Business Process Model and Notation: The Current State of Affairs

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Abstract. Context: With business process modelling, companies and organizations can gain explicit control over their processes. Currently, there are many notations in the area of business process modelling, where Business Process Model and Notation (BPMN) is denoted as the *de facto* standard. Aims: The aim of this research is to provide the state-of-the-art results addressing the acceptance of BPMN, while also examining the purposes of its usage. Furthermore, the advantages, disadvantages and other interests related to BPMN were also investigated. Method: To achieve these objectives, a Systematic Literature Review (SLR) and a semantic examination of articles' citations was conducted. Results: After completing SLR, out of a total of 852 articles, 31 were deemed relevant. The majority of the articles analyzed the notation and compared it with other modelling techniques. The remainder evaluated general aspects of the notation, e.g. history and versions of the standard, usage of the notation or tools. Conclusion: Our findings demonstrate that there are empirical insights about the level of BPMN acceptance. They suggest that BPMN is still widely perceived as the de facto standard in the process modelling domain and its usage is ever-increasing. However, many studies report that only a limited set of elements are commonly used and to this end, several extensions were proposed. The main purpose of BPMN remains the description of business processes.

Keywords: business process modelling, BPMN, acceptance, use, systematic literature review.

1. Introduction

Business process modelling (hereinafter referred to as BPMo) emerged in order to provide a better understanding of business processes in organizations [40]. The result of business process modelling is a process model, which consists of a set of activity models and execution constraints between them [52]. It is usually illustrated with activities and events that are associated with control flows [11]. Such processes can be modelled with different languages for process modelling, also known as techniques or notations. Choosing an appropriate language requires consideration, because not every modelling language is suitable for all aspects of the process [40]. This created the necessity for a standardization of modelling languages, which should satisfy the requirements of a high level of expressiveness and formality [7]. Therefore, the

standardization of processes inside and outside an organization is necessary to improve communication and optimize work [12].

From existing graphical languages for BPMo, the most robust communication between information technology (IT) and business was made with the Business Process Model and Notation (hereinafter referred to as BPMN) standard [2, 30]. BPMN was introduced in 2004, after several years of efforts at achieving standardization [40]. Examples of other visual process modelling languages, currently in use, are Flowcharts, UML Activity Diagrams, Petri nets, Event Process Chains (EPC).

BPMN is an ISO certified standard (ISO/IEC 19510:2013) for describing business process semantics, since its notation is generally easy to comprehend and is highly understandable for business and technical personnel [46]. BPMN also provides a high expressiveness and allows many extensions for different areas (e.g. security [47], business rules [26], business events [13], costs [24]). BPMN has also a wide support by several commercial and open source tools [40].

Because of the large variety of constructs, BPMN may be treated as a complex notation [27]. However, the fundamental question of 'how and why is BPMN used?' remains. According to Recker [40], the actual use of BPMN has not been fully examined. Additionally, there are no consistent findings, even though there are a wide range of articles in this area available from 2004, when the initial version of BPMN was published, until today.

Our research addresses the aforementioned issues by conducting research about the acceptance of BPMN. The findings were gathered based on relevant articles, which were gathered by applying a Systematic Literature Review (hereinafter referred to as SLR). In accordance with Kitchenham [22], an automated search did not find any software-related research that used a systematic review methodology.

While related works individually explored the significance of BPMN, our research gathered findings from existing literature together, with the aim of addressing the acceptance and use of BPMN in general. In order to achieve this goal, the article is organized as follows. The methodology and research details are given in section two. In section three, the results of the research are provided. In the fourth section, the acceptance, purposes of the use and advantages as well as disadvantages of BPMN are discussed in detail, within the scope of the research questions. Finally, the conclusion and implications are found at the end of the paper.

2.   Method

Systematic literature review (SLR) represents the identification, evaluation and interpretation of all available research that addresses our research questions. We conducted SLR by following the original SLR guidelines as defined by Kitchenham [21]. In summary, a SLR is conducted in three phases (Figure 1). The first group of tasks corresponds to the planning phase, where the first step is the identification of the need for an SLR. Researchers must identify if such a review is necessary. If there are no existing researches in the selected domain, the research group should be defined. Later, a proposal for the implementation needs to be set, especially if SLR is conducted by an external research group. After following the defined steps of phase one, two documents are created, namely research questions and research protocol [21].

The second group of tasks represent conducting phase. The first step of the second phase is the identification of research, which means breaking down research questions and testing the suitability of a search string. Based on inclusion and exclusion criteria, relevant research is logged and quality assessments are made. At the end of this phase, a data synthesis is made by collecting and summarizing the results of the relevant articles [21].

The third group of tasks represent reporting phase, which needs to be determined whereas the evaluation of the report is made by external experts, which represents the last stage of SLR.
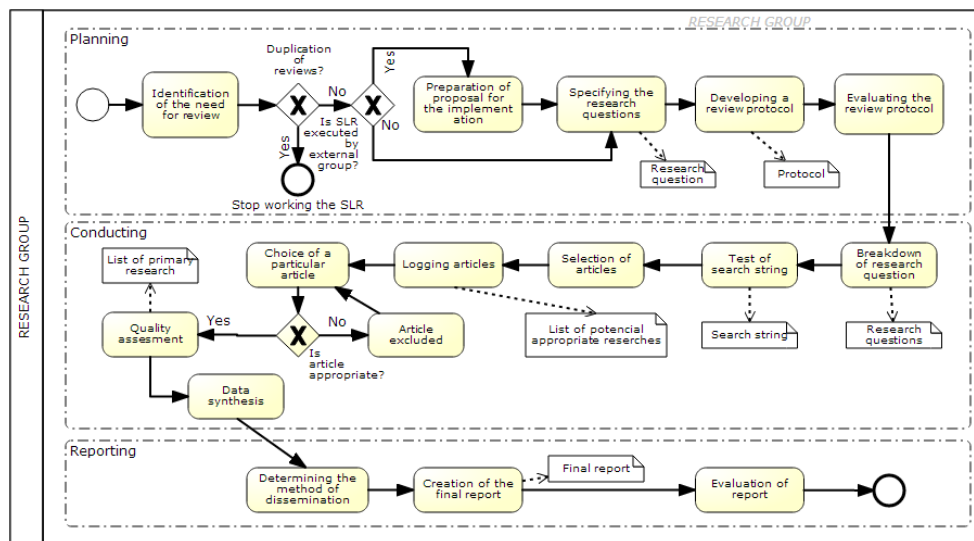

Figure 1. SLR represented in a BPMN diagram

SLR is a method that requires a high amount of strictness when conducting [21]. All planned steps of the methodology need to be accomplished. However, since every research has its own characteristics, it makes it impossible to carry them out precisely as instructed. So, in the following subsections, the research questions, the included and excluded criteria, the search process and data analysis are described in more detail and applied to the selected domain.

2.1.   Research questions

To obtain the research questions, we defined the following objectives of SLR: (1) review articles in order to identify the advantages and disadvantages of the use of BPMN, (2) obtain a clear picture of the acceptance of BPMN and (3) obtain new knowledge about BPMN, applicable for further investigation. The composition of the research question was performed by considering PICOC criteria [21] (Population, Intervention, Comparison, Outcomes and Context) (Table 1).

Table 1. PICOC criteria

Criterion	Acronym	Meaning	Our case
Population	P	Who?	Organizations where BPMN is applied
Intervention	I	What or how?	Review BPMN acceptance
Comparison	C	Compared to what?	/
Outcomes	O	What are you trying to accomplish?	Degree of BPMN acceptance (advantages and disadvantages)
Context	C	In what kind of circumstances?	Empirical studies from academic and business fields

Notes: Criterion – naming of PICOC criterion, Acronym – short naming of PICOC criteria, Meaning – issues placed in order to obtain a criterion, Our case – PICOC criteria for our case

As mentioned in the introduction, BPMN is used to design typical business activities. The aim of BPMN designers was to provide a language that would be easy to understand and usable for people with different roles and training - from top managers to IT professionals [30]. Because of its wide set of goals, a broad acceptance and different purposes of BPMN use were expected. To this end, we formulated the following research questions:

RQ 1. Are there any empirical insights about the level of BPMN acceptance?
RQ 2. For what purposes is BPMN used?
RQ 3. What are the advantages and disadvantages of BPMN use?

