An Exploratory View on Risk Management Constructs for Business Process Models

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Abstract: Business Process Modeling and Notation (BPMN) is a widely used process modeling notation both in academia and industry, with a structure that is easy to understand and use. It contains more than a hundred elements referring to various concepts. However, it does not cover risk management constructs. In this paper, we seek to identify the need and which aspects are important if we were to associate process models with risk management. We performed an exploratory research method with experts in the area of risk management that also work with process models. The work resulted various concepts that could be related in process models, such as risk presentation, control activities and risk mitigation. We conclude that experts would like to have such disciplines better integrated and that we have a starting point to design, for instance, a BPMN extension to cover such aspects.

1 INTRODUCTION

With the increasing size and complexity of processes in organizations, there has been a necessity to perform Business Process Management (BPM), improving management of aspects such as people, products and services (vom Brocke and Rosemann, 2015). Along with process modeling, managing risks has become increasingly important. Risks can be defined as future situations that have some impact in organizations, being mostly negative (Tsiga et al., 2017).

Business Process Modeling and notation (BPMN) is one of the most widely used modeling notations. It covers various stages of the BPM life cycle, allowing to build process models (Panagacos, 2012). It is important to use modeling rules to build efficient process models (Dumas et al., 2018). According to the Object Management Group (OMG), responsible for the architecture of BPMN, the notation does not have constructs concerning risk management (OMG, 2011).

Previous works discuss the possibility of associating risks to process models, e.g. zur Muehlen and Rosemann (2005). However, research that seeks to understand what is important to associate concerning risk management with process models are lacking. Event-driven Process Chain (EPC) has an approach that allows to inform risks and controls policy situations. Despite the literature discussion regarding process models containing risk management constructs, empirical analysis on the needs of such constructs is lacking. This paper intends do give a step towards this direction. We approach this point by means of an exploratory research method. Experts in the areas of processes and risk management answered a survey. Our analysis in this point is mainly qualitative, seeking to understand the needs as seen by experts.

This work is organized as follows. Section 2 presents the background, which involves BPM, BPMN, EPC and risk management. In Section 3 the related work is presented, followed by Section 4 presents the research design, which shows assumptions, aim, participants, material and data cleansing. Sections 5 presents the results from the survey. Finally, discussion and conclusions are presented, respectively in Sections 6 and 7.

2 BACKGROUND

In order to better understand the development of the paper, in the following sessions we present the related main concepts and references. BPM, BPMN, EPC and Risk Management are presented, respectively.

2.1 BPM

BPM seeks to ensure constant positive results and deliver maximum value to companies by improving their business processes (Panagacos, 2012).

The BPM life cycle has six stages (Dumas et al., 2018; vom Brocke and Rosemann, 2015; Panagacos, 2012; Weske, 2012): (i) process identification, (ii) process discovery, (iii) process analysis, (iv) process redesign, (v) process implementation and (vi) process monitoring and control.

BPM's life cycle helps to understand all technologies, processes, and steps involved in order to be adopted in any business environment (Dumas et al., 2018). It should be noted that the phases can occur in a continuous form, circularly, depending on the need, or even only once (Weske, 2012). BPM has notations and languages that allow to express and share their processes with stakeholders (Panagacos, 2012).

2.2 BPMN

BPMN is a notation containing a series of standard process design icons (Weske, 2012), which enables a better understanding of the designed business processes. The models produced may differ depending on the reason for which they are built.

Frequently, process participants perform very specific tasks and are rarely confronted with the process as a whole (vom Brocke and Rosemann, 2015). BPMN's main goals are to understand the process itself and share its understanding with the stakeholders (Panagacos, 2012).

BPMN has more than hundred symbols (Dumas et al., 2018). However, just some of them are really used, less common symbols can be aggregated according to the organization needs, e.g. in more complex projects. In BPMN modeling there are four groups of elements: flow objects, connecting objects, swimlanes and artifacts (Dumas et al., 2018; Panagacos, 2012; Weske, 2012).

Flow objects are the main graphic elements used to define the behavior of a business process, being divided into threes types: *activities*, *events* and *gateways*. *Connecting objects* present the way objects are connected and are divided into three types. Sequence flow, that presents the flow execution order. Message flow, presenting the flow of messages between sender and receiver. And *association*, used to associate artifacts (e.g. data or texts) to the flow objects.

