which presents 34 functional requirement themes for BRMS of which examples are (in this case related to the 'elicitation' of business rules): the ability to 'import sources', 'annotate sources', 'generate overviews' and 'perform impact-analyses'.

The second part aims to identify challenges that organizations face implementing BRM-solutions. The identification of challenges was performed for the 'elicitation', 'design', 'specification', 'verification', 'validation' and 'governance' capabilities of BRM, resulting in a total of 53 challenges. In the sixth chapter, 28 implementation challenges are identified with regards to specifically the 'elicitation', 'design' and 'specification' BRM-capabilities. Examples are the 'lack or low quality of governance of a fact vocabulary' and the 'unwanted dependency on external parties to translate law and regulations into business decisions and business logic'. In the seventh chapter, 17 implementation challenges are identified with regards to the 'verification' and 'validation' BRM capabilities. Examples are 'the trade-offs between precision, expressiveness, naturalness and simplicity of business rules', and 'the lack of (proper) validation regarding the business logic that is communicated with stakeholders' (i.e. Dutch citizens). Lastly, in the eighth chapter, eight implementation challenges are identified with regards to the 'governance' BRM capability. Examples are 'the lack of knowledge regarding existing governance standards' and 'the poor meta-data quality that hampers adequate governance'.

The third part focuses on the organization of BRM-governance, which is subdivided in two studies. In the ninth chapter a business control system is presented, with 14 performance indicators that can be used to evaluate the implementation of BRM capabilities. Examples of performance indicators are 'the amount of business rules that cannot be automated' and 'the time required to define, verify, and validate a single business rule'. Then, in the tenth chapter, a traceability framework for BRM is proposed that presents three traceability domains, being the *source* domain, the *implementation-independent* domain (which functions as a single point of truth) and the *implementation-dependent* domain (which encompasses the implemented 'pieces of law' across different information systems). Each of the domains comprise several (layered) elements that represent the different levels of abstraction for which a piece of law can be traced. A piece of law can, for example, be traced on five levels of abstraction: on law level, article level, paragraph level, sentence level, or word level. Organizations could utilize these domains and the layered elements as these make explicit the design choices that must be made to properly implement traceability.

The results of the research contribute to the body of knowledge on how to organize and govern BRM in organizations. Notably, results consist of the identification and elaboration of (sub)processes, design principles, capabilities and challenges. New insight are provided on, and mature, the information *systems* perspective in BRM research. Other scholars can take the research further, e.g. in further evaluation of the results and building on its outcomes.

Based on the outcomes of the various studies included in this thesis, it is summarized that organizations can define strategies from the research outcomes to design and implement their BRM capabilities, while avoiding or mitigating the challenges identified. At the time of writing, the results already affect organizations: some Dutch government agencies are utilizing the results for the (re)design of their BRM capabilities. Also, the process of making explicit the implementation challenges at the participating organizations resulted in these organizations actively investing resources to mitigate these challenges. Future research should aim to measure the effectiveness of the results and proposed artefacts in similar or dissimilar contexts.

15 NEDERLANDE SAMENVATTING

Het is voor organisaties van belang om besluitvorming en zogenaamde 'bedrijfslogica' goed in te richten. Organisaties in het algemeen, en zeker ook overheidsinstellingen, maken meer en meer gebruik van (semi-)geautomatiseerde besluitvormingsprocessen bij het leveren van hun producten en diensten. Organisaties krijgen grip op de naleving van wet- en regelgeving door de besluitvormingsprocessen goed te beheren. Een adequate vertaling van wet- en regelgeving naar producten en diensten is hierbij nodig. *Business Rules Management* (BRM) maakt een en ander mogelijk.

Het meeste onderzoek dat wordt uitgevoerd naar BRM kan worden geclassificeerd als technisch (vanuit een informatie*technologie*perspectief). Echter, onderzoek naar de implementatie van BRM *in* de organisatie (vanuit een informatie*systeem*perspectief), inclusief het beschouwen van allerlei organisatorische aspecten, ontbreekt grotendeels. Bovendien houdt het bestaande onderzoek naar BRM niet altijd voldoende rekening met de praktische toepassing van onderzoeksresultaten; met andere woorden: kan een organisatie de voorgestelde theorie of het opgeleverde resultaat daadwerkelijk gebruiken?

Bovenstaande kan verklaren dat de beroepspraktijk het lastig vindt om BRM in hun organisaties toe te passen. We zien dat 1) BRM-tooling onvolwassen is, 2) er geen tot weinig samenwerking tussen BRM-tooling leveranciers is, 3) er beperkte kennis is binnen organisaties over hoe BRM toe te passen. Als gevolg hiervan kunnen 4) organisaties BRM niet strategisch en structureel verankeren, en 5) zijn er maar weinig succesvolle implementaties van BRM-Systemen (BRMS) in organisaties.