2.2.   Search string and used digital sources

The search string was composed using the following steps: (1) identification of search terms from research questions, (2) identification of search terms in titles, keywords and in the abstracts of adequate articles, (3) identification of synonyms and alternate spellings of search terms. The search string was composed of search terms and logical operators, e.g. AND and OR. For the purpose of our research, the following search string was used:
("bpmn" OR "process modeling" OR "process modelling")
AND
("study" OR "process" OR "modeling" OR "modelling" OR "practice" OR "comparison" OR "usability" OR "business" OR "users" OR "languages" OR "empirical" OR "exploratory" OR "ontological" OR "survey" OR "methodology" OR "analysis" OR "acceptance").

After identifying the search string, digital sources were defined as well. The most relevant digital sources for IT field are given in [5] and include the following: ACM Digital Library, Engineering Village (Inspec and El Compendex), IEEE Xplore and

Science Direct. For our work we added two additional digital libraries: ISI Web of Knowledge and SpringerLink (Table 2).

Table 2. Included digital libraries

Digital library		Web page	Number of resources	Used string	Existing limitation
ACM Digital Library	ACM DL	dl.acm.org	NA	Short	Time interval Sorting by relevance
Engineering Village	EV	www.engineeringvillage.com	NA	Normal	Time interval Specific database Sorting by relevance
IEEE Xplore	IEEE	ieeexplore.ieee.org	3 521 378	Normal	Search within metadata
ISI Web of Knowledge	WOK	apps.webofknowledge.com	NA	Normal	Time interval Sorting by relevance
Science Direct	SD	www.sciencedirect.com	11 916 405	Normal	Time interval Type of publication
SpringerLink	SL	link.springer.com	7 900 915	Short	Time interval Sorting by relevance

Notes: Digital library – name of included digital library, Acronym – *short naming of digital library, Web page – web page of digital library, Number of resources – total number of resources in digital library*, Used string – used search string lengths in digital library, Existing limitations – limitations used in chosen digital library, NA – Not available

As evidenced from the fifth column in Table 2, different digital libraries support different lengths of search strings. In five cases out of six, an *expert search* was used, which allows the user to enter any string together with logical operators. The search can be limited as well by time interval, type of publication (book, journal, etc.) or with a specific database within the selected digital library. Additionally, since most search engines of the chosen digital libraries have the option of sorting results, we used *sorting by relevance*.

2.3.   Inclusion and exclusion criteria

To include relevant articles and exclude irrelevant ones, several criteria were used, which were applied over the summaries, keywords and partly over the title. If it was not possible to determine whether or not an article was suitable for SLR, a complete review of the content was made. The inclusion and exclusion criteria are presented in Table 3.

Table 3. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Articles that:	
- included academic and industrial fields	- did not mention BPMN
	- mentioned BPMN indirectly
- analyzed the use of BPMN	- were published before 2004
- analyzed the upgrade and transformation of BPMN	- represented grey literature
	- were not in English
Notes: Inclusion/exclusion criteria – criteria to include/exclude articles in/from SLR	

2.4.　　　Search process and evaluation

First, a pilot search was performed, by obtaining a list of ten relevant studies. When searching within digital libraries, ten out of ten articles were found. This represents a guarantee that the search string was adequately composed. The search process was conducted by three researchers. While the first two extracted the data from digital libraries, the third researcher validated the extraction. Based on the joint opinions, a list of suitable articles was established. If there was disagreement on a particular article, it was reviewed again and a final decision was made. This part of the search process was internally called the *primary evaluation* of articles. Additionally, there were another three evaluations. The percentage of excluded research in every evaluation is discussed in the following subsection.

2.5.　　　Data analysis

To properly manage the chosen literature, we used a desktop application called Mendeley [25], which is a free reference manager. Details of the sources were identified according to the information available and properly analyzed in spreadsheets.

Table 4. Attributes of analyzed articles

Attribute group	Attributes
Basic information	Title, author, source, type of source, year of publication, performers, domain
Analysis of abstract	Problem, results, research method
Analysis of research	Modelling technique, problem, purpose of the research, object of observation, data source
Implementation of the research	Hypothesis, theoretical model (TAM), pattern, research questions, validity, test research
Analysis of empirical data	Statistics, verification of hypothesis
Interpretations of results	Conclusions, further work
Notes: Attribute group – group of attributes with similar characteristics, Attributes – individual attributes collected from articles	

For a data analysis it was necessary to collect all relevant information (attributes) from the chosen articles. They were divided into six parts, each of them differing substantially (Table 4).

3.   Results

To identify suitable articles in digital libraries, the given inclusion and exclusion criteria were applied. We took all available articles (so-called unfiltered articles) and discarded any that did not meet the inclusion criteria. Those that corresponded to the criteria and to the research questions, were the foundation for further research. They are called filtered articles. In Table 5, the distribution of articles is given.

Table 5. Unfiltered and filtered articles

|	ACM DL	EV	IEEE	WOK	SD	SL	SUM
Unfiltered	681	7,340	7,939	8,899	9,288	650	34,797
Filtered	151	167	142	118	152	122	852

Notes: Unfiltered – all available articles from digital libraries, Filtered – articles that correspond to the criteria and to the research questions, SUM – the sum of all (unfiltered or filtered) articles from digital libraries

Furthermore, four phases of evaluation are presented. In every phase, each article was either relevant and was thus included or was considered irrelevant and was excluded from further evaluation. Selected articles from the first to third evaluation are further called *first (or second or third) stage relevant*. Similarly, excluded articles from first to third evaluation are called *first (or second or third) stage irrelevant*. The selected articles from the final evaluation are subject to a more detailed analysis and are uniquely called *relevant* articles. Finally, the excluded articles from the final evaluation are called *irrelevant* articles.

Graph 1 shows the relationships between *first stage relevant* and *first stage irrelevant* articles after primary, and before secondary evaluation. All six digital libraries were involved. As already mentioned and indicated in Table 5, 852 filtered articles were examined. The extraction process at this point was conducted based on the article's title (the topic).

After the primary evaluation, 26.76% of the gathered articles were *first stage relevant*, meaning that 228 articles were selected from the primary evaluation. The other 624 articles were excluded at this point of the research. The ratio between *first stage relevant* and *first stage irrelevant* was 1:2.8.