Swimlanes present a way to organize activities into visual categories, allowing better task management. They are divided into two categories: pool and lane. Finally, *artifacts* seek to aggregate information

to the process, as well as being used to represent a data input or output. Even though BPMN does not contain many key elements, building a process model involves following a few rules. Good modeling practices should be used which make the process easy for those involved to understand (Mendling et al., 2010).

Concerning risk management, the BPMN regulatory body (OMG) does not define any type of element that allows managing risks in process modeling. Which may be seen as a disadvantage if compared to EPC.

2.3 EPC

EPC is a process and workflow modeling language. It is used to configure the execution of business resource planning and business process improvement (Mendling, 2008). Unlike BPMN, EPC addresses some organizational aspects, such as risks and control policies (AG, 2019).

There are some similarities with BPMN. Among them, the exclusive, parallel and inclusive connectors, functions and events (Mendling, 2008). In BPMN pools and lanes are used to describe organizations, positions, tasks and functions. In EPC elements of the group of organizations are used, divided into organizational unit, position, position and group, which are directly associated with functions (Scheer et al., 2005). EPC contains data and risk elements group, which are not included in BPMN.

2.4 Risk Management

Together with process modeling, managing the risks involved in a business has become increasingly important in organizations. Risks are future situations that have some kind of impact on organizations, mostly negative (Tsiga et al., 2017). Thus, risk management is a strategic planning adopted by organizations to identify, analyze and prevent the risks to which they are subject (Chapelle, 2019). The risks an organization may be vulnerable to depend on its activities (Cope et al., 2010).

Risk management occurs in five steps (Chapelle, 2019; Cope et al., 2010; Lambert et al., 2006; Moeller, 2011; Tummala and Schoenherr, 2011; zur Muehlen and Rosemann, 2005). (i) risk identification, (ii) risk measurement, (iii) risk evaluation, (iv) risk treatment and (v) risk monitoring.

During the identification step, a qualitative analysis of the risks that may affect the process or its results is performed. In a qualitative analysis are identified, the causes, effects and forms of identification.

The measurement step seeks to define the probability and impact of each identified risk. At this step, the nature of the risks and the impacts that may occur to the project and organization objectives should be identified. Usually using a quantitative analysis.

Having the risks measured, their assessment is performed, defining their magnitude. Decisions are made at this step, if the risks are acceptable or need some treatment. Decisions are made according to the risk appetite of each organization.

Approaching the last steps of risk management, its forms are defined, divided into (i) acceptance, where the organization assumes the risk involved by adapting when problems occur. (ii) transfer, where the responsibility for risk is shifted from one party to another, typically occurs when third party service is adopted. (iii) mitigation, where plans or strategies are made to reduce the impact of the risks involved, e.g. using business process management for mitigation. Finally, (iv) avoid the risk, in which the risk is completely eliminated.

Lastly, in the final phase, risk monitoring is performed. For this, it is common to use tools that allow monitoring, tracing and reviewing risks during the execution of processes. Monitoring is an important step in reducing the impact and frequency of risks, and it is essential to identify new risks.

During the BPM life cycle, a risk check is performed during the process identification step (Dumas et al., 2018). The risks identified at this step already occur in the organization, and are the main source for process modeling alignment (zur Muehlen and Rosemann, 2005).

Although risks are not modeled together with processes, some studies look on how to address them. The following chapter presents papers that discuss ways to perform risk management in conjunction with process modeling.

3 RELATED WORK

Ahmed and Matulevičius (2014) presented a method for integrating security measures with process management. For this, the method consists of seven steps that describe how process analysis and security analysis can collaborate to result in a secure business process. The defined steps are: (i) Identify safety principles and objectives; (ii) Analyze risk safety; (iii) Elicit security requirements; (iv) Annotate business process models with security requirements; (v) Feed back business models annotated with security requirements; (vi) Present security solutions; (vii) Rationalise security solutions.

The method allows eliciting security requirements in business models, however a holistic method of secure risk management is required. It benefits business analytics by allowing to choose cost-effective solutions that fit the business. The method allows for earlier recognition of risks knowing that if it occurs later it can increase costs.

Radloff et al. (2015) presented an approach for extending EPC and other modeling languages with internal control elements. The extension includes procedural control defined classes, audit results, risks and control objectives. Each of the classes created represents functions in EPC, allowing better management of the internal controls. In order to be represented in the notation, new elements that better describe the means of control are proposed. The new elements seek to be easily understandable to those involved. Finally, the author conducted a case study to assess their approach understanding.

