Impact of Business Rule Management on Enterprise Architecture

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Abstract: Business Rule Management (BRM) is a means to make decision-making within organizations explicit and manageable. BRM functions within the context of an Enterprise Architecture (EA). The aim of EA is to enable the organization to achieve its strategic goals. Ideally, BRM and EA should be well aligned. This paper explores through study of case study documentation the BRM design choices that relate to EA and hence might influence the organizations ability to achieve a digital business strategy. We translate this exploration into five propositions relating BRM design choices to EA characteristics.

1 INTRODUCTION

Enterprises operate in dynamic contexts. Society is increasingly being digitized, disrupting businesses at an increasing rate. For enterprises, digital transformation is a prerequisite to being successful (Bharadwaj et al., 2013; Bowersox et al., 2005). Enterprises must make full use of emerging digital possibilities to understand their customers as well as to serve their customers (Catlin et al., 2014). By making use of all available data, both internal and external, enterprises can develop new services and improve existing services (Ross et al., 2016; van der Aalst, 2014; Chen et al., 2012; Erevelles et al., 2015). These services are increasingly tuned to the specific needs of the individual customer (Bonchek and France, 2015; Ross et al., 2016). Customers expect that all relevant information is incorporated, leading to services that are always spot-on. Only enterprises that develop a digital business strategy that possesses the ability to make full use of the available data and quickly respond to digital disruptions, can maintain their competitive advantage (Bharadwaj et al., 2013).

Execution of business processes and interacting with customers implies making decisions. Decisions are based on underlying business logic. Business logic originates from both external regulations and internal policies. An example from a government setting of such underlying business logic, is the business rule that applicants earning more than 150.000 euro on a yearly basis cannot receive any housing benefits. In dynamic contexts, to make full use of available data in service offerings, business logic must be flexible, transparent and consistent. This requires some form of Business Rule Management (BRM). BRM separates business logic from execution, thus making business rules explicit and, consequently, open to adaptation and inspection. BRM can be defined as the systematic and controlled approach, featuring a combination of methods, techniques and tools, to support the elicitation, design, specification, verification, validation, deployment, execution, governance and evaluation of business rules (Zoet, 2014).

Business rules represent one component in the organizational landscape. To ensure flexibility, transparency and consistency at enterprise level, many organizations employ Enterprise Architecture (EA). The aim of EA is to structure the enterprise in a way that fits its strategic objectives. EA can be defined as "the fundamental organization of a system embodied in its components, their relationships to each other and the environment, and the principles guiding its design and evolution" (ISO/IEC 42010:2007), where in the case of EA the system is an enterprise. From this definition we may conclude that BRM solutions, i.e. the implementations of business logic, are a part of EA and that the design choices underlying these solutions may impact EA and hence, the digital business strategy of the enterprise.

In this paper, we explore the alignment between BRM and EA. We investigate how BRM design choices relate to EA, especially with EA's

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contribution to realizing a digital business strategy in mind. The research question we want to answer is: "What is the relation between BRM design choices and EA's ability to support a digital business strategy?" The contribution of this paper is a set of propositions defining the impact of BRM design choices on EA. A good fit of BRM and EA is important for organizations to successfully deal with digital disruptions.

In section 2 the research method used is presented. Next, we explore the positioning of BRM in EA, in section 3. In section 4, we discuss the characteristics EA must possess to enable digital success, followed by an investigation of the relation between BRM design choices and these EA characteristics in section 5. Section 6 discusses the results. Section 7, finally, presents conclusions and limitations.

2 RESEARCH METHOD

To the best knowledge of the authors, the alignment between BRM and EA has not been studied extensively before. Following Edmondson & McManus (2007) we are dealing with nascent theory research, i.e. without extensive prior research results to build on. In accordance with this state our aim is to search for propositions relating BRM to EA as a first step towards a theory. This suggests a primarily qualitative research method. Studying the alignment between BRM and EA implies connecting two different fields of study. Both fields of study are relatively young. However, research on EA has grown over the past decades, whereas research on BRM is still rather immature, especially regarding non-technical, managerial type of research (Arnott and Pervan, 2014). Eisenhardt (1989) argues that case study research is an adequate approach to building theory by way of formulating propositions. Taking into account the different positions of BRM and EA theory, we chose to derive knowledge about BRM design choices from case study research and the relevant EA characteristics from the extant research literature, having it validated by experts.

