Factors Affecting Business Process and Business Rule Integration

Research-in-Progress Paper

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Abstract

Information systems architectures are becoming increasingly complex and fragmented. As a result, organizations struggle to cope with change propagation, compliance management and interoperability, to name a few. Two major components in current information system architectures are business process models and business rules. In practice, redundancy and inconsistency in business rule and business process models exists, highlighting the need for integrated modelling of business processes and business rules. An important pre-requisite of achieving integrated modelling is the ability to decide whether a rule should be embedded into a business process model or modelled independently in a rule repository. In current literature, little guidance can be found that can help modellers make such a decision. We identify this gap as a shortcoming that contributes to fragmented information system architectures and argue that to understand such a decision process, one needs to first identify the factors that can affect the decision. Accordingly, in this paper, we embark on a systematic review of process modelling and business rule modelling literature to identify such factors. Our work uncovered twelve factors and is a stepping-stone to developing a decision framework for business process model and business rule integration, and towards improved information system architectures.

Keywords

Business Process Management, Business Rule Management, Integrated Modelling

INTRODUCTION

The modelling of business processes and business rules has been the focus of Information Systems and Computer Science research over the last two decades (zur Muehlen *et al*. 2008). In more recent years, several researchers have motivated integrated modelling of business processes and business rules. Such integration is posited to result in improved information systems architectures through increased interoperability capacity, better change propagation of new requirements and better compliance management (see, for example, Di Bona *et al*. 2011; Mickeviciute and Butleris 2013; Nalepa *et al*. 2013; De Nicola *et al*. 2012; Xiao and Su 2012, among others). Previous research has made several contributions towards this end through analysing the representational capacity, deficiency and overlap of process and rule modelling languages (zur Muehlen and Indulska 2010), with a view towards their integrated use. Several initial approaches for the integration of business process models and business rules have also been proposed (Kovacic 2004; Rosemann *et al*. 2006; Sun *et al*. 2011).

Generally, all organizations will have some form of business process and business rule documentation. Some organizations may have more maturity in terms of formalized process models and/or rule repositories. Some of these organizations may further have execution frameworks to support the models for example business process management systems (BPMS) or rule engines. We argue, along the lines of zur Muehlen *et al*. (2008), that there are situations under which a business rule is better modelled independently in a business rule repository and then

linked to the process model, and when it is better embedded in a business process model. There are many, often severe, implications of incorrect decisions regarding separation or integration of business rules within the organization's process modelling landscape. For example, if a frequently changing business rule is integrated into an business process model, more time and effort is needed for its implementation and maintenance (zur Muehlen *et al*. 2008). On the other hand, actions and decisions based on a business process model that does not present all related business rules can lead to serious compliance breaches.

It follows, then, that an important aspect of integrated modelling is the understanding of such situations, or factors, and how they influence business rule representation. While the decision in regards to how a rule should be modelled is not a straightforward one (zur Muehlen et al. 2008), little guidance exists that can help modellers make such a decision. We identify this gap in the body of knowledge as a shortcoming that hampers the development of good quality integrated business process and rule models, and we see a need for the development of a decision framework to support such modelling decisions. The identification and understanding of all factors that can affect the representation of a rule is thus a foundation for such a framework. Accordingly, as a first step towards addressing this gap in the body of knowledge, we embark on a systematic review of process modelling and business rule modelling literature to identify all relevant factors, with a view to empirical validation.

In what follows, we present our review of related literature, through which we identified twelve factors that can influence such a modelling decision, *viz.* accessibility, aspect of change, awareness of impact, criticality, expressiveness, flexibility, governance responsibility, implementation responsibility, rate of change, reusability, rule source and scope of impact. These factors are indicated in literature, either directly or indirectly, to influence whether a business rule should or should not be embedded in a business process model. The identification of these factors is the first attempt to provide a consolidated understanding of situations that may affect business rule integration in process models. We see it as the necessary first step towards a comprehensive decision framework for integrated business process and rule modelling, which would provide much needed guidance to modellers.

The remainder of this paper is structured as follows. In the next section we present an overview of business process and business rule modelling, as well as existing efforts to identify factors that influence integration, or, indeed, integration efforts in the context of modelling. We then explain the methodology used in this study, followed by a summary and explanation of the identified factors. We conclude the paper with a discussion of limitations and next steps.