Ahmed and Matulevičius (2014) presented an approach concerning processes situations where data may be leaked. In these situations, the impact of the information present in this data may affect other parts of the process. However, no solutions for risks are presented and neither where the risks occurs in the process.

The paper of Radloff et al. (2015) shows a way to link internal controls to the modeled processes, since EPC by itself does not include this functionality. By using their approach, tasks can be performed more satisfactorily, since they will conform to the organization internal controls.

Regarding the works presented in this section, the work presented by Radloff et al. (2015) contributes an extension to the EPC related to internal controls. The author describes the possibility adapting it for BPMN. Ahmed and Matulevičius (2014) focuses on risk prevention, not showing where the risks are actually occurring. This works contribute to this paper by presenting some solutions to associate risks with process models. This paper, on the other hand, focus on collecting opinions from specialists about what is important to be presented in process models concerning risk management.

4 RESEARCH DESIGN

In this section we present our research design. This paper intends to analyze the lack of constructs to represent risk management in BPMN models. We start this journey by studying the experts view, whether they consider a good idea or not to link both. For this, we chose an exploratory research method, aim-

ing at a qualitative analysis (Recker, 2013; Wohlin et al., 2012).

First, we present our assumptions, followed by the aim of this paper. Then we present the demographics of the participants. After that, we present the material used to achieve our goal and finally the data cleansing applied.

4.1 Assumptions

We assume that risk management is a very important task and that it should be considered by companies, at least by the ones applying some sort of control in this regard. Consequently, we assume that it is a very important aspect to be considered when applying BPM. Finally, we assume that would be important to present such controls in BPMN models, from our understanding at least the risks related to activities and forms to mitigate them.

Some modeling languages like EPC provide support for risk management on its core set. This provides essential information about risks. Which reinforce the importance to present such concepts on BPMN models.

4.2 Aim

For this work, we try to explore the view of specialists working with business processes and risk management. The idea is to better understand which information could be interesting to have in BPMN models.

4.3 Participants

We collected data from eight specialists, they are collaborators of public and private organizations, and of educational institutions. All participants are from Brazil. In order to better understand our respondents, we asked four questions about their knowledge, measured with Likert scale. For question (i) work with processes in organizations, seven participants chose "three years or more" (which was the maximum) and one chose "between one and three years".

For questions (ii) work with process models and (iii) work with BPMN, the answers were repeated as for (i). For question (iv) work with risk management in organizations, the answers had bigger variations. Three respondents answered "three years or more". Three answered "between one and three years". And two answered "between six months and a year".

Based on these answers we can understand that the participants had good knowledge in the required concepts.

4.4 Material

In order to gather data from experts, we performed a survey, which allowed us to reach more participants. The questionnaire inquired about the importance of presenting risk related information in business process models. The questions were constructed and ordered to avoid bias and were divided into three sections (Wohlin et al., 2012).

In the first section, demographic questions were asked, seeking information from the respondents. Questions related basically to the time that each participant has interacted with: processes, process models, BPMN and risk management. With this, we can have an idea about the knowledge of the participants.

In the second section, we presented three questions about risks and process models that should be answered with free text. Those referred to (i) which information should be presented in process models to improve the work of the expert. (ii) Which information should be presented in the model to improve the process executor work. (iii) What could improve risk management in the context of process models. Here we tried to avoid bias towards our assumptions, in order to explore the ideas from the experts.

Finally, in the third section, we presented questions related to our assumptions, these were presented in the last section to not create bias. We asked four questions with Likert scale (1 to 6) and three questions with free text.

4.5 Data Cleansing

Two out of ten participants claimed they never worked with risk management. As we seek to explore the ideas of risk management experts, we did not consider their answers. Additionally, they replied "I do not know" for almost all questions. This reinforces that our questions relate to our goal.

5 RESULTS

As presented previously, the first section of the survey related to demographics. Following, we present the second section, where data related to risk management and process models were gathered. As presented in Section 4, the first questions had free text answers and their descriptions tried to avoid bias. In order to analyse the resulting data, all the authors followed the process bellow:

1. In an independent environment, extract the most important concepts from each answer, based on

each persons point of view. There might be N extracted concepts per answer;

2. In a shared environment, select the most depicted concepts (e.g. by three out of four authors). Try to standardize concepts that have very similar names;

3. In a shared environment, merge the answers:

    (a) Aggregate concepts by similarity in a table;

    (b) Add the frequency of similar concepts;

    (c) Democratically resolve concepts that are similar, but written with different words or specialization levels. Try to chose a standard concept based on the literature;

    (d) Join related concepts in groups;

Based on this process, Table 1 presents the results from the first question.

