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Identifying Challenges in BRM Implementations Regarding the Verification and Validation Capabilities at Governmental Institutions

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Abstract

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.

Keywords: *Business Rules Management, Verification & Validation, Implementation Challenges, Government*

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; Morgan, 2002; 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, ter Hofstede, & Weske, 2003). However, business decisions and logic approaches tasks from a guideline/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 (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.

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*" (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, 2016). 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 (OMG, 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*" (OMG, 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 1, row 4:

Table 1. Implementation-dependent business rule (in a decision table format)

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

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.

Research method justification

The method of data collection and analysis, as well as the research method justification, have been previously described in (Smit & Zoet, 2016). 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).

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.

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.

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.

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.

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.*"

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 decision 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, 2016). 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.*

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.

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