

# **Aligning business processes with regulatory requirements**

**a systematic literature review**

Jan-Ru Muller

10/06/2024

# Table of contents

<b>Introduction</b>	<b>4</b>
<b>1 Introduction</b>	<b>5</b>
<b>2 Research question(s)</b>	<b>6</b>
<b>3 Review plan</b>	<b>7</b>
3.1 Resources to be searched . . . . .	7
3.2 Search terms used . . . . .	7
3.3 Study selection criteria . . . . .	8
3.4 Data extraction strategy . . . . .	8
<b>4 Review execution</b>	<b>9</b>
4.1 Research identification . . . . .	9
4.2 Selection of studies . . . . .	9
4.3 Data collection . . . . .	10
4.4 Synthesis of extracted data . . . . .	10
<b>5 Review reporting</b>	<b>14</b>
5.1 Dissemination strategy . . . . .	14
5.2 Limitations . . . . .	14
5.3 Future research . . . . .	15
<b>Appendices</b>	<b>16</b>
<b>A Bibliographic data</b>	<b>16</b>
<b>Literature</b>	<b>23</b>

## List of Tables

3.1	Study selection criteria . . . . .	8
4.1	Relevance to research question . . . . .	11
A.1	Journals . . . . .	16
A.2	Authors . . . . .	17
A.3	Authors . . . . .	17
A.3	Authors . . . . .	18
A.4	Keywords . . . . .	19
A.5	Keywords . . . . .	21
A.5	Keywords . . . . .	22

## Introduction

# 1 Introduction

In the context of the DBA program at Vlerick Business School a literature review is one of two deliverables of year two. The research topic is “BPM for regulatory compliance”. The goal of this review is to get an overview of relevant literature and identify topics listed as possibilities for future research. The type of literature review is a systematic literature review (SLR). The SLR has been performed following the steps described in Kitchenham and Charters (2007).

Chapter 2 states the main research question, three subquestions and provides for a definition of the central concepts.

Chapter 3 is about the planning of the research. It describes the databases that were searched, the search terms used, the criteria for selecting articles and how the bibliographic data and the articles have been obtained.

Chapter 4 concerns the execution of the research. It describes the studies found, which studies have been selected, how the quality of the studies has been assessed, how the data was collected and a synthesis of the data.

Chapter 5 concerns the reporting of the research. It describes how the results of this study will be shared, limitations of the study and possibilities for further research suggesting possible improvements.

## 2 Research question(s)

The research question (RQ) and the three supporting sub-questions (SQ) that are addressed in this literature review are:

RQ: What are approaches for aligning business processes with regulatory requirements to achieve regulatory compliance by design?

SQ1: How can businesses identify relevant regulatory requirements?

SQ2: How can businesses analyze which business processes are affected by changes in regulatory requirements?

SQ3: How can businesses integrate compliance requirements into business process design?

The focus of this review is specifically the first question (RQ). The following is the research question repeated whereby the central terms and concepts in this review are boxed: What are approaches for aligning business processes with regulatory requirements to achieve regulatory compliance by design?

compliance by design

A definition of the three central concepts:

Business process management (BPM) is defined as all activities performed by businesses to discover, model, automate, analyze, measure, improve and optimize business processes (Liu, Müller, and Xu 2007). A business process coordinates the behavior of people, systems, information and things to produce business outcomes in support of a business strategy. Processes can be structured and repeatable, or unstructured and variable.

Regulatory compliance is defined as ensuring that business processes, operations, and practices are in accordance with a prescribed and/or agreed set of norms. These compliance requirements may stem from legislature and regulatory bodies (e.g., Sarbanes-Oxley, Basel II, HIPAA), standards and codes of practice (e.g., SCOR, ISO9000), and also business partner contracts (Hashmi (2015)).

Compliance by design refers to approaches and methodologies where compliance requirements are integrated into business process models and enterprise applications from the very beginning (Sadiq and Governatori 2010). This concept emphasizes embedding compliance within the fabric of business practices rather than treating it as a separate or after-the-fact activity (Lohmann 2013).

## 3 Review plan

### 3.1 Resources to be searched

An initial set of databases was selected to perform the literature search on. Both commercial and open access databases have been selected.

1. Web of Science (WoS), Publisher: [Clarivate](#)
2. ScienceDirect (SD), Publisher: [Elsevier](#)
3. SSNR, Publisher: [Elsevier](#)
4. arXiv, Publisher: [cs](#)
5. dblp, Publisher: [dblp](#)
6. Zenodo, Publisher: [Zenodo](#)

As a test we performed some initial searches. The results of the initial searches was reviewed. SSNR and Zenodo yielded few results as compared to the other databases. The selection of databases was reduced to WoS, SD, SSNR, ArXiv and dblp.