Dit onderzoek pakt deze observaties aan en voegt wetenschappelijke kennis toe op het informatie*systeem*perspectief van BRM. Het proefschrift richt zich op zogenaamde BRM-*capaciteiten*[11] (te weten 'elicitatie', 'ontwerp', 'specificatie', 'verificatie', 'validatie' en 'beheer'). Het stelt passende theorie voor en levert resultaten op die organisaties kunnen helpen bij de adoptie van BRM. De volgende hoofdonderzoeksvraag wordt behandeld:

- *Hoe kan BRM worden georganiseerd en beheerd?*

Om de hoofdonderzoeksvraag te beantwoorden, worden meerdere deelvragen gesteld en beantwoord, gebruikmakend van een *multimethod* benadering, waarbij rekening is gehouden met de beperkte wetenschappelijke kennis over de organisatorische aspec-

[11] Een capaciteit is het vermogen dat een organisatie, persoon of systeem bezit. Het definieert wat een organisatie, persoon of systeem doet of kan doen, maar niet hoe het dat doet (Object Management Group, 2016a).

ten van BRM. Toegepast worden literatuuronderzoek, *grounded theory* codering, focusgroepen, Delphi studies en *case studies*. Het onderzoek richt zicht verder vooral op de Nederlandse overheid, waaronder een aantal grote uitvoeringsinstanties. De resultaten van het onderzoek worden gepresenteerd in drie, met elkaar samenhangende, delen: 1) concepten en principes voor BRM 2) BRM-implementatie-uitdagingen, en 3) BRM-*governance*.

Voor wat betreft het eerste deel: in het tweede hoofdstuk wordt een BRM-referentieproces gepresenteerd met zeven hoofdprocessen, namelijk 'elicitatie', 'ontwerp', 'acceptatie', 'uitrol', 'uitvoering', 'beheer' en 'evaluatie', tezamen met onderliggende subprocessen. In het derde hoofdstuk worden 11 *compliance* principes geïdentificeerd en beschreven. Voorbeelden hiervan zijn 'alle bedrijfsregels verwijzen naar een (legale) bron' en 'transparantie met betrekking tot besluitvorming voor klanten en gebruikers'. In het vierde hoofdstuk wordt een verificatieraamwerk gepresenteerd dat 28 soorten verificaties bevat die organisaties kunnen implementeren voor een correcte (geautomatiseerde) besluitvorming. Voorbeelden zijn 'circulariteitsverificatie' (controleren of een conclusie van een bedrijfsregel wordt gebruikt als een conditie in de onderliggende beslissing, terwijl tegelijkertijd de conclusie van de onderliggende bedrijfsregel wordt gebruikt als conditie in de bovenliggende bedrijfsregel), 'equivalentieverificatie' (controleren op bedrijfsregels die anders zijn uitgedrukt, maar dezelfde uitkomst hebben), en 'verificatie van conflictconclusies' (controleren of er conclusies bestaan die zijn vastgesteld met behulp van verschillende bedrijfsregels en feiten). Dit deel wordt afgesloten met het vijfde hoofdstuk, waarin 34 functionele thema's worden gepresenteerd voor BRMS, waarvan voorbeelden (in dit geval gerelateerd aan het 'eliciteren' van beslissingen en bedrijfslogica) zijn: 'bronnen kunnen importeren', 'bronnen kunnen annoteren', 'overzichten kunnen genereren' en 'impact-analyses uit kunnen voeren'.

Het tweede deel richt zich op het identificeren van uitdagingen, waarmee organisaties die BRM-oplossingen implementeren, geconfronteerd worden. De identificatie van uitdagingen is uitgevoerd voor de 'elicitatie'-, 'ontwerp'-, 'specificatie'-, 'verificatie'-, 'validatie'- en 'beheer'-capaciteit van BRM. In totaal zijn er 53 uitdagingen gevonden. In het zesde hoofdstuk worden 28 implementatie-uitdagingen geïdentificeerd specifiek met betrekking tot de 'elicitatie', 'ontwerp' en 'specificatie' BRM-capaciteiten. Voorbeelden hiervan zijn het 'gebrek aan of een lage kwaliteit van het beheer van een feitwoordenboek' en de 'ongewenste afhankelijkheid van externe partijen om wet- en regelgeving te vertalen in beslissingen en bedrijfslogica'. In het zevende hoofdstuk worden 17 implementatie-uitdagingen geïdentificeerd met betrekking tot de 'verificatie' en 'validatie' BRM-capaciteiten. Enkele voorbeelden hiervan zijn 'de wisselwerking tussen de mate van precisie, expressiviteit, natuurlijkheid en eenvoud van bedrijfsregels' en 'het ontbreken van (juiste) validatie met betrekking tot de bedrijfslogica die wordt gecommuniceerd met stakeholders' (bijvoorbeeld Nederlandse burgers). Ten slotte worden in het achtste hoofdstuk acht implementatie-uitdagingen geïdentificeerd met betrekking tot de 'beheer' BRM-capaciteit; voorbeelden zijn 'het gebrek aan kennis met betrekking tot bestaande beheerstandaarden' en 'de slechte metadatakwaliteit die adequaat beheer belemmert'.