Table 1: Question: *Which risk management information should be presented in the process models to improve your work?*

	Extracted concepts	Freq.
1	Risk Presentation	4
	Signal critical points	1
2	Control activities	3
	Risk handling	1
3	Residual risk	1
	Relating models with the risk matrix	1
	Risk impact level	1

It is worth mentioning that the work to be improved pointed out in this question relates to risk management. From the results, we can understand that presenting the risks was the most cited concept to be in process models, followed by control activities. Which conforms with our assumptions. Additionally, five other concepts were mentioned by specialists. Concepts that are related but distinct were grouped, the leftmost query presents a number for each group. For instance, risk handling could be merged to control activities, however since it is a more specific concept, it is presented separately. Table 2 presents results from the second question.

The second question focus on what is important to whom performs the processes. The most cited answer is the risk presentation. Again, the related concepts were grouped together. Risk handling follows next based on frequency. Three other individual concepts were mentioned by the specialists. One interesting answer pointed that no information about risk management should be put in the process model for the executors. The specialist claimed that the model

Table 2: Question: *Which information regarding risk management should be presented in process models to improve the work from who performs the processes?*

	Extracted concepts	Freq.
1	Risk presentation	3
	Signaling critical points	2
2	Risk handling	2
	Control activities	1
	Risk mitigation	1
3	None	1
4	Relating info sources (e.g. normative)	1
5	Severity and risk repercussion	1

should be as simple as possible. Table 3 presents the results from the final question of second section.

Table 3: Question: *What could improve risk management in the context of process models?*

	Extracted concepts	Freq.
1	Presenting risks	4
	Presenting high impact risks	1
2	Agile tool for process monitoring	1
3	Querying standard processes via tools	1
4	Reviewing unnecessary controls	1
	Reviewing uncontrolled risks	1
5	Risk mitigation	1
6	Risk-based process improvement	1

This question opens to any information concerning any task that could be presented on models. The most cited concepts relate to risk presentation. A total of six groups of concepts were mentioned by the specialists.

In the third section of the form, Likert scale and free text questions were presented. Likert scale questions collected information about the importance of performing risk management in the organization. The Likert scale (from 1 to 6) defines the scale of not important to very important. For this, four questions were made: (i) importance of risk management to your organization, (ii) importance that stakeholders that perform activities know its risks, (iii) importance that stakeholders that perform activities know how to mitigate its risks and (iv) presenting information about risks management in process models will improve your organization. Note that here we impose our assumptions in the questions descriptions, Focusing in presenting and mitigating risks. Table 4 depicts the answers for each question.

Table 4: Importance of connecting risk management with process models.

	Imp. for organizations	Imp. to perform risk activities	Imp. to mitigate	Imp. to present risks
	6	5	5	6
	6	6	6	4
	6	6	6	6
	5	5	5	6
	4	5	6	1
	6	6	6	6
	1	6	6	6
	5	5	6	6
Average	4.87	5.5	5.75	5.12

Based on this table, we can understand that the experts consider all aspects to be very important. For the three first questions, it was somehow predictable, as the experts live this in their work day. For question four, it is interesting to acknowledge that most of them consider very important to present risk management information in process models.

Afterwards, the last three questions had free text answers seeking to explore the respondents view towards our assumptions.

Table 5 shows the answers for the first question of the third part of the questionnaire. These questions may have created some bias considering the questions previously asked.

Table 5: Question: *Which information should be presented to those involved in risky process model activities?*

	Extracted concepts	Freq.
1	Risk presentation	5
2	Impact vs. probability of risks	3
3	Control activities	2
	Risk handling	2
	Risk mitigation	1
4	Process progress control	1
5	Stakeholders identifying risks	1

This question directed the experts towards risky activities of the process model. With that, the most cited concept was risk presentation. The group relating to controls followed, and impact vs. probability came next. Two more concepts were pointed out afterwards.

The table 6 presents the second question from the third part of the questionnaire.