### 3.2 Search terms used

The initial search terms have been formulated as follows:

1. (“business process management” or BPM) and “regulatory compliance”
2. (“business process management” or BPM) and “legal compliance”
3. (“business process management” or BPM) and “compliance”
4. “business process management” and (“regulation” or “regulatory”)
5. “business process \*engineering” and “compliance”
6. “business process \*engineering” and (“regulation” or “regulatory”)

Here too a test has been performed using the search terms. It was found that the combination of “business process management” with “regulatory compliance” or “legal compliance” yielded few results. Consequently, 1 and 2 were skipped. We searched for “business process management” and “compliance” which includes both “regulatory compliance” and “legal compliance”.

### 3.3 Study selection criteria

The quality of an article is assessed on the basis of the 4 criteria(QA1 through QA4). The criteria are equally weighted. An article is assigned 1 point for every QA criterium that is met. An article will thus get score of 0 through 4. Other metrics like author h-index and journal impact factor will not be considered in the selection process.

Table 3.1: Study selection criteria

criteria	code	descriptions
inclusion	IC1	the title, abstract and full text are in english
	IC2	the publication is dated between 2000 and 2024
exclusion	EC1	the reference is to a book(chapter)
	EC2	the article has been retracted
	EC3	the type of article is a conference paper or a preprint
	EC4	a search term has a different meaning
	EC5	the application relates to a specific sector
	EC6	the title, abstract and full text are not in english
quality	QA1	the article is a peer-reviewed journal article
	QA2	the article appeared in one of the legible journals
	QA3	has a citation count higher than 5 per year since the year of publication
	QA4	the first and second author have combined more than 50 publications listed on google scholar

### 3.4 Data extraction strategy

The initial 6 data sources have been reduced to 4 (excluding Zenodo). For the remaining 5 data-sources queries will be formulated for each data source. The resulting records found will be listed in an excel file “slr\_logbook.xlsx”.



## 4 Review execution

### 4.1 Research identification

### 4.2 Selection of studies

The initial searches were done on all database fields. The search was subsequently made more specific by searching titles and abstracts. Lastly we searched titles, abstracts and keywords.

The WoS search yielded 29 hits. Excluding 4 articles with BPM in the title where BPM has a different meaning than “Business Process Management”. For example where BPM is an abbreviation of “Biodiesel Particulate Matter”. Excluding 1 article as it is a double, also occurring in the dblp search.

The ACM search ...

The SD search yielded 7 hits. On the basis of article type (1 book chapter and 1 short communication) we have excluded two articles. An additional article was excluded as the title referred to “Business Process Management Map”, which is a different concept.

The SSRN search yielded 2 results, both excluded as they are preprints.

The arXiv search yielded 0 records when looking for articles with “Business Process Management” or BPM in the title field. Two records were found on the basis of abstract and keyword matches. All the same these records have been subsequently excluded when the exclusion criteria have been applied.

The dblp search yielded 41 records, including 2 books and 35 conference papers. After exclusion 4 records remain, 3 journal articles and one PhD thesis. For the next step, the abstract scan, the thesis has been replaced by a journal article by the same author about the same topic.

The Zenodo search yielded 0 records when looking for articles with “Business Process Management” or BPM in the title field.

Six additional records have been included identified via different sources: 4 journal articles, 1 PhD thesis and 1 conference paper. Here too, for the next step in the process the thesis has been replaced by a journal article by the same author about the same topic.

The abstracts of the remaining 21 articles are listed in “Abstracts”, **?@tbl-review-abstracts**.

For the final list we only consider the 9 articles where three or more conditions are met (see: appendix E, **?@tbl-full-text-included**).

### 4.3 Data collection

The output of each query has either been a bib file or a ris file. All bib files have been converted to ris files. The mapping of bibliographic elements to the ris fields differs per data sources. A script has been written to get to a uniform ris-format.

The open access databases do not contain the full text articles if the articles are not open access. DBLP also doesn't contain abstracts. The absence of full text articles or abstracts is explained by constraints imposed by copyrights.

The excel file containing the article lists has been stored on zenodo for future reference ([zenodo 10795823](https://zenodo.org/record/10795823)).

### 4.4 Synthesis of extracted data

8-12 years ago: the two oldest papers in the dataset are Vanderfeesten, Reijers, and Van Der Aalst (2011) and Hadasch, Maedche, and Gregor (2016). The article of Irene Vanderfeesten is on the subject of her PhD thesis (Vanderfeesten, Reijers, and Van Der Aalst (2011)). It describes the concept of a Product Data Model which, in workflow systems, can be compared to a Bill of Material in manufacturing systems. The article doesn't mention future research but does mention collaboration with industrial partners to incorporate a PDM in a commercial tool. The Hadasch paper is a quantitative study about users' process compliance as a function of process explanations either in textual or diagram format (DE/DDE). Broadly stated, the paper concludes that the better explanations result in better compliance. Other than a recommendation that the findings of the paper be leveraged in future research, there is no specific guidance about future research.