In the second evaluation phase, all the articles that did not directly address the research questions were excluded (Graph 2). The inputs for the secondary evaluation were the 228 *first stage relevant* articles. The extraction process at this point was conducted based on the article's title (topic), abstract and key words.
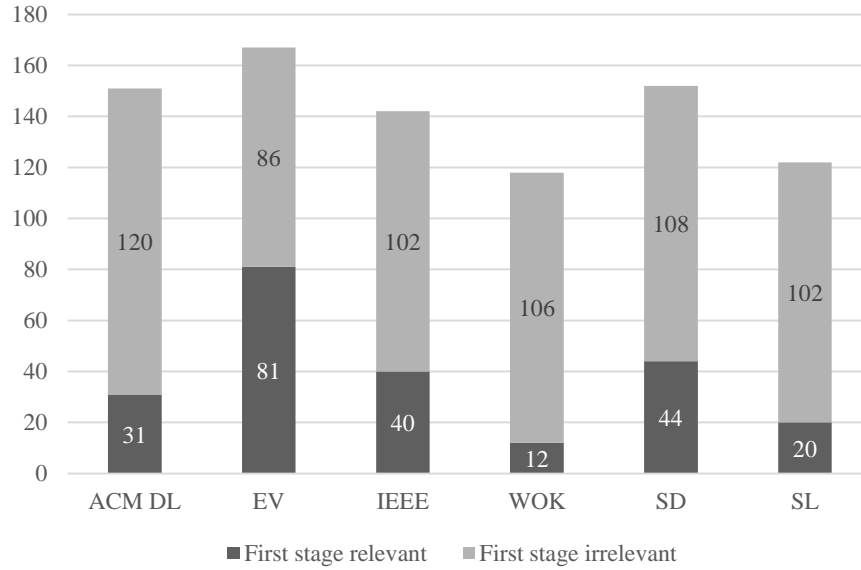
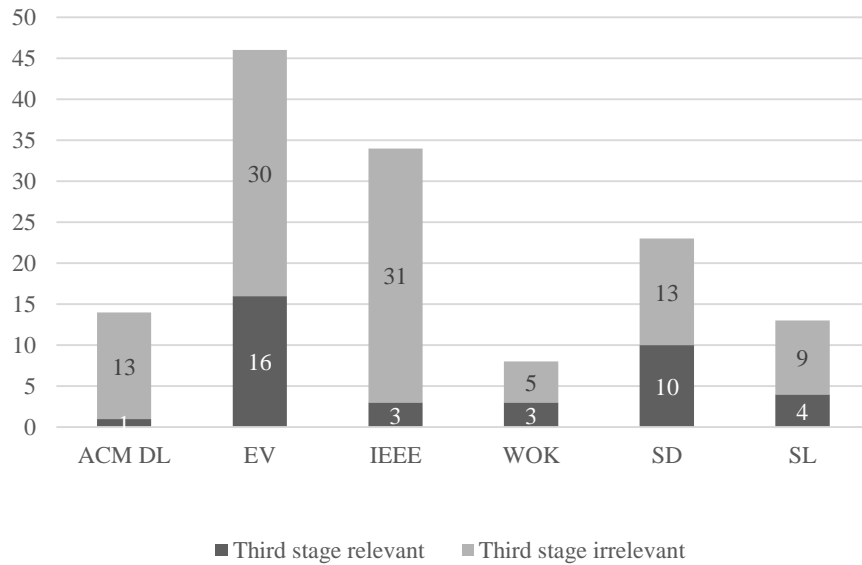**Graph 1.** Primary evaluation
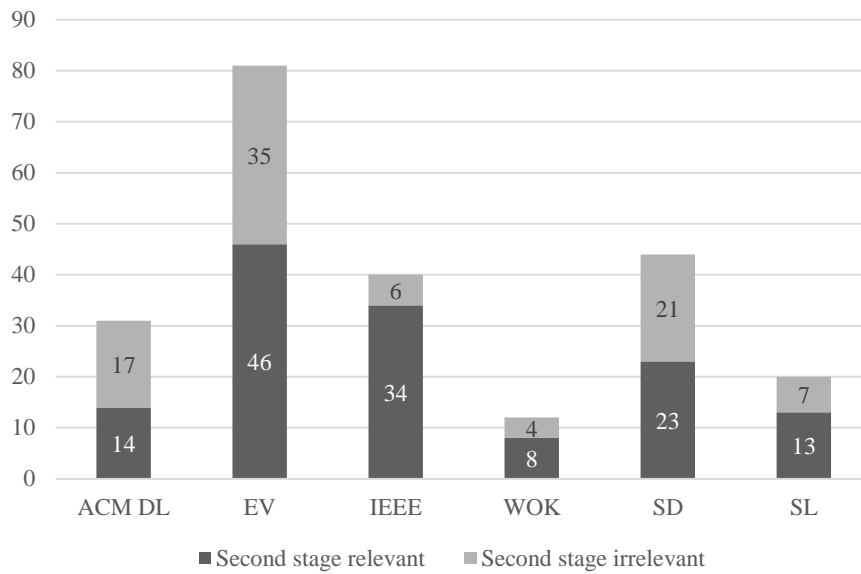
Graph 2. Secondary evaluation

Second stage relevant articles in this evaluation represent 60.53% of all the articles at this stage, and 16.20% of all 852 articles. This means that 138 articles were selected as

second stage relevant from the secondary evaluation. The majority, or 46 of *second stage relevant* articles, were found in the digital library Engineering Village.

After that, a third evaluation was conducted (Graph 3). The input was 138 *second stage relevant* articles from the secondary evaluation. The extraction process at this point was conducted based on the entire article's content.

■ Third stage relevant   ■ Third stage irrelevant

Graph 3. Tertiary evaluation

After tertiary evaluation, 26.81% of articles were left, which corresponded to 37 *third stage relevant* articles, which constitute 4.34% of all 852 articles. These articles were used as inputs for the final, quarterly evaluation (Graph 4). The extraction process at this point was conducted based on a detailed review of the entire content.

■ Final relevant   ■ Final irrelavant
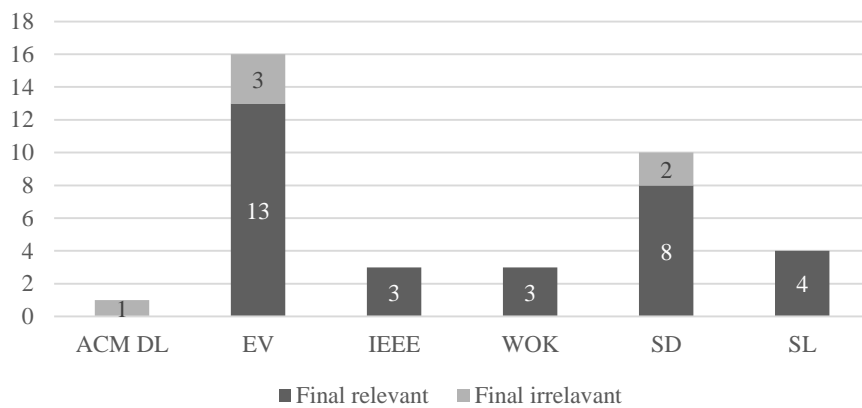
Graph 4. Final evaluation

At this stage, only six articles were *irrelevant* and 31 articles were left for further research. This final group of *relevant* articles made up 83.78% of all the articles in this phase and 3.64% of all 852 analyzed articles.

To summarize our findings, all evaluation stages are presented in Figure 2. The first pie chart shows the number of all articles found when entering the search string, without any evaluation. Based on a pre-evaluation, 852 articles were selected and given to further evaluation. The other four pie charts represent each of the evaluations made and number of each stage's relevant or irrelevant articles.
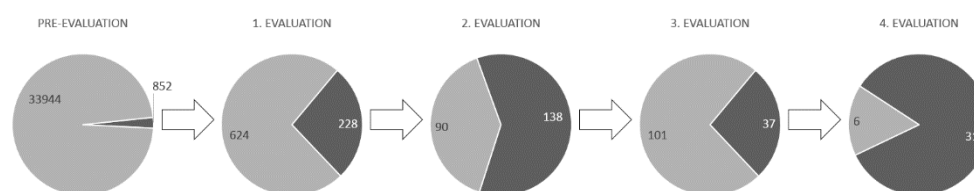
Figure 2. Evaluation process

The results were obtained in accordance with the SLR methods, thus no additional evaluation was performed. Furthermore, data from each article was recorded using the attributes from Table 4. The final result of the whole search process is presented in Table 6, which consists of the following columns: *ID*, *author*, *date*, *study type*, *topic area*, *research method*, and *digital library*.

**Table 6.** Systematic review studies

ID	Author	Date	Study type	Topic area	Research method	DL
A1	Aagesen and Krogstie [1]	2010	Presentation	BP in general	*Case study	SL
A2	Birkmeier and Overhage [2]	2010	Comparison, evaluation	BP in general	Experiment	EV
A3	Börger [4]	2011	Analysis	BP in general	*Analysis	SL
A4	Bulander [6]	2010	Evaluation	BP in practice	Questionnaire	IEEE
A5	Chinosi and Trombetta [7]	2012	Evaluation	BP in general	Questionnaire	SD
A6	Cruz et al. [10]	2012	Analysis	BP in general	*Case study	IEEE
A7	Dubani et al. [16]	2010	Analysis	BP in practice	Case study	EV
A8	Figl et al. [18]	2013	Comparison	BP in general	Experiment	SD
A9	Kruczynski [23]	2010	Evaluation	BP in general	Experiment, interview	EV
A10	Kumar et al. [49]	2014	Presentation	Extension of BP	*Analysis	IEEE
A11	Magnani and	2007	Presentation,	Extension	*Case study	EV

ID	Author	Date	Study type	Topic area	Research method	DL
	Montesi [24]		analysis	of BP		
A12	Muehlen and Recker [28]	2008	Evaluation	BP in general	*Analysis	EV
A13	Muehlen et al. [27]	2007	Evaluation	BP in general	*Case study	EV
A14	Müller and Rogge-Solti [29]	2011	Presentation	BP in practice	*Case study	EV
A15	Ottensooser et al.[33]	2012	Comparison, evaluation	BP in general	Experiment	SD
A16	Recker [38]	2008	Evaluation	BP in general	Questionnaire	EV
A17	Recker [44]	2012	Comparison, evaluation	BP in general	Questionnaire	SD
A18	Recker [40]	2010	Evaluation	BP in general	Questionnaire, interview	EV
A19	Recker [42]	2010	Analysis	BP in general	Questionnaire	SD
A20	Recker [41]	2010	Analysis	BP in general	Questionnaire	WOK
A21	Recker [39]	2009	Comparison	BP in general	*Analysis	WOK
A22	Recker [43]	2012	Analysis	BP in general	*Analysis	SL
A23	Recker and Rosemann [36]	2010	Evaluation	BP in general	Questionnaire	SD
A24	Recker et al. [34]	2010	Evaluation	BP in general	Interview	EV
A25	Recker et al. [37]	2006	Comparison	BP in general	*Case study	EV
A26	Recker et al. [35]	2011	Evaluation	BP in practice	Questionnaire	EV
A27				BP in general		
	Reisig [45]	2013	Analysis		*Analysis	SL
A28	Ritter et al. [46]	2011	Presentation	BP in practice	*Case study	EV
A29	Rosemann et al. [48]	2006	Comparison	BP in general	*Analysis	WOK
A30	Solís-Martínez et al.[50]	2014	Presentation	Extension of BP	*Analysis	SD
A31	Verdouw et al. [51]	2010	Presentation	BP in practice	Interview	SD

As represented in Table 6, the most common research method was a questioner (in 10 relevant articles), followed by analysis. Majority of articles (or 22 articles) addressed business process in general (e.g. complexity of process notations, conceptual modelling, and usefulness of different process notations). As also evident from the analysis of the

results, the collaboration between researchers varies, therefore some of the authors occur several times.