The research presented in this paper is based on the results of several case studies that are executed by the co-authors in the past few years and address various topics related to BRM (Smit, 2018). From the documentation of these case studies, the first author harvested the relevant insights about BRM design choices that emerged in these studies. In parallel, insights were derived from extant literature how EA can contribute to the achievement of a digital business strategy. Next, we compared the insights from the case studies with those from the literature. This led to a set of four propositions describing the relation between BRM design choices and EA characteristics. These propositions represent a first step towards a theory of BRM impact on EA. The next step, which is outside the scope of this paper, will be to test the propositions using a survey or additional case studies.

The case studies from which the relevant BRM design choices are harvested, all originate from a mainly Dutch governmental context. Dutch governmental organizations are, at an increasing rate, being given the task to digitize products and services for civilians and organizations. To this end, many governmental organizations started to design and implement BRM. All case studies evaluated in this study applied a similar research method, collecting data through one or multiple series of focus groups and Delphi studies. Additionally, the organizations included in the case studies were visited and/or interviewed and secondary data on the implementation of BRM were collected. Based on the different types of data collected, grounded theory was applied for data analysis, see (Smit, 2018) for details. Additional results are taken from the study of eight years of historical data from a British governmental organization (Smit and Zoet, 2016).

3 POSITIONING BRM AS PART OF EA

EA concerns the fundamental organization of a system embodied in its components, their relationships to each other and the environment, and the principles guiding its design and evolution (ISO/IEC 42010:2007). In this case, the system is an entire enterprise, defined as any organization of people, processes and means that share a common goal (The Open Group, 2009). Thus, an enterprise can be a company or institution, but it can also be a network of cooperating parties. As the enterprise is the scope of EA, the components to be considered are diverse, varying from the products and services offered by the enterprise to the processes that deliver these products and services, the data and applications being used and the IT hardware.

Several architecture frameworks exist, which structure the components of EA and the relations between them (for instance Zachman, 1987; Lankhorst et al., 2005; van 't Wout et al., 2010). Most frameworks distinguish two dimensions: one dimension referring to the object of consideration, e.g. business processes, data, applications or

infrastructure, and the other dimension referring to different levels of perspective, e.g. contextual, conceptual or physical. A well-known example and one of the earliest frameworks is proposed by Zachman (1987). As with early information technology architectures, the original framework suggested by Zachman does not contain business rules as a primitive construct. The concept of business rules is not limited to one cell, it connects various cells. The Department of Defense Architecture Framework (DODAF) recognizes two different types of business rules (Department of Defense, 2010). Firstly, business rules are applied to constrain process flows and secondly business rules are applied to structure decisions. This distinction between viewing business rules narrowly in terms of their application in processes or broadly as structuring decisions in general, is found elsewhere as well. In the Reference Model for Open Distributed Processing (RM-ODP), business rules are applied to constrain process flows, while business rules in the Agile Service Development framework are applied to structure decisions (Lankhorst et al., 2012). We conclude that the concept of business rules is a broad construct that recent frameworks incorporate differently. Concerning the object of consideration, business rules can be related both to the process view and the data view. Concerning the level of perspective, the definition of business rules belongs to the conceptual level, while the implementation belongs to the physical level.

In this paper, in accordance with the underlying case studies, we adhere to the broader definition of business rules as structuring decisions. According to the ArchiMate 3.0 specification (The Open Group, 2016), 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”, where business logic can be defined as: “a collection of business rules, business decision tables, or executable analytic models to make individual business decisions” (Object Management Group, 2016).

With regard to the structural elements of a BRM solution, three domains can be distinguished. The source domain contains the sources for decision-making, such as regulations and policies. The implementation-independent domain contains the definition of business rules and fact types in conceptual terms. The implementation-dependent domain contains the realization of the business rules and fact types in actual systems, such as work instructions or automated systems. The way the interconnection between these domains is designed has an impact on how easily business rules can be adapted to changing circumstances. Decisions are structured into contexts. A context is a coherent and contained collection of knowledge required to determine (part of) a decision. For instance, the decision about granting child benefit rights consists of checking child conditions on the one hand and applicant conditions on the other hand. Within a context a distinction is made between business rules and fact type models. A business rule expresses what is or is not allowed within the enterprise. A fact type model expresses the factual business knowledge of the enterprise, connecting core business concepts in a way that reflects the real world. The way business rules and fact types are structured may impact the ease with which decisions made can be explained and justified as well as the ease with which the underlying knowledge can be adapted.