BACKGROUND CONCEPTS AND RELATED WORK

A business process is "a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer" (Hammer and Champy 1993). The related activities are structured to accomplish a specific goal that will create value for the organization. Such structures also involve business rules, which describe the constraints and requirements guiding and controlling the behaviour of business activities. Laws, regulations, policies and best practices are typical sources of business rules (Kovacic 2004).

Business process modeling, thus, is a process of extracting, organizing and representing business activities to guide the analysis, implementation and evolvement of business processes (Harmon and Wolf 2011). Business process modelling languages can be classified into two categories, namely procedural languages and rule based languages. A business process, accordingly, can be represented as a process model, or as a set of business rules, or a combination of both in separate representations.

In a procedural process modelling language, processes are modelled graphically, with activities represented as nodes or boxes, which are connected by control flow arcs or arrows (Lu and Sadiq 2007). The Business Process Modelling Notation[1] (BPMN) is one example of such a procedural modelling language and is now a procedural process modelling standard (Recker *et al*. 2006). Common constructs in BPMN include events, activities, decision gateways, connectors and swimlanes, with these then arranged into graphical models through the act of process modelling.

Business rule modelling is the process of extracting constraints and requirements from laws, policies and other sources, and representing these requirements using formal languages. Business rule modelling can make the constraints and requirements accessible and manageable by business users, as well as machine-readable, thus helping to guide system implementation and achieve automated compliance checking and monitoring. A rule-based modelling language is based on formal logic. In a rule-based language, process logic is expressed by a set of rules. Each rule is associated with one or more business activity, specifying properties of the activity, such as

1 Business Process Model and Notation (BPMN) is a graphical representation for modelling business processes.

the pre- and post-conditions (Lu and Sadiq 2007). One example of such a language is Semantics of Business Vocabulary and Business Rules[2] (SBVR). In SBVR, a rule generally consists of terms, facts, modal operators and quantifiers, without a visual representation.

Business process modelling and business rule modelling both focus on the capture of organizational practice. They are complementary approaches as they address distinct aspects of organizational practices. However, the two approaches evolved separately in the last several decades and failed to integrate into a more powerful approach. Each type of representation has its strengths and weaknesses. Table 1 summarizes the strengths and limitations of the two modelling methods based on (Lu and Sadiq 2007). We summarize the capacity of the two types of languages, relative to each other, and classify that relative comparison (Low, Fair, High, etc.) for each criterion with a short explanation. In brief, rule-based languages offer better expressibility, flexibility and dynamism. However, their most significant shortcomings are their complexity and lack of visual representation, which requires higher modelling expertise and results in lower understandability. To the contrary, procedural notations have limited flexibility and dynamism support, but the (relative) simplicity and understandability of most of the notations, thanks to their abstract syntax and visualization, has resulted in strong organisational uptake.

Table 1. Comparison of procedural and rule-based languages

Criteria	**Procedural Language**	**Rule-based Language**
Expressibility	Fair. Able to express structure, data, and execution requirements.	High. Rule expressions can represent more workflow patterns than procedure based languages.
Flexibility	Low. Processes can only be executed on complete process models, in which all possible execution scenarios are explicitly specified.	High. More flexible as incomplete specification for task dependency is supported.
Dynamism	Delayed. Supported for real time model change is limited.	Runtime. Rule expressions can be revised at runtime to realize ad hoc changes to process logic.
Complexity	Simple. Modelling languages have more abstract syntax and simpler semantics, thus less complexity in model representation and verification.	Complex. Model languages have a logical syntax and require expertise when modelling.
Understandability	High. Easy to understand due to the visual elements.	Low. Model languages have no visual appeal.

To further highlight the differences, we use a simplified car sales process to demonstrate the two types of languages. We show the example process using BPMN (see Figure 1) and SBVR.