Collected data from relevant articles was analyzed and the results are presented below (Graph 5 to Graph 9). Each article has its own publishing source. We introduced an attribute *Source* that has the following range of values: journals, conferences, and books (Graph 5).
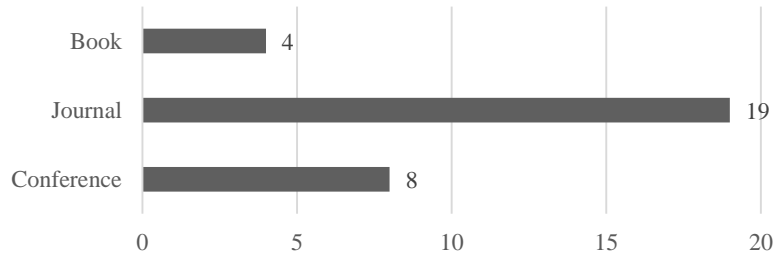
Graph 5. Source type

The most articles (i.e. 19) are journal contributions. Conference articles also constitutes a large share (i.e. 8).

The second analyzed attribute is *Number of articles by year*. The attributes' values range from the years 2006 to 2014, as can be seen in Graph 6. The search was limited from the year 2004 onwards, since the first version of the BPMN was published that year. The graph represents a distribution of articles by year after two different evaluation phases (second and final evaluation). As previously mentioned, the extraction process of second evaluation was conducted by reviewing the whole content of articles, while the year of the publication was also collected at that point.
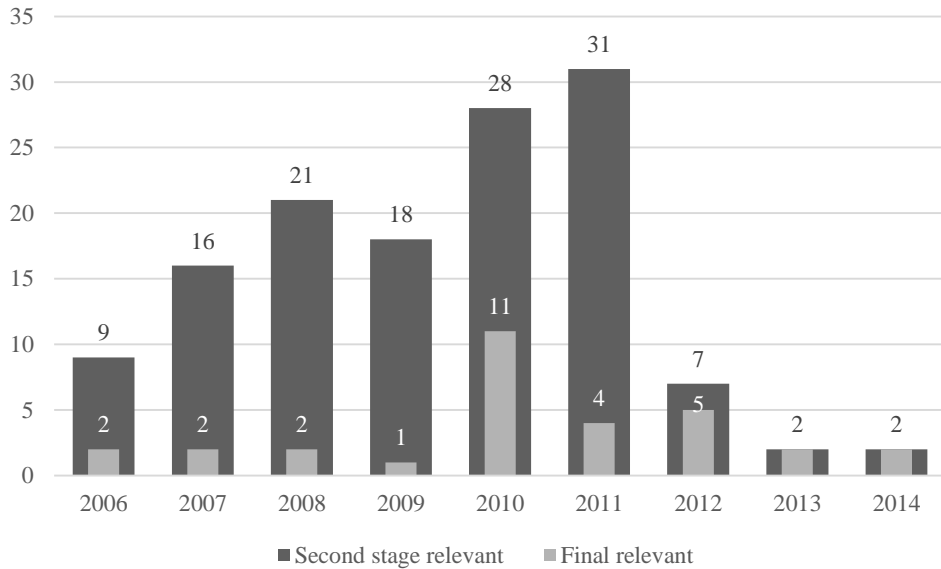
Graph 6. Number of articles by year

As can be seen, the number of articles regarding BPMN differs depending on the year of publication. After the second evaluation, the distribution was growing equally, especially from 2006 to 2011. The results after the final evaluation are slightly different. The maximum number was reached in 2010, with 11 suitable articles.

The next attribute we examined was the *Research domain*. Every suitable article was categorized into one of the predefined domains with the following range of values: *business processes in general*, *business processes in practice*, and the *extensions of business process* (Graph 7). The domain *Business process in general* deals with general aspects of the BPMN. The second domain refers to articles, where the practical use of BPMN was introduced. Possible extensions in BPMN are covered in the third domain.
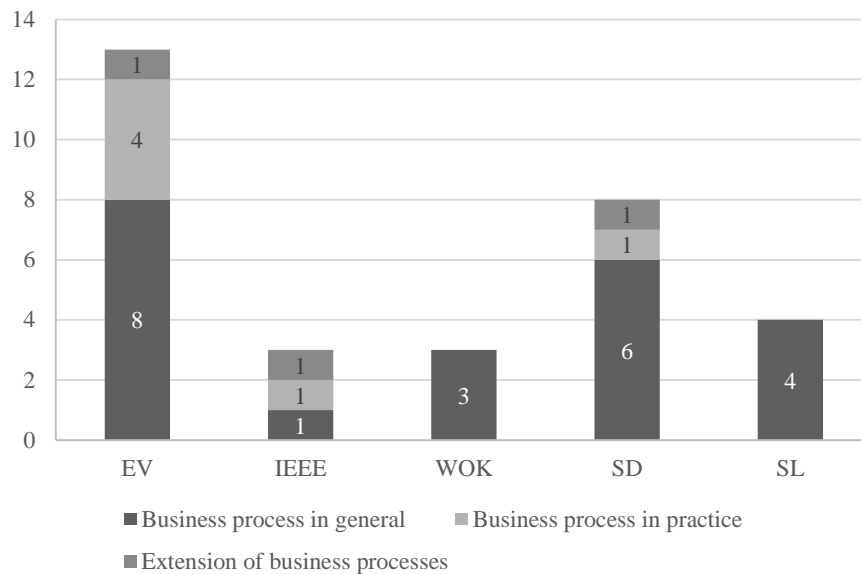

Graph 7. Research domain

The domain *Business process in general* is best represented, with 70.96%. Articles within this domain discuss the frequency of use of a certain element of BPMN, modelling tools, advantages and disadvantages of BPMN, etc.

The research methods that were used in articles are shown in Graph 8. The identified methods that occurred were case study, interview, experiment, questionnaire and analysis.

As can be seen, the most used method was questionnaire. However, it should be stressed that 48.38% of research did not explicitly specify the research method they used (marked as not explicitly specified in the graph).

Furthermore, we also explored the *Purpose of the research*, where the main reason for the research was examined. As is evident from Graph 9, the purpose was mainly to present, evaluate, compare or analyze BPMN.
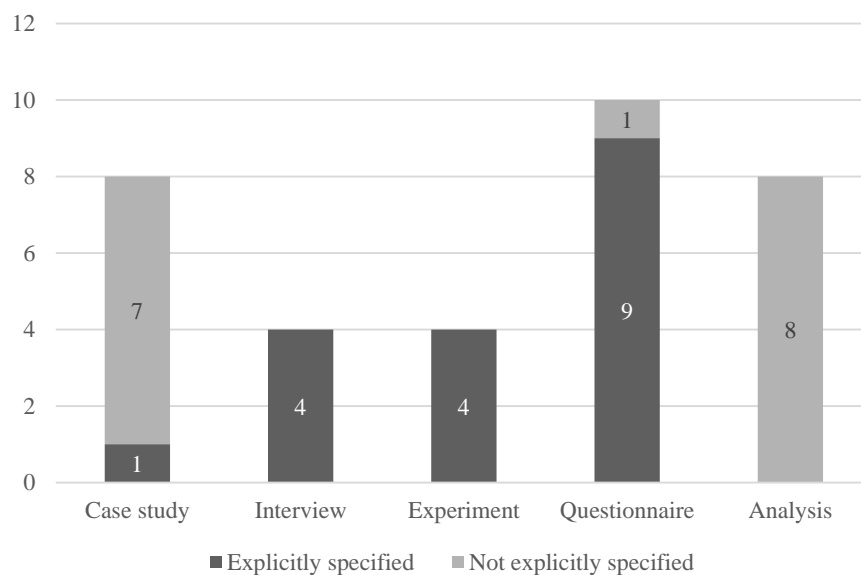
Graph 8. Research method
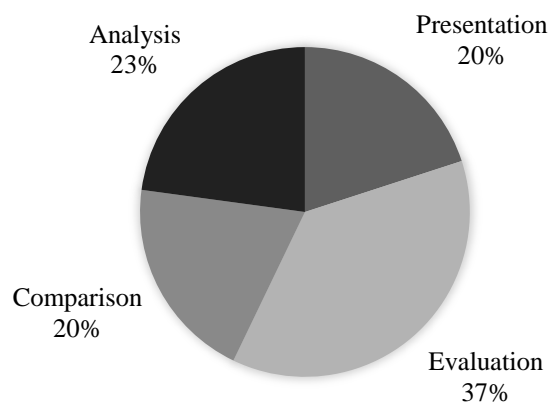
Graph 9. Purpose of research

Our research included 37% of articles that addressed BPMN evaluation. The authors were primarily evaluating the suitability for use, the biggest issues of users, evaluating the modelling tools, etc.