4-8 years ago: the four papers published in the 2016-2019 timeslot are Van Der Aalst (2018), Hashmi and Governatori (2017), Hashmi et al. (2018) and van der Aa, Leopold, and Reijers (2017). The van der Aalst paper compares and contrasts spreadsheet technology with process mining technology. It mentions checking for compliance as the activity whereby a process as run in reality is compared to a normative model. The article mentions future process mining research should be about automatically improving processes by changing underlying process models. The first Hashmi paper compares six Compliance Modeling Frameworks (CMFs). There are two pointers to future research directions. 1) Studying the formal semantics of the norms modeling languages. 2) Studying the useability of the norms modeling constructs in practice. The second Hashmi paper is a SLR where 79 papers were included in the study. The study provides a comprehensive overview of the attributes of compliance in BPM. There is a general direction for future research given: to improve modeling languages to take into account all compliance requirements. The article by van der Aa et al. is about the possible divergence of process descriptions and graphical process models. A quantitative analysis is performed on 53 real-life model-text pairs. One of the suggested future research directions is to also capture process information in other formats. Among the examples given of such other formats are rules and regulations.

0-4 years ago: the three most recent papers in the set are the papers and Kir and Erdogan (2021), Bernardo Junior and De Padua (2023) and Viriyasitavat et al. (2023). The Kir paper introduces *agileBPM*, a modeling methodology. The main differentiator is that next to control flow *agileBPM* also

captures knowledge, rules and goals. A prototype of the system is compared to other similar systems (ADEPT, SmartPM, Planlets, Go4Flex). The paper doesn't mention future research. The Bernardo paper includes a SLR, interviews and expert consultations. Agile BPM is defined. Future research is suggested to be on practices necessary for empirical application of BPM in organizations. The Viriyasitavat article is a SLR on the use of blockchain technology for business process compliance. The paper argues that blockchain technologies can and are applied for business process compliance. Existing work has a focus on technical implementation of the functionalities of traditional BPM systems. However the use of blockchain technologies also allows for new functionalities. The further research section specifically mentions organizational and legal aspects.

Table 4.1: Relevance to research question

	Year	Article	Alignment Concepts	Future Research
1	2011	Vanderfeesten et al.	ProductData Model	N
2	2016	Hadasch et al.	(Diagram)Descriptive Explanations	N
3	2017	Van der Aa et al.	Consistency between representation	Y (specific)
4	2018	Van Der Aalst	Prescriptive Analytics	Y (general)
5	2018	Hashmi et al.	Compliance Modeling Frameworks	Y (specific)
6	2018	Hashmi et al.	Compliance Modeling Languages	Y (general)
7	2021	Kir et al.	Context Awareness / Norm adoption	N
8	2023	Viriyasitavat et al.	Blockchain	Y (general)
9	2023	Bernardo Junior et al.	-	Y (general)

All papers mention approaches for alignment of business processes with regulatory requirements except the Bernardo Junior paper about agile BPM.

From these 9 papers reviewed, 6 mention future research directions. Two papers mention specific future research topic, for example around “consistency between different process representations” and “the useability of norm modelling constructs”.

**Paper digest** All areas Any time Type: Paper Query: (BPM or 'Business Process Management') and “Regulatory Compliance”

#### Related Work

[1] Kevin D. Barber; Frank W. Dewhurst; R. L. D. H. Burns; J. B. B. Rogers; “Business-process Modelling and Simulation for Manufacturing Management: A Practical Way Forward”, BUS. PROCESS. MANAG. J., 2003. (IF: 3) [2] Ying Liu; Samuel Müller; Ke Xu; “A Static Compliance-checking Framework for Business Process Models”, IBM SYST. J., 2007. (IF: 5) [3] Ulrich Lang; Rudolf Schreiner; “Managing Business Compliance Using Model-driven Security Management”, 2008. [4] Bruno de Moura Araujo; Eber A. Schmitz; Alexandre L. Correa; Antonio J. Alencar; “A Method for Validating The Compliance of Business Processes to Business Rules”, 2010. (IF: 3) [5] Marwane El Kharbili; Qin Ma; Pierre Kelsen; Elke Pulvermüller; “CoReL: Policy-Based and