As part of EA, BRM solutions are part of the EA models and subject to the EA principles. Based upon the definition of EA, the match between EA and its components can be considered from two perspectives: 1) the connection of the BRM solution to the rest of the enterprise and to its environment and 2) the extent to which the principles guiding the design and evolution of the BRM solution are consistent with the principles guiding the enterprise, i.e. the EA principles. Our assumption is that the extent to which the design choices that govern the implementation of a BRM solution and the EA principles are consistent with each other determines the overall quality of business rule application within the enterprise, in terms of contributing to the digital business strategy. To determine the alignment between BRM and EA, we must investigate the design of the BRM solution and relate this to the characteristics of EA that contribute to the digital business strategy.

4 EA AND DIGITAL BUSINESS STRATEGY

Realizing a digital business strategy implies certain characteristics. We identified five themes that emerged from the literature on digitalization as being important to a successful digital business strategy: adaptiveness, participation in an ecosystem, transparency, openness and allowing for multiple dynamics. We validated these themes in a focus group of 4 enterprise architecture professionals with many years of experience. They recognized the five characteristics as being very relevant. However, they

proposed that openness is part of transparency. In answer to the question whether they missed an important characteristic, they added the characteristic of customer centricity. This led to the following five characteristics being identified as important to enterprises in achieving their digital business strategy and reflected in EA.

- Adaptiveness: todays enterprises must be flexible in their offerings to survive (Keen & Williams, 2013). Keen and Williams argue that EA must cater for ever-continuing shifts in value. Value that is determined by the customer, not by the enterprise, and therefore less predictable. EA must be designed for optimal capture of digital opportunities. The increasing adoption of agile approaches by organizations is indicative of the need for adaptiveness. EA must enable unanticipated changes in the organization's environment. Fine (2000) argues that flexibility is about smartly alternating the adaption of product development, process development and supply chain development (3-dimensional concurrent engineering). This requires modularity between the dimensions. EA must ensure that the required flexibility is built-in in the organization.
- Ecosystem Participation: the flexibility required of enterprises can only be realized in cooperation with other parties (Pagani, 2013). Most organizations cannot deliver in time all capabilities needed to keep up the required fast pace of innovation. This implies that the capability of participating successfully in an ecosystem is a key capability of the organization. Enterprise boundaries are losing their fixedness and are becoming fluent (Keen & Williams, 2013). Also, enterprises come and go in increasing rate. Analysis over the past shows that the lifespan of enterprises is reducing rapidly (Anthony, Viguerie and Waldeck, 2016). Because of these developments, EA must enable fast in-, out- and co-sourcing. As organizational boundaries are becoming increasingly less fixed and important, building an architecture on current existing boundaries is not wise. Instead, the enterprise architecture should be organization-agnostic, effectively fulfilling the strategic goals of the organization independent of actual organizational boundaries. This approach will allow for flexible sourcing in fast changing ecosystems. Designs should cater for the possibility that any business capability could be executed by any party. This means that capabilities should be well-defined and independent of other capabilities. In this way EA can enable successful participation in the enterprise's ecosystem. Cooperation with other parties, as well as engaging more with customers requires a certain amount of openness of the organization. (Pagani, 2013). At a structural level, this requires interoperability (Guédria et al., 2013).
- Transparency: society increasingly demands transparency from organizations. New European regulation demands transparency from enterprises in the use of customer's data, putting high fines on non-compliance (GDPR, 2017). Transparency concerns both the way organizations handle the data they acquire when interacting with customers and delivering services and how they arrive at the decisions they make, for instance regarding applications for loans, admission to education or housing. EA must ensure the traceability required to be transparent.
- Multidynamic: many enterprises experience hybrid situations, with the need to simultaneously manage robust core transaction systems and experiment with new technologies. As a consequence, different rhythms of development and operations may occur within the same organization, requiring different EA principles (Ross et al., 2016; Da Rold et al., 2014; Messaglio & Hotle, 2012). Ross et al. (2016) argue that enterprises must distinguish between their operational backbone and their digital services backbone. The operational backbone provides the capabilities for operational excellence. It constitutes the set of business and technology capabilities that ensure the efficiency, scalability, reliability, quality, and predictability of core operations. The digital services backbone facilitates rapid innovation and responsiveness to new market opportunities. It is the set of business and technology capabilities that enable rapid development and implementation of digital innovations. Ross et al. (2016) argue that while the technological differences between the two backbones are likely to diminish with time, the need for their differing organizational characteristics will likely remain.
- Customer-centric. Customer centricity is about truly putting the customer first, thinking outside-in, instead of inside-out. The rise of data-driven services offers consumers a lot of choice. Customers will no longer be loyal to enterprises that do not cater to their needs. In the past, as far as IT was concerned, enterprise architecture tended to focus on internal efficiency, whereas nowadays customer experience seems to be a main driver. Enterprises are more and more putting the customer in the centre (Keen & Williams, 2013). Large organizations are introducing the new role of customer journey manager or customer journey

expert. Processes become increasingly centered around the customer, instead of around a product or service. Offerings and interactions are increasingly tuned to the specific needs of the individual customer (Bonchek & France, 2015; Ross et al., 2016). Increasingly, customers are actively involved in service creation (co-creation): with the customer instead of for the customer.