3.1. Analysis of references

The connection between the 31 relevant articles obtained during SLR is represented in Figure 3. Connections (arrows) represent citations between articles, where each article (node) can have either an incoming or outgoing connection, or both. If a connection goes from node A to node B, this means that article A quoted article B. The graph designed from references of articles, was made with Prefuse – the information visualization toolkit [15].

It should be noted, that from the set of all relevant articles, only 12 of them have incoming and outgoing connections. Furthermore, three articles have incoming connections and another 10 articles have outgoing connections. There are also six articles that have no reference to other relevant articles and were also not cited in other articles. These articles are: A4, A7, A10, A11, A28, A31 and are not shown in Figure 3.
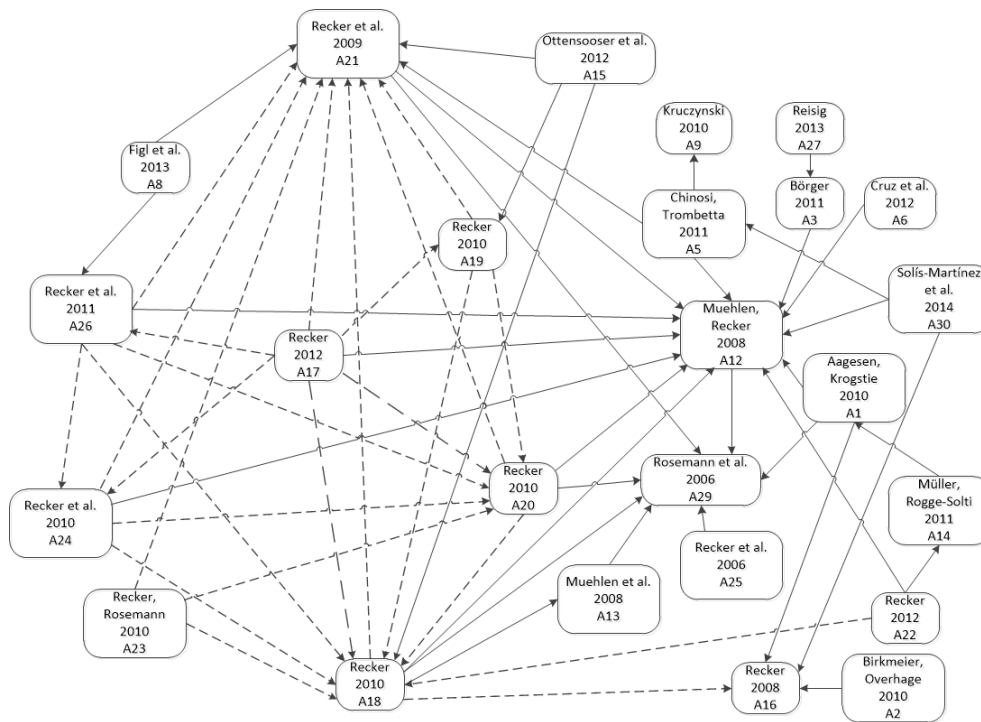
Figure 3. Network of relevant articles

Articles with the maximum number of incoming connections are as follows: A12, A21, A18 and A29. These connections clearly illustrate the frequency of referencing of articles. Article A12 has 12 incoming connections and is the most frequently cited article of our SLR. It is followed by article A21, with 10 incoming connections. The articles with the highest number of outgoing connections are A17 (seven connections), A18 and A26 (each with five connections).

The number of connections between articles varies. The average number of all connections of all relevant articles is 1.87. The most cited article, A12, has 20.69% of

all connections. All four of the most cited articles together account for 63.79% of all connections.

Citations between articles were investigated also from the perspective of self-citations. While there are several different types of self-citations, we analyzed the relevant articles according to [9], which defines self-citation also as a citation, where *'the papers share the first author'*.

The results of our analysis indicate, that 41% of all citations are made up of self-citations, which is in accordance with the number of self-citations as reported by Couto et al. [9]. In research [8], authors reported that the scientific work tends to receive between 20% and 40% of self-citations. This is also visualized in Figure 3, where dashed arrows represent self-citations, which share the first author.

Self-citations enable researchers to connect their present work with the previous findings without too much repetition [9] and are also a natural part of the communication process [8].

To complement the graph in Figure 3, a deeper examination of each connection between relevant articles was made. The objective was to determine in which part the article was quoted, e.g. in the introduction, related work, research method, etc. Table 7 presents the result of this analysis. The attributes *Location of quote* and *Number of quotes* are the most essential attributes. The allowed values of the attribute *Location of quote* are Introduction, Background and theory, Related works, Research method, Results, validation of Hypotheses/RQ, Discussion, Conclusion, Implications for the future, and Limitations. The allowed values of the attribute *Purpose of quote* are: Reconcile (largely explained indication of *Target article*), Opposing (*Source article* opposes to *Target article*), Direct quote (direct indication of *Target article*), and Example (presentation of an example from *Target article*).

Only 22 articles were marked as *Source articles*. Another six out of 31 did not contain any quotes from a relevant article, whereas another three articles were included indirectly, because they have only been quoted by other relevant articles, but did not quote any of them.

Table 7. Locations of quotes

Source article	Source year	Target article	Target year	Year diff.	Loc. of quote	Num. of quotes	Purpose of quote
A1	2010	A16	2008	2	Background and theory	3	Reconcile
					Conclusion	1	
		A29	2006	4	Background and theory	2	Reconcile, Opposing
		A12	2008	2	Results	3	Reconcile
A2	2010	A16	2008	2	Background and theory	1	Reconcile
A3	2011	A12	2008	4	Discussion	3	Reconcile, Opposing
A5	2012	A9	2010	0	Related works	1	Reconcile
		A12	2008	2	Results	1	Opposing
		A21	2009	1	Related works	1	Reconcile
A6	2012	A12	2008	4	Conclusion	1	Reconcile

Source article	Source year	Target article	Target year	Year diff.	Loc. of quote	Num. of quotes	Purpose of quote
A8	2013	A26	2011	1	Discussion	1	Opposing
		A21	2009	3	Research method	1	Reconcile
A12	2008	A29	2006	2	Introduction	1	Reconcile
A13	2007	A29	2006	1	Introduction	1	Reconcile
					Results	1	
A14	2011	A1	2010	1	Background and theory	1	Reconcile
A15	2012	A19	2010	2	Related works	1	Reconcile
		A18	2010	2	Introduction	1	Reconcile
		A21	2009	3	Introduction	1	Reconcile
					Background and theory	1	
					Related work	1	
A17	2012	A24	2010	2	Background and theory	4	Example, Direct Quote
					Discussion	1	Reconcile
					Limitations	1	
					Introduction	1	
		A26	2011	1	Background and theory	3	Reconcile
					Discussion	1	Direct quote
					Conclusion	1	Reconcile
		A21	2009	3	Introduction	1	Reconcile
					Introduction	2	Reconcile
		A20	2010	2	Background and theory	4	Reconcile, example
					Results	3	Reconcile
					Conclusion	2	
					Introduction	1	
		A12	2008	4	Background and theory	1	Reconcile
					Introduction	1	
		A18	2010	2	Background and theory	1	Reconcile
					Research method	1	
					Introduction	1	
		A19	2010	2	Background and theory	1	Reconcile
					Results	1	
A18	2010	A29	2006	4	Background and theory	1	Reconcile
		A13	2007		Background and theory	1	Reconcile
				3	Conclusion	1	