Model-Driven Regulatory Compliance Management”, 2011 IEEE 15TH INTERNATIONAL ENTERPRISE DISTRIBUTED OBJECT ..., 2011. (IF: 3) [6] Guido Boella; Marijn Janssen; Joris Hulstijn; Llio Humphreys; Leon van der Torre; “Managing Legal Interpretation in Regulatory Compliance”, 2013. (IF: 3) [7] Amal Elgammal; Tom Butler; “Towards A Framework for Semantically-Enabled Compliance Management in Financial Services”, 2014. (IF: 3) [8] Shazia Wasim Sadiq; Guido Governatori; “Managing Regulatory Compliance in Business Processes”, 2015. (IF: 4) [9] Patrick Delfmann; Michael Hübers; “Towards Supporting Business Process Compliance Checking with Compliance Pattern Catalogues - A Financial Industry Case Study”, ENTERP. MODEL. INF. SYST. ARCHIT. INT. J. CONCEPT. MODEL., 2015. (IF: 3) [10] Mustafa Hashmi; Guido Governatori; Moe Thandar Wynn; “Normative Requirements for Regulatory Compliance: An Abstract Formal Framework”, INFORMATION SYSTEMS FRONTIERS, 2016. (IF: 3)

### Summary of the Related Work

Business process modelling (BPM) and business process simulation (BPS) help to facilitate process thinking. (Barber et. al., 2003) suggest a practical way forward until hardware and software limitations are overcome. As enterprises increasingly use business process management systems to automate their business processes, technologies to automatically check the compliance of process models against compliance rules are becoming important. (Liu et. al., 2007) present a method to improve the reliability and minimize the risk of failure of business process management systems from a compliance perspective. This is because, especially with regulatory compliance, both business and government have to expect large financial and reputational losses if compliance cannot be ensured and demonstrated. (Lang et. al., 2008) illustrate the theory behind Model Driven Security for compliance, provide an improved and extended architecture, as well as a case study in the healthcare industry using the OpenPMF 2.0 technology. Regulatory compliance of business operations and practices is increasingly becoming an area of great concern for management, costing tens of billions of dollars in compliance actions a year. (Araujo et. al., 2010) present a method for validating business processes with respect to the business rules. In the discipline of business process management in particular, compliance is considered as an important driver of the efficiency, reliability and market value of companies. For this purpose (Kharbili et. al., 2011) contribute CoReL, a domain-specific modeling language for representing compliance requirements that has a graphical concrete syntax. Legal Knowledge Management systems that combine repositories of legislation with legal ontologies can support the work of in-house compliance managers. (Boella et. al., 2013) extend the Legal Knowledge Management system Eunomos to deal with alternative interpretations of norms connecting it with Business Process Management systems. (Elgammal et. al., 2014) propose a semantically-enabled compliance management framework. In the heart of the framework is an integrated semantic repository incorporating regulatory, business and compliance knowledge; i.e., CMKB. (Sadiq et. al., 2015) present an overarching methodology for aligning business and control objectives. The chapter concludes with a discussion on the role of BPM as a driver for regulatory compliance and a presentation of open questions and challenges. In the business process compliance management literature, (Delfmann et. al., 2015) find an abundance of approaches supporting business process compliance checking. With this objective of (Delfmann et. al., 2015) at making a step towards comprehensive catalogues of compliance rules that can be used as input for business process compliance checking approaches. By definition, regulatory rules (in legal context called norms) intend to achieve specific behaviour from business processes, and might be relevant to the whole or part of a business process. (Hashmi et. al., 2016) present an abstract framework consisting

of a list of norms and a generic compliance checking approach on the idea of (possible) execution of processes.

## 5 Review reporting

### 5.1 Dissemination strategy

A subsequent version of this review will be part of the PhD work. The aim is to get three by-products out of this review:

- A poster that explains this literature review process and its results to be presented on a research day.
- A version of the software script that is installable and useable by somebody else.
- An open access publication.

### 5.2 Limitations

The database searches resulted in a set of relevant articles for the subject of this review. Selecting a different set of databases would have resulted in a different set of relevant articles. The selection of databases was made from the databases available to us. We did not consider databases that require additional payment for access.

It is also noted that search results may differ among different databases. If the content of two databases is identical, the same query run against both databases can yield different results. The differences stem, among others, from different search fields, different query languages, different API's and different search engines. Examples of notable differences are:

- for WoS: the search results may differ depending on the subscription that is available to the user.
- for SD: the search results may differ as query's are interpreted based on language heuristics ([source](#)). Also, SD does not support wildcards.
- for dblp: the *CompleteSearch* engine autocompletes search terms, see Bast and Weber (2006).
- for arXiv: wildcards can not be used as the first character of a search term ([source](#)). For example “\*engineering” will trigger an error message.

To assess the quality of the 21 identified articles a set of 4 indicators has been considered. There are many other indicators which can be used to assess the quality of an article. Changing the number of indicators and/or changing the selection of parameters could alter which full text articles are selected for the review.