Het derde deel richt zich op de organisatie van BRM-beheer en is onderverdeeld in twee studies. Het negende hoofdstuk presenteert een bedrijfscontrolesysteem met 14 prestatie-indicatoren die gebruikt kunnen worden om de implementatie van BRM-capaciteiten te evalueren. Voorbeelden van prestatie-indicatoren zijn 'de hoeveelheid bedrijfsregels die niet geautomatiseerd kunnen worden' en 'de tijd die nodig is om een bedrijfsregel te definiëren, te verifiëren en te valideren'. Vervolgens wordt in het tiende hoofdstuk een traceerbaarheidsraamwerk voor BRM voorgesteld, dat kan worden gebruikt om te volgen hoe wetsonderdelen in de organisatie worden geïmplementeerd en hoe geïmplementeerde wetsonderdelen kunnen worden herleid naar de bron. Dit raamwerk bestaat uit drie domeinen: het brondomein, het implementatieonafhankelijke domein (dat dient als het geldig vertrekpunt) en het implementatieafhankelijke domein (dat de geïmplementeerde wetsonderdelen in verschillende informatiesystemen bevat). Elk van de domeinen bestaat uit verschillende (gelaagde) elementen die de verschillende niveaus van abstractie vertegenwoordigen waarnaar een wetsonderdeel kan worden terugherleid. Een wetsonderdeel kan daarbij op vijf abstractieniveaus te herleiden zijn: op wetgevingsniveau, artikelniveau, alineaniveau, zinsniveau of woordniveau. Organisaties kunnen deze domeinen en de gelaagde elementen in de praktijk gebruiken, omdat ze de ontwerpkeuzes expliciet maken waarmee de traceerbaarheid kan worden geïmplementeerd.

De resultaten uit dit proefschrift voegen toe aan kennis voor wat betreft de organisatie en *governance* van BRM. Ze bestaan onder andere uit de identificatie en verdere verkenning van (sub-)processen, ontwerpprincipes, capaciteiten en uitdagingen voor BRM. Het proefschrift biedt nieuwe inzichten op het informatie*systeem*perspectief van BRM en andere onderzoekers kunnen onze resultaten gebruiken.

Op basis van de uitkomsten van de verschillende studies in dit proefschrift, kunnen organisaties strategieën definiëren voor BRM-organisatie en -beheer. BRM-capaciteiten kunnen worden ingericht, rekening houdend met de geïdentificeerde uitdagingen. Op het moment van schrijven zijn de resultaten al van invloed op diverse organisaties: sommige Nederlandse uitvoeringsinstanties gebruiken de resultaten voor het (her-)ontwerpen van hun BRM-capaciteiten. Ook resulteerde het proces van het expliciteren van de implementatie-uitdagingen erin dat bij het onderzoek betrokken organisaties actief middelen investeerden om geïdentificeerde uitdagingen op te lossen of te mitigeren. Toekomstig onderzoek moet gericht zijn op de effectiviteit van de resultaten in vergelijkbare of andere contexten.

16 CURRICULUM VITAE

Koen Smit was born on July 16^{th}, 1989 in Utrecht, the Netherlands. From 2009 to 2013, he studied Business Informatics at HU University of Applied Sciences Utrecht and graduated Cum laude. His Bachelor's thesis, entitled "Borgen van HKZ-normen bij kleine zorginstellingen" was awarded with the Business Process Management student award. He obtained his Master's degree in Business Informatics from Utrecht University in 2015.

In 2013 he joined HU University of Applied Sciences Utrecht where he currently holds the position of researcher and lecturer. Three years later he started his PhD research as an external researcher at the Open Universiteit.

Koen is a board member of the Dutch expert group on BRM for the Dutch government, which is a group of governmental experts that share knowledge and organize BRM conferences with the aim to increase collaboration and further advance the Dutch government in utilizing BRM. Furthermore, he actively (co-) chairs sessions in which BRM-related research is presented and discussed, i.e. at PACIS and eKNOW and has fulfilled the role of reviewer for journals and conferences such as ECIS, AMCIS, PACIS, ACIS, HICSS and eKNOW.