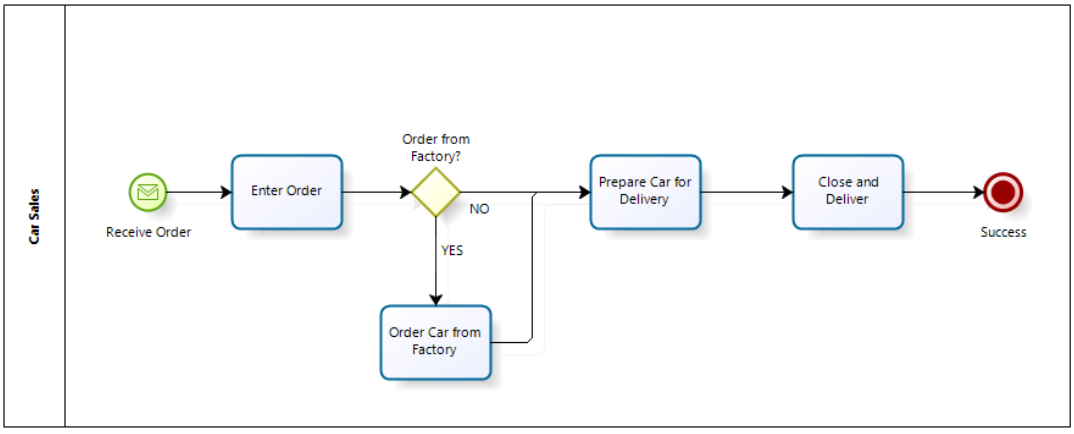

Figure 1: A simplified car sales process modelled in BPMN.

The process represented in Figure 1 can be also represented as a set of business rules. The following is the same business process logic represented using SBVR:

1. It is obligatory that Sales performs task Enter Order after Receive Order.

2 Semantics of Business Vocabulary and Business Rules (SBVR) is a standard of the Object Management Group (OMG) as a formal business rule language.

2. It is obligatory that after Enter Order, execute Order from Factory.
3. It is obligatory that if Order from Factory? EQUALS YES, execute task Order Car from Factory.
4. It is obligatory that if Order from Factory? EQUALS NO, execute task Deliver Car.
5. It is obligatory that after Order Car from Factory, execute task Deliver Car.

While a process may be modelled through both approaches, we argue, along the lines of zur Muehlen *et al*. (2008), that not all types of business rules are suitable for integration into graphical business process models. Thus, the decision of how and where to model a business rule becomes an important issue. The wrong decision will increase the cost of system maintenance, reduce business process flexibility, and jeopardize compliance. For example, if a business rule that governs a task that exists in several business process models is integrated into all relevant models, multiple instances of that rule need to be updated if it changes, increasing the risk of inconsistency as well as the amount of re-work involved. To the contrary, modelling such a business rule independently in a rule repository, and linking it to relevant models, will make the rule easier to manage since there is only one business rule instance.

There is a scarcity of research that examines or consolidates factors that are relevant for business process model and business rule integration. zur Muehlen *et al*. (2008) were the first to argue the need for a decision framework to guide such integration. They identified five factors expected to influence the representation of a business rule *viz.* change frequency, implementation responsibility, understanding of implications, source of change, and scope. Earlier, Cetin *et al*. (2006) identified complexity, criticality, frequency of change, type of access and implementation responsibility as five business rule attributes.

Several works have proposed integrated modelling methods. Sadiq *et al*. (2007) developed an integrated modelling approach for business process and compliance rules (internal controls). Milanović *et al*. (2009) extended BPMN into rBPMN with the addition of a rule representation in a set of rule gateways. Sapkota and van Sinderen (2010) embedded rules into decision points in BPMN processes models. Cheng *et al*. (2011) proposed a transformation method from SBVR to BPMN thus to automate the transformation from rule-based languages to procedural languages, which is a prerequisite for integrating business rules into business process models.

METHODOLOGY

Our overarching research methodology is that of Design Science, which is useful when creating and evaluating IT artifacts intended to solve identified problems in practice (Peffers *et al*. 2007). The artefacts of design science can be constructs, models, methods and instantiations (Hevner *et al*. 2004). In our work, we are, ultimately, interested in developing a decision framework, and the integration factors are constructs which will form a part of this artefact.