### 5.3 Future research

In follow-on research it may be interesting to include openAIRE (Open Access Infrastructure for Research in Europe) as a data source. Schumm et al. (2010), p. 11 reference research that has been performed under the 2008-2011 COMPAS research project funded by the EU and coordinated by the Technische Universität Wien. More information about the research output of these projects will be available via OpenAIRE. When OpenAIRE will be included as a data source we will also again include Zenodo. Zenodo was created as part of the OpenAIRE initiative.

For reproducibility a future version of this literature review shall have the protocol altered. For commercial databases one and the same query can yield different results if it is run with two different licenses. This has been found to be the case with Web of Science. For the query used in this review the Vlerick Business School license of WoS yielded 42 hits while the Amsterdam University of Applied Sciences license of WoS yielded 24 hits (to be included in appendix). It is assumed the average user does not have precise information of the licenses that Academic institutions hold. As such WoS is better not used in the early stages of the search. The protocol could instead dictate the use of open databases, such as OpenAlex, for the early stages of the search. Commercial databases would then be used in a later stage to get abstracts and full texts of selected articles that are not available from open databases.

For quality assessment we have now used a self-constructed indicator (QA4) that has as inputs the number of publications by the first and second author. If further research is conducted it can be considered to replace this indicator with the ubiquitous h-index (Poirrier, Moreno, and Huerta-Canepa (2021)). Also, the fact that only 1 article is from the eligible journals list seems to indicate that either the list needs to be revised. Alternatively a different indicator, such as the journal impact factor, can be a substitute quality indicator.

Finally, where it relates to compliance checks, in the literature there is a divide between “design time” and “run time”. As the RQ of this research refers to compliance by design, future research may have more of different search terms to also filter research about “design time” compliance checking.

# A Bibliographic data

## Journals

The publisher and the ISSN number have been looked up at [crossref](#) using the journal name in the bibtex file.

Table A.1: Journals

before journals=



## Authors

Table A.2: Authors

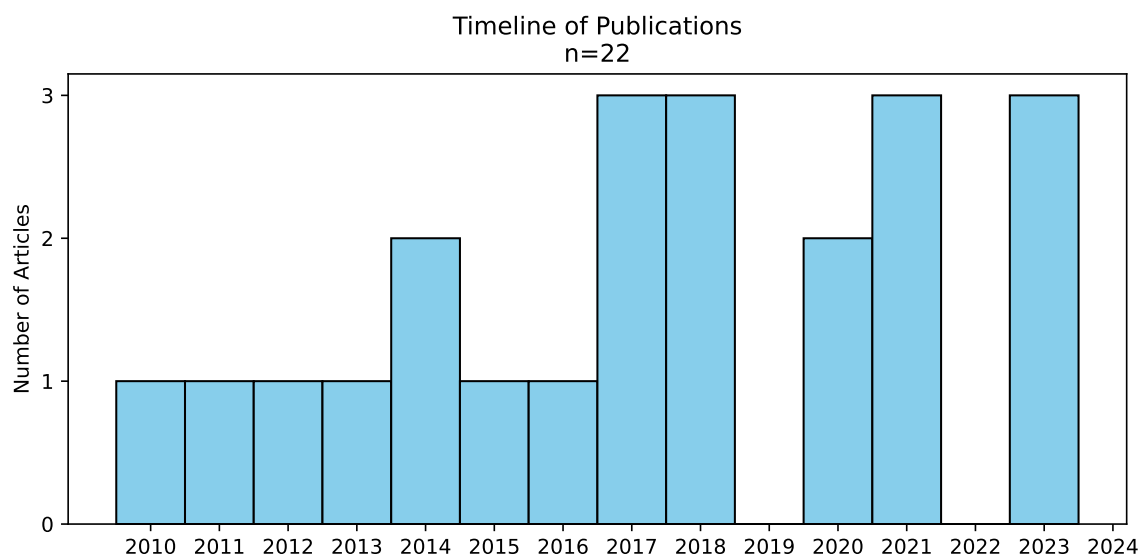
First Author	Other Authors
Yiwei Gong	Marijn Janssen
Silke Holzmüller-Laue	Bernd Göde, Heidi Fleischer, Kerstin Thurow
Huseyin Kir	Nadia Erdogan
Domenico Raucci	Antonella Santone, Francesco Mercaldo, Tomasz Dyczkowski
Ronaldo Bernardo Junior	Silvia Ines Dallavalle de Padua
Han van der Aa	Henrik Leopold, Hajo A. Reijers
Mustafa Hashmi	Guido Governatori, Ho-Pun Lam, Moe Thandar Wynn
M. Bevilacqua	F.E. Ciarapica, C. Paciarotti
Mustafa Hashmi	Guido Governatori
Rolands Koncevičs	Ludmila Pepicina, Andrejs Gaidukovs, Māris Dargis and Rita Burbo, Ainārs Auziņš
Niels Lohmann	
Shazia Sadiq	Guido Governatori
David Schumm	Oktay Turetken, Natallia Kokash, Amal Elgammal and Frank Leymann, Willem-Jan van den Heuvel
Andrea Zasada	Mustafa Hashmi, Michael Fellmann, David Knuplesch
Elham Ramezani	Dirk Fahland, Wil van der Aalst
Irene Vanderfeesten	Hajo A. Reijers, Wil van der Aalst

