Management Control System for Business Rules Management

Koen Smit
Digital Smart Services
HU University of Applied Sciences Utrecht
Utrecht, the Netherlands
koen.smit@hu.nl

Martijn Zoet
Optimizing Knowledge-Intensive Business Processes
Zuyd University of Applied Sciences
Sittard, the Netherlands
martijn.zoet@zuyd.nl

***Abstract* — 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 [33], 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.**

Keywords-Business Rules Management; Business Rules; Performance Measurement; Performance Indicator.

I. 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 [7][27]. A business rule is [23] "*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 [4]. 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, impact assessments can take significant time, which results in situations where the business rules already have changed again while the impact assessment is still ongoing [2]. 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 [7][32]. 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 [9]. 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) [13]. 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 [19][31]. 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.

II. 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 [9]. In our research we adhere to the popular definition provided by Amaratunga & Baldry [3]: "*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 [25]: "*The process by which the efficiency and effectiveness of an action can be quantified."* To visualize the relationship between both concepts, Kerklaan [19] 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 1.

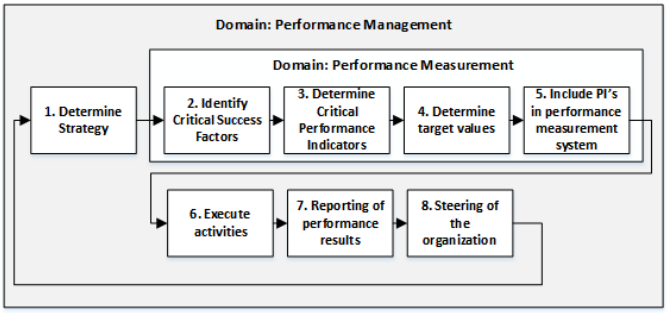

Figure 1. Performance Measurement within Performance Management

III. Performance Measurement Systems

Taking into account possible research avenues in the light of Performance Management and Performance Measurement, Ferreira and Otley [13] 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 [14]. Although a lot of performance systems exist, in general, they can be grouped into four base types [19]: 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 [19]: "*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 [18][26]. Comparative research executed by [25] 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.

IV. 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 [8], see Figure 2.

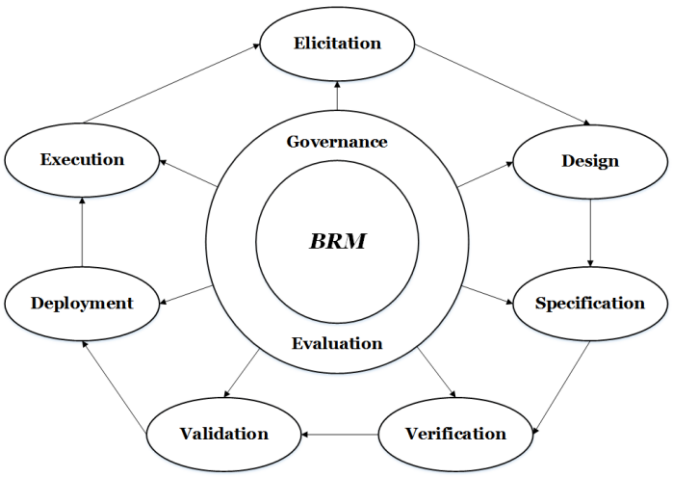

Figure 2. BRM capability overview.

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 [21]. 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 [22]. 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 [34]. 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 [35]. 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 [35]. 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 [34]. An implementation-dependent value proposition can be source code, handbooks or procedures [23]. 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 [23]. 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 [5].

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 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.

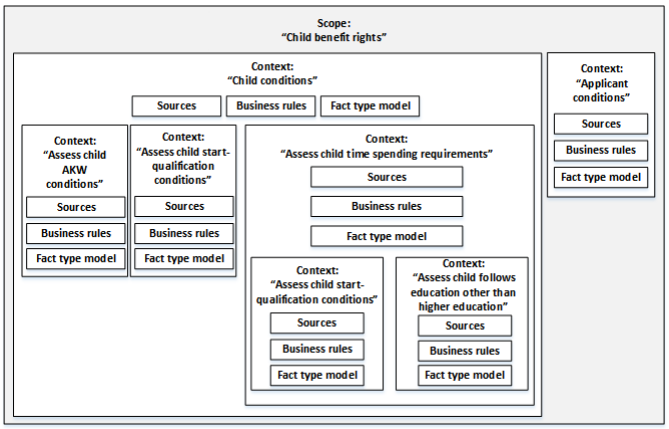

Figure 3. Overview of the relationship between a scope and multiple contexts

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 [16]. 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 [20][28][34]. 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 [17], the blue chamber [6]. 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 [10]. 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 [33]. 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 [18]: 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.

V. 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 [20][27][34]. Focus of research in nascent research fields should lie on identifying new constructs and establishing relationships between identified constructs [12]. 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 [11][24][29][30]. 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.

VI. 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 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.

A. 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 [33]. 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 [11] and Glaser [15] 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.

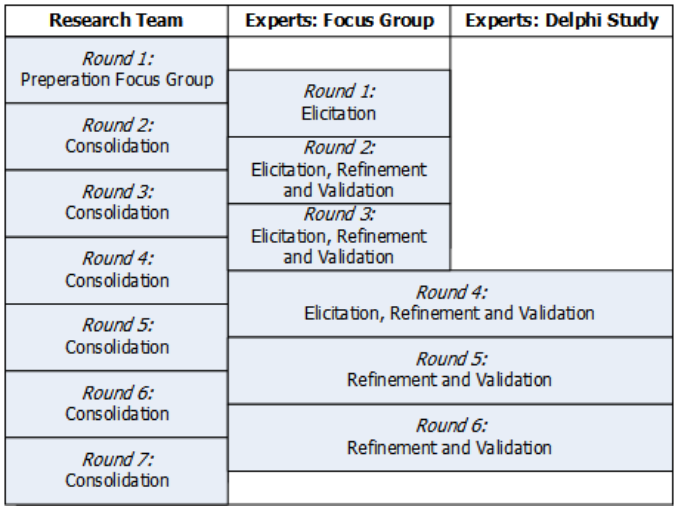

Figure 4. Data collection process design

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.

B. *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?"

VII. 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.

TABLE I. EXAMPLE OF PI RESULT: TIME MEASUREMENT TO DEFINE, VERIFY, AND VALIDATE A BUSINESS RULE.

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

A. 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 I, 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.

B. 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.

C. 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.

D. The 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.

E. 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 II.

TABLE II. PI'S for BRM

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.

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.

VIII. 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.

IX. 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.

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