Table 2. Data Set of 1990-2013 publications

Type	**Acronym**	**# papers**	**# relevant papers**
Conferences	ACIS, AMCIS, CAiSE, ECIS, ER, HICSS, ICIQ, ICIS, IFIP, IRMA, IS Foundations, PACIS, BPM, WIDM, WISE, CIKM, SIGIR, VLDB	27,326	29
Journals	BPMJ, CAIS, EJIS, I&M, ISF, ISJ (Black-well), ISJ (Sarasota), JAIS, ISR, MISQ, MISQ Executive, TKDE, DKE, CACM, DSS, TOIS	15,695	49

To identify all factors mentioned in literature, we conducted a systematic literature review based on a comprehensive set of journals and conferences. To ensure a broad coverage of the research topic, we selected well-regarded Information Systems and Computer Science academic publications (see www.aisnet.org and www.core.edu.au) published between 1990-2013[3], a period of time after the initial proposal of integration of the two approaches (Krogstie *et al*. 1991). Our dataset, summarised in Table 2, consisted of 43,021 articles. Each article was inspected and prepared (with OCR) for a full text search. Subsequently, a full text search was conducted using the term "business rule". A stemming search was used to ensure variants of the keyword as also identified. We regarded a paper as relevant if the keyword "business rule" occurred 3 times or more within the body of the text and only selected those papers for the next round of analysis that met this criterion. Based on this elimination process, 255 relevant papers were identified. Each of the 255 papers was read and analysed for

3 Collection years vary depending on the span of the conference and journal.

relevance. A paper was identified as relevant if a characteristic of business rule like change frequency, reusability or impact is discussed or mentioned. This step resulted in 78 papers.

The set of 78 relevant papers then underwent coding with a dedicated coding protocol. Our coding protocol, implemented via an Excel spreadsheet, consisted of the article title, characteristics of business rules mentioned in the article, which could be, or point to, potential factors, the explanation and context of a characters from each article, and any related comments from the researcher. The final coding protocol was designed and agreed by the three researchers after an initial coding of several articles to help refine the protocol.

Each identified factor was coded as a row, with source title and context as well as comments coded in corresponding columns (see example in Table 3). One researcher carried out the initial coding exercise and then refined the result with the two researchers. The refinement included: 1) Selecting business rule characteristics which have the potential to be factors and excluding unrelated characteristics; 2) Identifying and clustering synonymous factors; 3) Selecting a representative label for each factor and clarifying its definition. The result was refined over three iterations until all three researchers were satisfied with the selection and definition of each factor.

Table 3. Example of Coding Snippet

Factor	**Source Title**	**Context**	**Comment**
Checking Responsibility	From the Stone Age to the Cloud: A Case Study of Risk-Focused Process Improvement	The problem of rule checking by embedded programs is that (1) rules handled by programs are limited to simple ones; comprehension of complex rules are left for humans.	Renamed as Governance Responsibility as a result of refinement.

INTEGRATION FACTORS

In the following we present a discussion of the twelve factors identified through the literature review and, thus, present the first consolidated view of factors thought to be relevant to the business rule and business process model integration discussion. Table 4 presents a high level summary of the twelve factors, their synonyms, together with total number of sources in which the factor was mentioned, followed by some example sources[4]. Each factor is explained in following subsections.

Table 4. Integrations Factors

Factor	**Synonyms**	**# of Refs**	**Example Sources**
Accessibility	Openness	5	(Kim and Jain 2005; Van Roosmalen and Hoppenbrouwers 2008)
Aspect of Change	None	3	(Loucopoulos and Kadir 2008; Nelson *et al.* 2010)
Awareness of Impact	Comprehension	5	(zur Muehlen *et al.* 2008; Taveter and Wagner 2001)
Criticality	Importance, Cost of Violation	8	(Otto *et al.* 2010; Zoet *et al.* 2011)
Expressiveness	Representation-Complexity	11	(Kontopoulos *et al.* 2008; Lu and Sadiq 2007)
Flexibility	Agility, Swift Reaction	15	(Weigand *et al.* 2008; Witman 2009)
Governance Responsibility	Checking responsibility	5	(Ho and zur Muehlen 2009; Iwaihara *et al.* 2004)
Implementation Responsibility	Deployment responsibility	2	(Bajec and Krisper 2005; zur Muehlen *et al.* 2008)
Rate of Change	Evolvement, Modification	23	(Moreira *et al.* 2003, 2006; Neely *et al.* 2006)
Reusability	None	12	(Kontopoulos *et al.* 2008; Loucopoulos and Kadir 2008)
Rule Source	Origin	3	(McCarthy *et al.* 2002; zur Muehlen *et al.* 2008)
Scope of Impact	None	4	(Kovacic and Groznik 2004; zur Muehlen *et al.* 2008)

4 Due to page limitations, we are unable to list all identified sources here. table with all relevant references is available from authors on request.