Table A.3: Authors

First Author	Other Authors
Bernardo Junior, Ronaldo	De Padua, Silvia Ines Dallavalle
Bevilacqua, M.	Ciarapica, F.E., Paciarotti, C.
Corsius, Mischa	Hoppenbrouwers, Stijn, Lokin, Mariette, Baars, Elan, {Sangers-Van Cappellen}, Gertrude, Wilmont, Ilona
Ramezani, Elham	Fahland, Dirk, {van der Aalst}, Wil M. P.
Koncevics, Rolands	Penicina, Ludmila, Gaidukovs, Andrejs, Dargis, Maris, Burbo, Rita, Auzins, Ainars
Awad, Ahmed Mahmoud Hany Aly	
Elgammal, A	Sebahi, S, Turetken, O, Hacid, {MS}, Papazoglou, {MP}, {van den Heuvel}, {WJ}
Hadasch, Frank	Maedche, Alexander, Gregor, Shirley
Hashmi, Mustafa	Governatori, Guido
Hashmi, Mustafa	Governatori, Guido, Lam, Ho-Pun, Wynn, Moe Thandar
{Holzm{u}ller-Laue}, Silke	G{ö}de, Bernd, Fleischer, Heidi, Thurow, Kerstin
Kir, Huseyin	Erdogan, Nadia
Ly, Linh Thao	Maggi, Fabrizio Maria, Montali, Marco, {Rinderle-Ma}, Stefanie, Van Der Aalst, Wil MP
Mendling, Jan	Weber, Ingo, Aalst, Wil Van Der, Brocke, Jan Vom, Cabanillas, Cristina, Daniel, Florian, Debois, S{ø}ren, Ciccio, Claudio Di, Dumas, Marlon, Dustdar, Schahram
Raucci, Domenico	Santone, Antonella, Mercaldo, Francesco, Dyczkowski, Tomasz
{van der Aa}, Han	Leopold, Henrik, Reijers, Hajo A.
Van Der Aalst, Wil	
Vanderfeesten, Irene	Reijers, Hajo A., Van Der Aalst, Wil M.P.
Viriyasitavat, Wattana	Da Xu, Li, Dhiman, Gaurav, Bi, Zhuming
Viriyasitavat, Wattana	

Table A.3: Authors

First Author	Other Authors
Vo, Ngoc Phuoc An	Manotas, Irene, Popescu, Octavian, Cerniauskas, Algimantas, Sheinin, Vadim
Zasada, Andrea	Hashmi, Mustafa, Fellmann, Michael, Knuplesch, David



## Keywords

Table A.4: Keywords

Citation Key	Keywords
bernardojuniorA	Agility,bpm governance,Business And Economics–Management,Business process management,challenges,Communication,critical success factors,Customer satisfaction,implementation capabilities,intuition,knowledge systems,Literature reviews,operations strategy,organization,Systematic review
bevilacquaBusin	Emergency management,IDEF0,Information supply,Information system,Public,Risk information,Safety management
corsiusRegelSpr	CNL
DBLP:conf/bpm/R	auditing,compliance checking,compliance specification,configurable compliance rules,question tree
DBLP:journals/r	Business process compliance,compliance management,compliance management tools,open source business process modelling tools
DBLP:phd/de/Awa	No keywords
elgammalBusines	No keywords
hadaschInfluenc	No keywords
hashmi2017norms	Business Processes,Compliance,Compliance Management Frameworks,Modelling Constructs,Modelling Languages,Norms
hashmiAreWeDone	Business process compliance,Business processes,Compliance Management Frameworks,Normative requirements,Norms compliance
holzmuller-laue	BPMN,end-to-end workflow,laboratory automation,model-based application development,systems integration
kirKnowledgeint	Agent-based business process management,Agile business process management,Business process management,Knowledge-intensive processes,Process adaptation,Process modeling and execution
lyComplianceMon	Business process compliance,Compliance monitoring,Operational support
mendlingBlockch	Top100
raucciBMPerspe	Banking Processes,Business Process Management,Formal Methods,Internal Control Systems,Investment Services,Segregation of Duties
vanderaaCompari	Business process management,Business process modeling,Compliance checking,Inconsistency detection,Matching,Natural language processing
vanderaalstSpre	No keywords
vanderfeestenPr	Business Process Modelling,Product Data Model,Workflow Management
viriyasitavatBl	No keywords
viriyasitavatBl	Block-chain technology (BCT),Business process management (BPM),Industry 4.0,Internet of Things (IoT),Quality of Service (QoS),Service selection and composition,Smart contracts,Trustworthiness
voRecognizingSp	Computer Science - Computation and Language
zasadaEvaluatio	business processes,compliance rules modelling,conceptual modelling,expressiveness,language complexity,regulatory compliance

The keywords have been added to the bibtex file after consulting the publishers website and/or the web of science ser-

vice.