Source article	Source year	Target article	Target year	Year diff.	Loc. of quote	Num. of quotes	Purpose of quote
		A16	2008	2	Background and theory	1	Reconcile
		A12	2008	2	Background and theory	1	Reconcile
					Results	2	
					Conclusion	1	
		A21	2009	1	Introduction	1	Reconcile
					Background and theory	1	
A19	2010	A20	2010	0	Introduction	1	Reconcile
					Background and theory	1	
		A18	2010	0	Introduction	1	Reconcile
		A21	2009	1	Background and theory	1	Reconcile
A20	2010	A21	2009	1	Introduction	1	Reconcile
					Implications for future	1	
		A18	2010	0	Introduction	1	Reconcile
					Background and theory	1	
		A29	2006	4	Background and theory	2	Reconcile
		A12	2008	2	Background and theory	1	Reconcile
A21	2009	A29	2006	3	Introduction	1	Reconcile
		A12	2008	1	Results	1	Reconcile
A22	2012	A12	2008	4	Background and theory	1	Reconcile
		A18	2010	2	Introduction	1	Reconcile
		A14	2011	1	Background and theory	1	Reconcile
A23	2010	A18	2010	0	Background and theory	1	Direct quote
		A20	2010	0	Validation of hypotheses/RQ	1	Direct quote
					Implications for future	2	Reconcile
		A21	2009	1	Introduction	1	
					Background and theory	3	Example
					Limitations	1	
A24	2010	A20	2010	0	Background and theory	1	Reconcile
		A18	2010	0	Introduction	1	Reconcile
					Background	1	

Source article	Source year	Target article	Target year	Year diff.	Loc. of quote	Num. of quotes	Purpose of quote
		A21	2009	1	and theory Background and theory	4	Reconcile
					Validation of hypotheses/RQ	3	
		A12	2008	2	Background and theory	1	Reconcile
					Results	1	
A25	2006	A29	2006	0	Related work	1	Reconcile
					Results	2	Opposing
A26	2011	A24	2010	1	Background and theory	1	Reconcile
					Discussion	1	
					Implications	1	
		A21	2009	2	Introduction	1	Reconcile
					Background and theory	1	
		A20	2010	1	Background and theory	1	Reconcile
					Results	1	
					Discussion	1	
		A18	2010	1	Research method	1	Reconcile
		A12	2008	3	Discussion	1	Reconcile
A27	2013	A3	2011	1	Discussion	2	Opposing
A30	2014	A5	2012	2	Introduction	2	Direct quote
					Background	1	Direct quote
					Results	1	Reconcile
		A12	2008	6	Results	2	Reconcile
		A16	2008	6	Background	1	Reconcile
					Results	1	Reconcile

Notes: Source article – articles, where the references were reviewed, Source year – the year when the source article was published, Target article – cited article, Target year – the year when the target article was published, Year differential – difference in years between source and target article, Location of quote – represents the location, where the target article was quoted, Number of quotes – represents the number of quotes of target article in source article, within certain location, Purpose of quote – represents the purpose of the use of the quote

As shown in the table above, the total number of identified citations in all relevant articles was 128. The average number of citations per article is 4.13. 17.97% of all citations were identified in the introduction. The highest percentage of citations (39.84%) was identified in the part *Background and theory,* another 15.63% of citations were found in chapters, where the results of the studies were presented. In other

locations, the percentages are lower: Conclusion (5.47%), Discussion (7.03%), Related works (3.91%), Validation of hypothesis/RQ (3.13%), Implications for future work (3.13%), Research method (2.34%), and Limitations (1.56%). The purpose, of the great majority (77.94%) of citations, was *Reconcile*. The percentages of the other purposes are: Opposing (8.82%), Direct quote (8.82%) and Example (4.41%).

4.   Discussion

In the first part of this section, we discuss three main issues, covered in our research questions. In the second part of this section, other fields of interest, identified through research, are discussed.

4.1.   Answers to research questions

Based on the relevant articles (Table 6), the answers to the RQ, defined in section 2.1 are provided.

Are there any empirical insights about the level of BPMN acceptance?

In order to answer the stated research question, the subset of relevant articles, which addressed the level of acceptance of BPMN were further analyzed.

The earliest known research regarding the acceptance of BPMN was conducted in 2006, which is reasonable, since the standard was first introduced in 2004. In light of this, [A29] and its earlier study [A25] stated that BPMN was a recently proposed standard driven by the demand for a graphical notation that complements the BPEL4WS standard for executable business processes. This gave BPMN a technical focus although the intention of the BPMN designers was to develop a modelling technique that could be applied to typical business modelling activities as well.

Three years after the introduction of BPMN, an article [A4] from 2007 presented a business process modelling game to learn BPMN 1.0 notation. The article reported that serious games could be a good opportunity to enrich higher education, to simulate scenarios of the real world and to enhance didactics for students. This was once again addressed in a 2008 [A16], where authors argued that BPMN is accepted and used among business people as well as among academics. This was again confirmed in 2010 [A1], where authors reported that BPMN seeks to serve both: (1) a broad audience in the business segment and (2) to reach out to the technical community. An example of the use of BPMN in the educational field was demonstrated in article [A4], where once again, a business process modelling game to learn BPMN notation was presented.

Another perspective of BPMN acceptance is presented in article [A12], which was published in 2008. It investigates subsets of modelling constructs and how their usage varies among different areas of use. The authors analysed 120 models and found out that BPMN 1.0 was used in groups of several, well-defined construct clusters. However, less than 20% of its vocabulary was regularly used and some constructs (i.e. BPMN elements) did not occur in any of the models analysed. Similar issues were also

discussed in [A13], where the authors concluded that, in some cases, an increase in constructs did not always lead to better modelling results.

The acceptance of BPMN is also reflected in a number of modelling tools that support BPMN, which are clearly defined in BPMN 2.0 specification [32]. BPMN 2.0 states that a software can claim compliance or conformance with BPMN if and only if the software fully matches the applicable compliance points, defined in the specification. On the other hand, if a software only partially matches such compliance points, a software can claim only that it is based on BPMN. In this light, authors specified ten modelling tools and exposed the most popular tool, namely Microsoft Visio [A18]. However, according to BPMN 2.0 specification, Microsoft Visio cannot be classified into BPMN process modelling tools. Instead, it is only a diagraming tool [31] since it does not implement BPMN abstract and DI meta-models. As such, diagraming tools do not ensure any syntax check and do not enable implementation or simulation, which can be achieved by meta-model based tools (e.g. Bonita, Signavio, BizAgi, IBM WebSphere).

An article [A24] from 2010 performed an analysis of BPMN using a theory of ontological expressiveness and explored actual grammar use. Their research uncovered five contextual factors that appear to influence the usage of BPMN: the use of modelling tools, the use of modelling conventions, the modeller experience, the modelling role and the modelling purpose. As stated by authors, BPMN satisfies these conditions. Therefore, BPMN is justifiably proclaimed as the *de facto* standard for process modelling [A18]. A high degree of acceptance is also indicated in [A19] from 2010, where the results show that in average, BPMN users do not undergo any formal training in grammar usage. In total, 418 participants learned BPMN via self-education, while 109 attended any kind of formal training. Modellers from IT found BPMN grammar to be particularly useful for their (IT-oriented) process modelling tasks, as reported by [A20], [A23].

More recently, research [A15] conducted in 2012 analysed the success in interpreting a business process description. In light of the experiment, participants used an established graphical notation (BPMN) and an alternative textual notation (based on written use-cases). The best results came from presenting the business process twice: in form of a written use-cases, followed by equivalent BPMN diagrams. As the authors concluded, this was the most effective way to build up a comprehensive process.

A few months after the BPMN 2.0 specification was published (2012), article [A5] reported that BPMN was still being perceived as the leading standard with respect to business process and workflow modelling languages. It also reported that BPMN 2.0 was being used by nearly 40% of the interviewed users, while almost 30% of them used BPMN 1.2 and 15% used a combination of both.

The above results of the first research question are summarized in Table 8.

Additionally, empirical insights about the level of acceptance can also be provided from Google Trends [20]. Although not part of the SLR, the data from Google Trends is still relevant. With the use of Google Trends we were able to get an insight into how often "BPMN" search string appears, which represents the degree of popularity over the ten years (from 2004 until 2014). The growth is shown on Graph 10. Values represents the level of acceptance by Google Trends, with a range between 0 (minimum) and 100 (maximum).