Accessibility

Accessibility refers to the user's ability to view and manipulate a business rule. Making business rule repositories accessible to stakeholders whenever they need it, as well as in a format that is suitable to their needs, is a basic requirement of information systems (Kim and Jain 2005). Defining the owner information of a business rule model is important in determining the access rights and responsibility for a business rules repository (Loucopoulos and Kadir 2008). Separating the rules can make them easily accessible to business users, and potentially reduce the complexity and waiting times in making changes required in response to specific external or internal changes in requirements (Van Roosmalen and Hoppenbrouwers 2008).

Aspect of Change

Aspect of Change refers to the component of the rule that can be changed. In addition to the rate of change, the component to be changed has implications on the complexity of the implementation. The components of a rule that could change are the trigger condition, the reaction, or the values of parameters (Nelson *et al*. 2010), as well as rule phrases and design elements (Loucopoulos and Kadir 2008). While a graphical process model may expose some simple configuration to business users, i.e. setting a new value for a parameter, more complex business rule changes may only be possible at a deeper level, thus pointing towards a business rule language representation.

Awareness of Impact

Awareness of Impact refers to how comprehensively the implications of a business rule, or its revisions, are understood. Business users may have to bring to bear their additional external knowledge to understand the implications of a business rule (Taveter and Wagner 2001). If the impacts of a business rule are not comprehensively understood, e.g. a change in one department's business practices is necessitated by a change in another department and the effects cannot be safely predicted, thus the deployment and implementation of the rule may need justification or re-engineering in the future (zur Muehlen *et al*. 2008). The advantage of rule models is "easier and faster implementation in case adjustments needs to be made" (zur Muehlen *et al*. 2008).

Criticality

Criticality refers to the importance of the rule. It can often be indicated by the cost of violating the rule (Otto *et al*. 2010). A violation can lead to failed transactions, which may have a limited impact or may result in large, publicized scandals (Sadiq *et al*. 2007). Embedding a business rule into a business process model can ensure that the business rule is implemented enterprise-wide and this is unavoidable. A standalone business rule, on the other hand, has a risk of being overlooked when users perform manual tasks relying on process models as guidelines for operations.

Expressiveness

Expressiveness is the extent to which the rule can be precisely modelled. The clarity and simplicity of business rules may differ based on chosen representation (Lu and Sadiq 2007). Certain kinds of business rules cannot be clearly expressed in a business process modelling language due to language representation limitations. Furthermore, some business rules may be easier to understand when modelled in the context of a graphical business process model due to the visual nature of process models, while other business rules may be easier to understand when modelled standalone due to the more precise rule representation capability of rule modelling languages (Kontopoulos *et al*. 2008).

Flexibility

Flexibility refers to the effort and time required for the business process to change when a rule changes. Some business rules are required to take effect immediately to ensure the agility of the system (Van Roosmalen and Hoppenbrouwers 2008). Similarly there can be others that may not have strict constraints on time of initiation. (Cappelli *et al*. 2010; Weigand *et al*. 2008; Witman 2009), or may require a certain delay before the rule becomes effective (e.g. planned tax changes in the beginning of the financial year).

Governance Responsibility

Governance Responsibility refers to who ensures that related business activities are in compliance with business rules. Some rules can be checked automatically for assurance, while others require manual audits (Ho and zur Muehlen 2009; Iwaihara *et al*. 2004). If the business rule is to be checked automatically in the system, machine readability and execution will be a basic requirement, while context availability and user-friendly representation

will be more important if the rule is to be checked by human. Further, business rules modelled in rule repositories can be executed automatically while business rule modelled in business process models can provide more contextual information to guide the manual check.