Table A.5: Keywords

Citation Key	Keywords
Bernardo Junior and De Padua (2023)	Agility, bpm governance, Business And Economics–Management, Business process management, challenges, Communication, critical success factors, Customer satisfaction, implementation capabilities, intuition, knowledge systems, Literature reviews, operations strategy, organization, Systematic review
Bevilacqua, Ciarapica, and Paciarotti (2012)	Emergency management, IDEF0, Information supply, Information system, Public, Risk information, Safety management
Corsius et al. (2021)	CNL
Ramezani, Fahland, and van der Aalst (2013)	auditing, compliance checking, compliance specification, configurable compliance rules, question tree
Koncevics et al. (2017)	Business process compliance, compliance management, compliance management tools, open source business process modelling tools
Awad (2010)	No keywords
Elgammal et al. (2014)	No keywords
Hadasch, Maedche, and Gregor (2016)	No keywords
Hashmi and Governatori (2017)	Business Processes, Compliance, Compliance Management Frameworks, Modelling Constructs, Modelling Languages, Norms
Hashmi et al. (2018)	Business process compliance, Business processes, Compliance Management Frameworks, Normative requirements, Norms compliance
Holzmüller-Lau et al. (2014)	BPMN, end-to-end workflow, laboratory automation, model-based application development, systems integration
Kir and Erdogan (2021)	Agent-based business process management, Agile business process management, Business process management, Knowledge-intensive processes, Process adaptation, Process modeling and execution
Ly et al. (2015)	Business process compliance, Compliance monitoring, Operational support
Mendling et al. (2018)	Top100
Raucci et al. (2020)	Banking Processes, Business Process Management, Formal Methods, Internal Control Systems, Investment Services, Segregation of Duties
van der Aa, Leopold, and Reijers (2017)	Business process management, Business process modeling, Compliance checking, Inconsistency detection, Matching, Natural language processing
Van Der Aalst (2018)	No keywords

Table A.5: Keywords

Citation Key	Keywords
Vanderfeesten, Reijers, and Van Der Aalst (2011)	Business Process Modelling, Product Data Model, Workflow Management
Viriyasitavat et al. (2023)	No keywords
Viriyasitavat (2020)	Block-chain technology (BCT), Business process management (BPM), Industry 4.0, Internet of Things (IoT), Quality of Service (QoS), Service selection and composition, Smart contracts, Trustworthiness
Vo et al. (2021)	Computer Science - Computation and Language
Zasada et al. (2023)	business processes, compliance rules modelling, conceptual modelling, expressiveness, language complexity, regulatory compliance

The keywords have been added to the bibtex file after consulting the publishers website and/or the web of science service.