The way BRM is implemented in the organization ideally should be aligned with the way EA deals with the above trends.

5 BRM DESIGN CHOICES IMPACTING EA CHARACTERISTICS

As a first step in determining how BRM design choices might impact EA, the first author analysed eight case study publications by the co-authors, from the years 2014 (two publications), 2015 (one publication) and 2016 (five publications). The publications were annotated for concepts that pertain to EA, i.e. concepts related to structure in terms of components and relations between components. From these case study analyses, several underlying design choices for BRM emerged. These can be categorized into design choices regarding the basic structural model of a BRM solution and design choices pertaining to traceability between BRM solution components. In addition, one of the publications reported on a set of 22 BRM design principles resulting from the case studies. As such design principles are meant to guide actual BRM design, it is relevant to investigate how each of them relates to EA.

- Structural Model. The structural model of BRM solutions concerns the way a BRM solution is structured into components and the way it interacts with other components. For instance, a BRM solution that isolates and explicates business rules in a manner that is understandable by persons, instead of hard-coding rules in software, can greatly contribute to transparency as decisions made by the organization are potentially easier to explain. Also, this provides more intuitive access to business rules, which has a positive impact on adaptiveness. The extent to which the structural model clearly separates the business rule inferencing method, business rule repository and business rule authoring service greatly influences adaptiveness. A clear distinction between the implementation-independent business rule formulation and the implementation-dependent formalization, increases the options for exploiting business rules. Thus, business rules can be valorised as knowledge, as a service, as a software system or embedded within a product. This separation between ‘know and flow’ (Zoet, 2014) enables new application of business rules, such as in smart contracts within blockchain implementations.
  Three main business rule architectures (BRA) can be distinguished: rule family-oriented architecture, fact-oriented architecture and decision-oriented architecture (Smit & Zoet, 2016b).
- Traceability. In Smit, Zoet & Berkhout (2016a) a traceability framework is presented. The framework is directed at traceability of legal requirements in a governmental environment. The framework distinguishes three domains in which elements are managed and traces implemented. The source domain comprises the laws and regulations as defined by the legal authorities. The implementation-independent artifact domain comprises artifacts that are free from technology-specific aspects. The implementation-dependent artifact domain contains technology- or vendor-specific elements. Traces between these domains can occur on various levels. Traces between the implementation-independent artifact domain and the implementation-dependent artifact domain can occur between business rules and software systems, services, components, classes or lines of code. The design decisions made concerning traceability determine the detail in which organizations can explain their IT-supported decision-making. This has a direct impact on the transparency of EA.
- Guiding Design Principles. In a combined focus group and Delphi study, 22 principles governing sound BR design were identified (Zoet & Smit, 2016). In table 1, these 22 principles are related to the digital business strategy trends EA should support, discussed in the previous section. Each cross indicates an impact of a guiding design principle on a digital business strategy trend.

The allocation of relationships in Table 1 was established using the expertise of the four authors of this paper. Two authors can be considered experts in the field of EA and have extensive experience (20+ years) in the practical application of EA. Besides, one of the EA experts is a PhD student and the other holds an EA-related PhD and holds a professorship partly related to EA. The other two authors can be considered experts in the field of BRM and have extensive experience (7+ years) in both the academic as well as the practical application of BRM. Both

researched their PhD projects in relation to BRM and one expert holds a professorship related to BRM. All four experts individually coded the relationships between EA characteristics and the identified BRM principles, thus exploring the impact of BRM on EA. Each expert was provided upfront with the definitions of the EA characteristics as well as the descriptions of the BRM guiding principles. This ensured that every expert had a similar, if not the same, frame of reference when allocating the relationships. After the coding was completed, two experts, one from the EA and one from the BRM side, discussed the results of the individual coding. In this process, the experts evaluated the amount of votes a relationship had (binary, there either was a relationship or not), and the arguments for a given relationship.

Table 1: Allocation of impact of BRM principles on EA characteristics.