Implementation Responsibility

Implementation Responsibility refers to who is charged with implementing the business rule. Who implements a rule may affect how the rule is modelled. Business users or technical staff could be responsible for the implementation, thus affecting the choice of modelling approach (Bajec and Krisper 2005; zur Muehlen *et al*. 2008). Business users generally have the configuration responsibility over business rules in business rule repositories (zur Muehlen *et al*. 2008) and may not have process modelling expertise, whereas technical staff or the IT department may be responsible for the implementation of business processes (Leymann and Roller 2000). Accordingly, the choice of where to model a business rule is likely to depend on the expertise of the person who will be responsible for the implementation.

Rate of Change

Rate of Change refers to the frequency with which a business rule is likely to be revised. Business rules are regularly revised in response to changes in regulations and policies (Moreira *et al*. 2003). Frequent business rule change requires mechanisms that support easy modification and propagation. Depending on the level of formal specification, it may be easier to change an individual business rule, modelled in a business rule language and stored in a business rule repository, than to change the business rule embedded in a process model. One could argue that frequently changed business rules should be modelled in a stand-alone fashion, rather than being embedded into graphical process models where they would be labour-intensive and cumbersome to update (Moreira *et al*. 2003), while stable business rules can be integrated into a business process model. Of course, such a decision will be moderated by the actual rate of change, as well as other factors.

Reusability

Reusability refers to the potential for a rule to be used in new contexts. Scattered (Kontopoulos *et al*. 2008; Ofner *et al*. 2012) and duplicated (Loucopoulos and Kadir 2008) rules make it difficult to evaluate and maintain the integrity and consistency (Nelson *et al*. 2010; Norta and Eshuis 2010). If a reusable business rule is embedded in a business process model, the development, testing, and maintenance efforts may be increased when that rule changes and requires update (Loucopoulos and Kadir 2008; Mammar *et al*. 2005). To the contrary, since a business rule in a business rule repository only has one instance and is accessible to all processes, modelling such a rule in a business rule notation and storing it in a business rule engine could ease maintenance efforts.

Rule Source

Rule Source refers to the origin of the business rule. Possible sources could be external laws and regulations, over which an organisation has no control, as well as internal policies and strategies (McCarthy *et al*. 2002). Requirements defined by external regulatory bodies can be "critical to the organization, while being outside the scope of their control. Particularly when the changes pertain to compliance with regulations" (zur Muehlen *et al*. 2008). Modelling external business rules as part of a business process ensures that an audit trail is created, thus, it facilitates compliance management and audit (zur Muehlen *et al.* 2008).

Scope of Impact

Scope of Impact refers to how broad the impact of the rule will be. The impact of a business rule can be focused on an activity, an entire process, a department or the whole organization (zur Muehlen *et al*. 2008). If an organization-wide business rule is embedded in a large number of business process models any update to the rule will lead to a change in a large number of models, thus triggering re-work and risk for inconsistency (Kovacic and Groznik 2004; zur Muehlen *et al*. 2008). If the same business rule resides in a business rule repository, the update effort will be limited to an individual business rule instance, while being linked to potentially several process models.

CONCLUSIONS AND FUTURE RESEARCH

In this paper, we introduce twelve factors that are posited to influence whether a business rule should be embedded in a business process model. The factors are identified through a systematic literature review of well-regarded Information Systems and Computer Science academic publications spanning a period of over two decades. This work provides the first comprehensive identification and consolidation of factors that may

influence business process model and business rule integration. Thus, it forms the first step, and an important foundation, for the development of a decision framework for integrated business process and business rule modelling. Such a framework would allow modellers to decide, in a well-informed manner and with full understanding of consequences, how and where to model a business rule. In turn, these informed modelling decisions would reduce redundancy and inconsistency of rules across various components of an organisation's information system architecture.

Our work is not without limitations. Notably, the identified factors have not been empirically evaluated to determine their impact in practice. Our future research consists of empirical validation of the identified set of factors with academics and practitioners, followed by the development and validation of the decision framework. The output of the decision framework will be a recommended placement of business rule, i.e. whether a business rule should be embedded in a business process model, or modelled independently in a rule repository. We also recognise that there are executable processes and business process models developed for other purposes, e.g. communication and knowledge management. In our work we have not clearly differentiated between factors that might apply in different contexts, however, this aspect requires closer attention in future work.

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