Based on the data, it is possible to acknowledge that actions to mitigate risks present in the process model was the most cited aspect. Followed by pre-

Table 6: Question: *Which information should be presented to those involved with risky activities from process models, in order to mitigate them?*

	Extracted concepts	Freq.
1	Risk mitigation actions	4
	Control activities	1
	Risk handling	1
2	Risk presentation	2
	Residual risk	1
3	Impact x probability of risks	1
	Risk impact on other processes	1
4	Stakeholder to report problems	1
5	Risk-based process improvement	1

Table 7: Question: *What could be done in order to BPMN models better approach risk management?*

	Extracted concepts	Freq.
1	Risk presentation	3
	Presentation of inherent risks	1
2	Risk management and BPM together	1
4	Relate process model and risk matrix	1
5	Control activities	1
6	Link to normative	1
7	Querying tool	1
8	Using models for stakeholders training	1

senting risks and the impact of risks.

Two more concepts were given by the specialists.

Finally, Table 7 refers to the last question of the questionnaire.

This was a general open question, allowing the participants to express what would be more interesting from their point of view. The most frequent aspect

was risk presentation. Six more options were given by the specialists. One expert mentioned that adding elements to the model is not the most important thing, but applying BPM and risk management together.

The next section presents towards an extension to associate risks with the BPMN. The extension was based on the concepts given by the specialists.

6 DISCUSSION

In this section, we discuss the results, pinpoint implications for research and present threats to validity.

6.1 Results

Our survey results suggests that experts would like to have risk management information presented in process models. Suggesting that having such information in BPMN models would have good acceptability amongst them. The results also suggest that our assumption towards relating risk to process models activities and presenting how to mitigate risk within process models seems to be the view of experts.

Section 5 presents the concepts extracted from the free text answers gave by specialists. Some aspects are clear, e.g. they believe that information about risks should be presented in process models. Having that, we understand that people would have a clear view on steps of the process that should have higher attention.

In addition to the concept itself, some other suggestions were made:

- Identify the risks altogether with the stakeholders that work in each process;
- Present the impact level of the risks;
- Relate risks to activities in the process models;
- Where to find information about handling the risk;
- The main risks are the ones to be presented;

When the experts considered the stakeholders that execute the processes, we perceive a focus on mitigation actions additionally to risk presentation. Aside the concepts, some other suggestions refer to:

- Presenting the risk will make it easier for the executor, providing confidence;
- Where to find normative and manuals, also information about handling the risk;
- Severity and repercussion also appear;
- Minimizing risks is important;

This answers bring the idea that experts see process models as an additional vehicle to communicate how

stakeholders should perform their activities considering risk management.

When asking questions related to our assumptions: presenting risks and mitigation actions, we see some concepts increasing frequency. In both cases, impact and probability are mentioned. Those concepts refer to risk severity (Moeller, 2011).

Some specialists suggest presenting different information regarding risk. For instance, to present residual risk or inherent risk. All suggestions are to be taken into account, however not all information can be fit into a process model.

Very few answers were negative on connecting process models with risks, one of which concerns model complexity. This is a very good point that should be considered and it has been studied throughout the literature (Mendling et al., 2010). Therefore, the amount of information and presentation manner have to be cautiously studied.

6.2 Implications for Research

This work suggests the interest of experts towards relating risk management concepts in process models. With the exploratory profile of this paper, it contributes with a starting point to researchers intending to study new constructs to process models. The concepts also help who develop the activities to perform with more attention, avoiding risky situations.

6.3 Threats to Validity

Although in this paper we focus on a exploratory qualitative analysis and no statistical tests were performed, external validity could be improved by increasing the number of specialists. Also, having specialists from different countries would be interesting.

With the application of a survey, we had a trade-off, on the good side we were able to reach more specialists. On the bad side, we lost some power of understanding. By means of interviews, for instance, we would have the chance to ask additional explanation in the occurrence of unclear statements.

On the next section, the conclusions of this paper are presented. Contributions and future works are addressed.

7 CONCLUSIONS

This paper seeks to explore the idea of constructing process models with risk information, aiming to identify its importance. To this end, specialists from Brazil answered a questionnaire about the importance

of risk management associated to modeling processes. We had assumptions prior to this paper that presenting risks and risk mitigation actions would be interesting.

Based on the results and discussions, it was possible to obtain a direction on concepts to associate risk management with process models. Three concepts were the most cited by the specialists: risk presentation, control activities and risk mitigation. Aside of many other information to be considered when planning to bring those areas together.

Therefore, this work contributes by providing a starting point to create an adequate association approach. The mentioned concepts provide a base to construct a useful extension for notations such as BPMN.

We intend to further analyse the creation of a BPMN extension. Aspects related to, among others, semiotics and cognitive psychology will be considered. Experiments to test the extension will be carried out. With this, we hope to allow experts from organizations to apply the extension and improve risk management in their work places, better integrated with BPM.

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