		Adaptiveness	Ecosystem	Transparency	Multi-dynamic	Customer-centric
1	Automated decisions			X	X	
2	IT formulates not BR			X		X
3	No big bang approach	X				
4	Authorization		X	X		X
5	Ownership of decision		X	X		
6	Traceable decisions	X	X	X		X
7	Two-time dimensions data					X
8	Source referral	X	X	X		
9	P.E.N.S criteria determined				X	
10	Reuse before buy	X				
11	Best-of-suite approach		X			
12	Gaming	X		X		X
13	Sharing knowledge		X	X		
14	Context structure	X	X			
15	Create once use multiple	X	X			
16	Communication standards	X	X			
17	Flexible decisions	X		X		X
18	Government standards		X			
19	Separation know and flow	X				
20	Management perspective	X				
21	Transparency			X		X
22	Compliancy by design			X		

From Table 1 we can conclude that the guiding principles governing business rule design as identified in the case studies primarily affect the adaptiveness and the transparency of EA, as well as the contribution of EA to participation in the ecosystem. The other trends are only primarily impacted by one or two design principles.

6 DISCUSSION

Analysis of the way in which BRM solutions are designed shows several EA-relevant design choices. From the structural model perspective, we saw that the way implementation-independent business rule formulation and implementation-dependent formalization are distinguished influences both adaptiveness and transparency. Adaptiveness, not only in the ease with which business rules can be adapted or implementation can be updated, but also in the ease with which enterprises can create new value from their business rule knowledge and implementation, possibly creating new positions in the ecosystem they participate in. In addition, the choices made in the way business rules and fact types are structured (rule family-oriented, fact-oriented or decision-oriented architecture) directly influence adaptiveness. Transparency is, besides the separation of implementation-independent and implementation-dependent domains, also greatly influenced by the granularity of the traceability in the BRM components, from source to implementation-independent to implementation-dependent. Finally, it appears that adaptiveness and transparency are also impacted by half of the design principles that govern BRM implementation. In addition, participation in an ecosystem is also supported by almost half of the design principles.

From the above we can derive five propositions. The first proposition expresses the nature of the impact of BRM design choices on EA:

- Proposition 1. BRM primarily impacts adaptiveness and transparency, and to a slightly lesser extent, participation in an ecosystem.

The other four propositions refine this relation, further detailing the relation between specific BRM design choices and EA:

- Proposition 2. The choice of business rule architecture directly impacts the adaptiveness of EA.
- Proposition 3. The level of detail designed into the traceability of BRM directly impacts the transparency of EA.

- Proposition 4. The distinction between implementation-dependent and implementation-independent business rules directly impacts both the adaptiveness and the transparency of EA.
- Proposition 5. The design principles defined by BRM experts primarily impact adaptiveness, transparency and participation in an ecosystem.

The design of BRM solutions has direct impact on the ability of EA to contribute to a digital business strategy. We have seen how various characteristics of BRM choices influence various characteristics of EA. However, we should bear in mind, that in context, the relation between BRM design choices and EA characteristics may be influenced by other factors and that the interplay between many factors determines the nature of EA. Thus, BRM can increase transparency by making decision-making understandable and traceable. If, however, business rules are used by a machine learning component, traceability might to a certain extent be lost again. And whereas the rule family-oriented architecture scores best on modifiability, thus contributing to the adaptiveness of EA, it remains to be seen whether it also scores best on transparency.

Reasoning the other way around, to make the most of BRM, EA must also possess an adequate level of quality. For instance, a high maturity level of data management within the organization enables better integration of BRM solutions in the entire EA, offering better opportunities for automation and service innovation. Also, an EA based on the concept of services will be better positioned to make the most of a well-designed BRM solution. If this is the case, a well-designed BRM solution allows various business models, not only using business rules for offering products and services, but offering the business rule knowledge itself, either to be implemented by another party or as a service in its own right. As a final example, the level of traceability implemented in the BRM solution must be sustained in EA. It is not sufficient to be able to explain what business rules are defined and how they relate to regulation if the organization cannot explain the validity of the input to the rules or the legality of the use of the outcomes.

7 CONCLUSIONS

In a digitized society, organizations face new challenges and new opportunities. BRM can play an important role in dealing with the challenges as well as in seizing the opportunities. Challenges such as increased demand for transparency and the need for flexible sourcing as well as opportunities such as new service offerings and more personalized services are addressed by careful BRM design. To fully exploit the possibilities of business rules, they must be smoothly fitted in the overall EA.

Based on case study research we developed a number of propositions concerning the relation between BRM design and EA. It appears that BRM primarily impacts adaptiveness and transparency, and to a slightly lesser extent participation in an ecosystem. To validate our propositions, future research is needed into operationalizing EA adaptiveness and EA transparency. In addition, we propose future research into the trade-off between various BRM characteristics.

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