Table 8. Findings for 1. RQ

Article	Publication year	Major findings
A29, A25	2006	BPMN was proposed standard that stemmed from demand for graphical notation that complements other standards.
A4	2007	Serious games could be a good opportunity to enrich higher education, to simulate scenarios of the real world and to enhance didactics for students.
A13	2007	In some cases an increase in constructs does not lead to better modelling results.
A16	2008	BPMN is accepted and used among business people as well as among academics.
A12	2008	BPMN 1.0 was used in groups of several, well-defined construct clusters, but less than 20% of its vocabulary was regularly used and some constructs did not occur in any of the models analysed.
A1	2010	BPMN seeks to serve to a broad audience in the business segment and to reach out to the technical community.
A24	2010	Research uncovered five contextual factors that appear to influence the usage of BPMN: the use of modelling tools, the use of modelling conventions, the modeller experience, the modelling role and the modelling purpose. According to previous presented research, BPMN satisfies these conditions
A18, A19	2010	BPMN is justifiably proclaimed as the *de facto* standard for process modelling.
A20, A23	2010	Modellers from IT found BPMN grammar to be particularly useful for their (IT-oriented) process modelling tasks.
A15	2012	The most effective way to build up a comprehensive process is to present the business process twice: in the sequence of a written use case set, followed by its equivalent set of BPMN diagrams.
A5	2012	It also reported that BPMN 2.0 was being used by nearly 40% of the interviewed users, while almost 30% of them used BPMN 1.2 and 15% used a combination of both.

The milestones of BPMN are in accordance with the publication of newer versions of the standard. The biggest difference between the values were detected in 2007, almost three years after BPMN 1.0 was published, and right before version 1.1. The highest value was reached in 2011, a few months after version 2.0 was released. In 2014 the demand increases again.
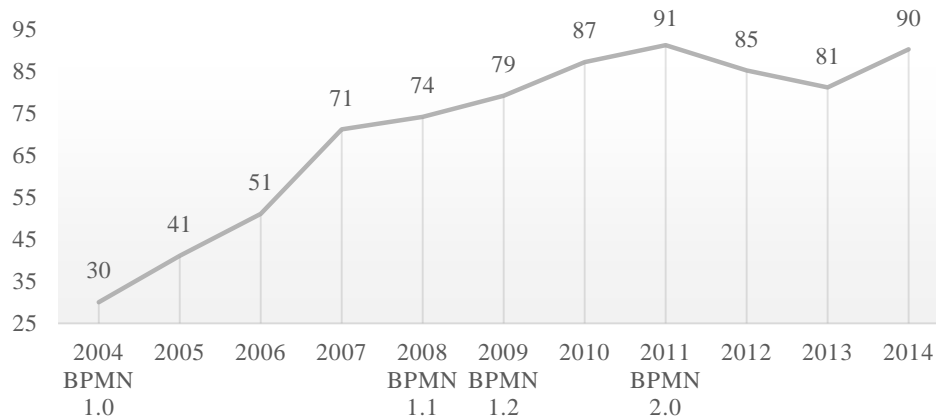
Graph 10. BPMN acceptance by Google Trends[*]

According to Graph 6, where the relevant articles are ordered by the year of publication, this data can be compared to Google trends (Graph 10). An increase between 2008 and 2011 can be noted in both graphs. However, the validity of this conclusion might be impacted due to the low number of relevant articles.

Additionally, the value from Graph 10, can be mapped to Gartner's Hype Cycle [19]. We can say with great certainty that BPMN has already passed the first phase, called "Technology Trigger." The high level of popularity in the years 2009, 2010, and 2011 and subsequent decrease in popularity over the last two years, indicates that BPMN is now somewhere in the second phase of Gartner's Hype.

After all the given facts from relevant articles and other given criteria, we can provide a response to the first research question. Empirical insights about the level of acceptance are present and the number of insights (i.e. Google Trends) grows through the years. We can confirm that, with respect to all existing and reviewed literature, BPMN is now a strongly accepted standard in the field of business process modelling. However, the degree of acceptance may be subject to further research.

For what purposes is BPMN used?

In addition to analysing the acceptance of BPMN, we also investigated for what purposes the standard used was used. To this end, it was concluded that BPMN appears to have been designed to fit a wider variety of process modelling purposes, beyond the typical communication and requirements specification [A21]. BPMN is generally used for typical AS-IS application areas such as: business analysis, workflow specification, requirements analysis, and system configuration [A18]. Article [A5] indicates that BPMN can also be used for description, e.g. documenting (52%), simulation (11%), and execution of processes (37%).

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[*] Assessed on: 4 November 2014
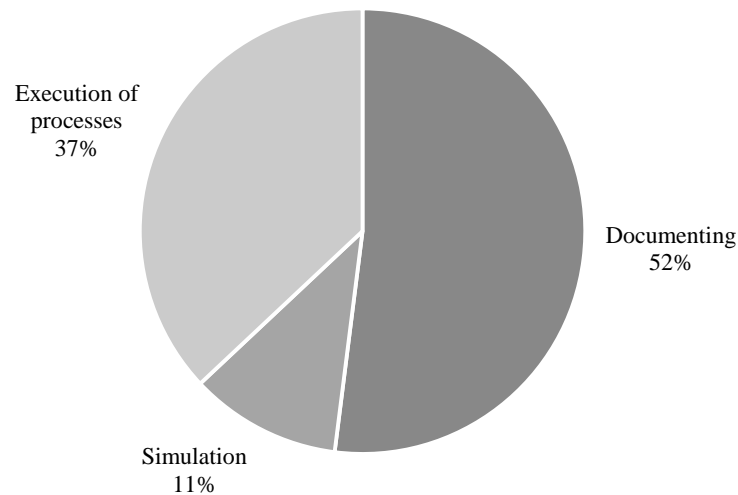
Graph 11. Purpose of use

This numbers are confirmed with states from article [A18] from 2010, which said that Microsoft Visio is the most popular tool for modelling. There we see that the purpose of the use is more than half of the cases, writing the documentation. There is actually no need for syntax checks and execution or simulation.

Furthermore, the authors stated that BPMN was probably the best choice for descriptive purposes at the time of the research (2011) in academia and other organizations [A6].

BPMN has also been used for modelling processes in the industry. Article [A31] presents the practical uses of BPMN in a reference model for designing business processes in a demand-driven fruit supply chain. The BPMN was chosen in order to ensure a smooth connection to SOA-based information systems. The authors further discussed that the developed model in BPMN makes a valuable starting-point for the implementation of the designed process models in an SOA platform.

BPMN is also often used in combination with other technologies. Article [A8] focused on a concrete example with an IT background. The experiment showed that YAWL notation suffered from weak discriminability of the XOR and AND routing symbols. In contrast, BPMN offers various options for XOR routing symbols. In [A28] it was shown how a network model[1] can be derived from BPMN, which was selected based on the expectations of using a widely adopted standard.

Despite many different purposes for the use of the BPMN, we concur that the basic and most important purpose of use remains the description of business processes.

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[1] *Network model* is defined as subset of BPMN 2.0 by mapping it onto the basic entities of the network.

What are the advantages and disadvantages of the use of BPMN?

The advantages of BPMN identified in relevant articles are as follows. At its core, BPMN allows for the creation of a Business Process Diagram, which represents the activities of the business process and the flow controls that define the order in which they are performed [A7]. According to [A9], BPMN is considered easy to understand and apply. BPMN also supports the transformation of business models in execution languages, like BPEL, which is a definite advantage of BPMN. Also, organizational structures are modelled in manageable pools or swim-lanes. Thus, a good optical representation of the B2B (business-to-business) and B2C (business-to-consumer) sector can be achieved.

When comparing BPMN to EPC, which is an alternative notation for business process modelling, the comparison in [A19] notes that both notations differ considerably in their ability to define real world domains in a complete and clear manner. Specifically, they found BPMN to be more ontologically complete than EPC. One of the most important advantages is also the composition of BPMN. Article [A25] shows that BPMN performs well in terms of capturing the control flow and handling data in a process.

A different perspective is presented by the authors in [A11], where extensions of BPMN are proposed. They define relevant subsets of BPMN, extend them with the concept of cost, which enables process re-engineering and analysis. On the basis of the article, we can assume that BPMN is commonly used in combination with other technologies and is also very extensible.

In article [A30] an approach capable of adapting a simplified version of BPMN to different specific domains, generating simpler BPMN notations specifically adapted to the given domain. Another adoption of BPMN is reported in [A10], where author introduce a concept of configurable BPMN to model and represent all the possible variations of the Enterprise domain.

With regard to the tools that support BPMN modelling, article [A17] examines how the use of seven different features of modelling tools affects usage beliefs. The authors stress that, in general, tool functionality can positively contribute to usefulness and ease-of-use perceptions as well as general satisfaction with the modelling language. Similar issues are discussed in [A26].

The relevant articles, obtained by the SLR, also address the disadvantages of BPMN. Specifically, in [A14] authors try to adjust BPMN to the needs of the medical/health domain. In the paper, the idea of incorporating role information in colours of tasks in the BPMN model, is presented. They state that the utilization of BPMN as modelling language in a specific domain may be difficult.

Article from 2011 [A3] extensively highlights the weak points in BPMN. Author exposes that BPMN fails to guarantee that standard-confirming business process models are interoperable, further it fails to constitute a basis for reliable communication of business models between different stakeholders, etc. In contrast, article [A27] argues that criteria in [A3] overemphasize less important aspects, while ignoring some decisive ones.

In article [A2] the main objective is to identify whether or not BPMN is more usable for business users than the technically-oriented Activity Diagram. The results of the research indicate that the UML Activity Diagram is at least as usable as BPMN since neither user effectiveness, efficiency, nor satisfaction differ significantly between the

notations. One very specific disadvantage, detected in the article, is that the semantics of the UML Activity Diagram in version 2.x has been more clearly defined than in BPMN and the separation of control and data flow introduces additional complexity.

In [A11], it is reported that BPMN is very powerful with respect to the representation of activities and their cooperation, but it does not natively support the concept of cost in process, which would enable process re-engineering and analysis.

It can be concluded that the rapid spread of BPMN would suggest that advantages outnumber the disadvantages. When taking the aforementioned disadvantages into consideration, the standard is still perceived as the *de facto* standard in the business process modelling field [A5].

4.2.   Others fields of interest

Our research aprioristically includes the aforementioned research questions. Posteriorly, we also came across relevant topics, which are presented below.

To use BPMN in practice, the use of modelling tools is strongly encouraged. There is also the option of drawing a business process by hand, but it is not a common practice. Modelling with tools is much easier for the user, because it usually offers a certain (core or full) range of elements and supports the validation of end-models. Some tools also provide model repositories in which models can be stored and also imported into different notations for process modelling. In 1993, the first work sequences appeared to aid users describe the workflows and to document the process steps [7]. Nowadays, the situation is different in the following manner. Article [7] reports that 60% of interviewees used a tool with an embedded simulation environment. The most preferred BPMN editor is BizAgi [3], but the best open-source software is Bonita, according to [7]. Another article [44], which also deals with modelling tools, reports that they became very sophisticated and provided extended functionality. In the scope of our SLR, the most frequently reported tools were identified, where Microsoft Visio was by far the most popular tool.

As previously mentioned, one tool can enable few different notations for process modelling. One modelling language can complement the other, in order to achieve the best modelling results possible. During our SLR research, the extensions for BPMN were identified. In [47] the authors concur that a great part of the success of the modelling has to do with the ability to express the different needs of a business as well as to have a notation in which the needs can be described. BPMN provides an opportunity to incorporate, e.g. security requirements, which allows us to improve this aspect of the system from the early stages of software development. The other example of extending BPMN is described in [14], where the weaknesses of BPMN are identified, regarding its suitability for choreography modelling. To this end, several extensions are proposed to overcome these limitations.

Some users identified BPMN as complex [17], and see the solution of this in simplifying the BPMN notation. They change the elements that could provoke confusion and came to the conclusion that their proposed solution, SBPMN (Simple BPMN), allows users of all levels to model or design the processes without any technical knowledge.

Another identified perspective of our research were the alternatives to BPMN. The first alternative is UML AD (Unified Modelling Language Activity Diagram). In article

[2] the usability of BPMN 1.1 and UML AD 2.x was analysed. The authors agreed that UML AD is at least as usable as BPMN. Another comparable notation to BPMN is EPC (Event-driven Process Chain). In [23] an acceptance comparison between BPMN and EPC was made. The analysis show that BPMN leads to more stringent modelling, which diminishes the number of modelling errors. The authors also highlighted that BPMN was developed ten years later than EPC and could be based on existing experiences. It is also important to remember that the transformation from EPC into BPMN is still possible.

Figure 4 shows the current chapter and provides a quick summary of important content of BPMN discussed in this section. All six concepts are further specified and rely only on conclusions made in the context of this research.
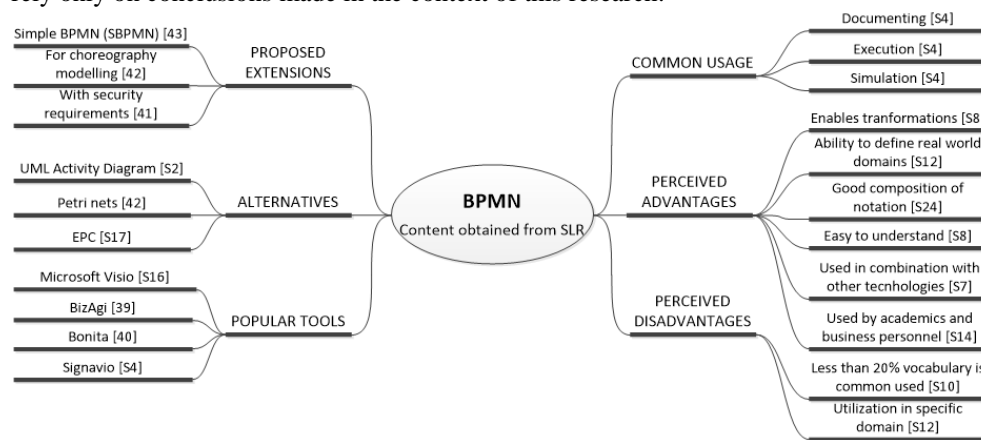

Figure 4. A summary of relevant content

5.   Conclusions

BPMN still holds the title as the *de facto* standard in the process modelling field. This can be confirmed with articles from our SLR. It can be also stated that BPMN is suitable for modelling many different types of processes. Also, BPMN is readable even for those without any knowledge of the notation. An important aspect of existing literature is an analysis of BPMN elements. Some findings suggest that only a limited set of elements are used more frequently. It was also reported that some users might not understand all the elements and consequently do not use them. Considering such limitations, BPMN is still often used, especially in combination with other languages/notations for process modelling.

Since many articles deal with BPMN, we focused only on those involved with acceptance of BPMN. Our results clearly indicate that BPMN is a strongly accepted notation for process modelling. However, the following limitations should be considered when viewing the results. To find relevant literature, it was necessary to compose an adequate search string. Search strings must have an adjusted length and are written using logical operators and quotes. The search string we conducted had to be modified, because of the different requirements of digital libraries' search engines. An adjusted length was especially needed in SpringerLink. Search engines also provide

different information when searching (e.g. abstract, authors, title, keywords), where the majority (67%) had several options to manage the results. The second limitation is choosing adequate digital libraries. Digital libraries have been selected in relation to source [21]. We used: ACM Digital Library, Engineering Village, IEEEXplore, ISI Web of Knowledge, Science Direct and SpringerLink. To access the desired literature, we relied on access provided by the University of Maribor, which represents a third limitation.

5.1.   Implications and future work

The presented results have implications in both theory and practice. From a theoretical point of view, there is still a lot of potential for research in the field of BPMN. For example, in [29] the authors presented a BPMN notation, where instead of lanes, they used different colours to distinguish different roles. Additional research from different business perspectives (e.g. with colouring lanes) could help optimize the notation. This could help to additionally raise the level of usage. As stated in [43], there are "known knowns" about BPMN and, on the other hand, "unknown unknowns", meaning that several fields of research remain unknown. To reveal a small part of these unknowns, we plan on conducting a survey on the acceptance of BPMN on the basis of current research. Additionally, in order to better judge the usability of BPMN for business users, a deeper understanding of its advantages and disadvantages has to be reached.

   In practice, the widespread use of the BPMN standard is a clear sign for companies to at least partially start adopting the standard. As previously mentioned, BPMN can ensure a bridge between IT and the business sector. BPMN models can ensure transparent business processes and obligate the company to optimize processes, reduce costs, and increase productivity. All the identified purposes of use, advantages and disadvantages in our research can also be a benefit to vendors of BPMN modelling tools. They can upgrade their product with an extended set of elements, or even add features to entice users (for example, allowing colour at all levels of the model). Another proposal for vendors would also be to enable extensions in tools (e.g. extensions for choreography modelling [14] or security requirements [47]).

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