## Literature

- Awad, Ahmed Mahmoud Hany Aly. 2010. "A Compliance Management Framework for Business Process Models." PhD thesis, University of Potsdam.
- Bast, Holger, and Ingmar Weber. 2006. "Type Less, Find More: Fast Autocompletion Search with a Succinct Index." In *Proceedings of the 29th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval*, 364–71. Seattle Washington USA: ACM. <https://doi.org/10.1145/1148170.1148234>.
- Bernardo Junior, Ronaldo, and Silvia Ines Dallavalle De Padua. 2023. "Toward Agile Business Process Management: Description of Concepts and a Proposed Definition." *Knowl Process Manag* 30 (1): 14–32. <https://doi.org/10.1002/kpm.1737>.
- Bevilacqua, M., F. E. Ciarapica, and C. Paciarotti. 2012. "Business Process Reengineering of Emergency Management Procedures: A Case Study." *Safety Science* 50 (5): 1368–76. <https://doi.org/10.1016/j.ssci.2012.01.002>.
- Corsius, Mischa, Stijn Hoppenbrouwers, Mariette Lokin, Elian Baars, Gertrude Sangers-Van Cappellen, and Ilona Wilmont. 2021. "RegelSprak: A CNL for Executable Tax Rules Specification." In *Proceedings of the Seventh International Workshop on Controlled Natural Language (CNL 2020/21)*.
- Elgammal, A, S Sebahi, O Turetken, MS Hacid, MP Papazoglou, and WJ van den Heuvel. 2014. "Business Process Compliance Management: An Integrated Proactive Approach." In *CRAFTING GLOBAL COMPETITIVE ECONOMIES: 2020 VISION STRATEGIC PLANNING & SMART IMPLEMENTATION, VOLS I-IV*, edited by KS Soliman, 764–81.
- Hadasch, Frank, Alexander Maedche, and Shirley Gregor. 2016. "The Influence of Directive Explanations on Users' Business Process Compliance Performance." *Business Process Management Journal* 22 (3): 458–83. <https://doi.org/10.1108/BPMJ-05-2015-0067>.
- Hashmi, Mustafa. 2015. "Evaluating Business Process Compliance Management Frameworks." PhD thesis, Queensland University of Technology.
- Hashmi, Mustafa, and Guido Governatori. 2017. "Norms Modeling Constructs of Business Process Compliance Management Frameworks: A Conceptual Evaluation." *Artificial Intelligence and Law* 26 (September): 251–305. <https://doi.org/10.1007/s10506-017-9215-8>.
- Hashmi, Mustafa, Guido Governatori, Ho-Pun Lam, and Moe Thandar Wynn. 2018. "Are We Done with Business Process Compliance: State of the Art and Challenges Ahead." *Knowl Inf Syst* 57 (1): 79–133. <https://doi.org/10.1007/s10115-017-1142-1>.
- Holzmüller-Laue, Silke, Bernd Göde, Heidi Fleischer, and Kerstin Thurow. 2014. "Improved Compliance by BPM-Driven Workflow Automation." *SLAS Technology* 19 (6): 528–45. <https://doi.org/10.1177/2211068214549626>.
- Kir, Huseyin, and Nadia Erdogan. 2021. "A Knowledge-Intensive Adaptive Business Process Management Framework." *Information Systems* 95 (January): 101639. <https://doi.org/10.1016/j.is.2020.101639>.
- Kitchenham, Barbara, and Stuart Charters. 2007. "Guidelines for Performing Systematic Literature Reviews in Software Engineering."
- Koncevics, Rolands, Ludmila Penicina, Andrejs Gaidukovs, Maris Dargis, Rita Burbo, and Ainars Auzins. 2017. "Comparative Analysis of Business Process Modelling Tools for Compliance Management Support." *Appl. Comput. Syst.* 21 (1): 22–27. <https://doi.org/10.1515/ACSS-2017-0003>.

- Liu, Y., S. Müller, and K. Xu. 2007. "A Static Compliance-Checking Framework for Business Process Models." *IBM Systems Journal* 46 (2): 335–61.
- Lohmann, Niels. 2013. "Compliance by Design for Artifact-Centric Business Processes." *Information Systems* 38 (4): 606–18. <https://doi.org/10.1016/j.is.2012.07.003>.
- Ly, Linh Thao, Fabrizio Maria Maggi, Marco Montali, Stefanie Rinderle-Ma, and Wil MP Van Der Aalst. 2015. "Compliance Monitoring in Business Processes: Functionalities, Application, and Tool-Support." *Information Systems*, 2.309, 54: 209–34.
- Mendling, Jan, Ingo Weber, Wil Van Der Aalst, Jan Vom Brocke, Cristina Cabanillas, Florian Daniel, Søren Debois, Claudio Di Ciccio, Marlon Dumas, and Schahram Dustdar. 2018. "Blockchains for Business Process Management-Challenges and Opportunities." *ACM Transactions on Management Information Systems (TMIS)* 9 (1): 1–16.
- Poirrier, Maurice, Sebastian Moreno, and Gonzalo Huerta-Canepa. 2021. "Robust h-Index." Article. *SCIENTOMETRICS* 126 (3): 1969–81. <https://doi.org/10.1007/s11192-020-03857-z>.
- Ramezani, Elham, Dirk Fahland, and Wil M. P. van der Aalst. 2013. "Supporting Domain Experts to Select and Configure Precise Compliance Rules." In *Business Process Management Workshops - BPM 2013 International Workshops, Beijing, China, August 26, 2013, Revised Papers*, edited by Niels Lohmann, Minseok Song, and Petia Wohed, 171:498–512. Lecture Notes in Business Information Processing. Springer. [https://doi.org/10.1007/978-3-319-06257-0\\_39](https://doi.org/10.1007/978-3-319-06257-0_39).
- Rauci, Domenico, Antonella Santone, Francesco Mercaldo, and Tomasz Dyczkowski. 2020. "BPM Perspectives to Support ICSs: Exploiting the Integration of Formal Verifications into Investment Service Provision Processes." *Industrial Management & Data Systems* 120 (7): 1383–1400. <https://doi.org/10.1108/IMDS-11-2019-0593>.
- Sadiq, Shazia, and Guido Governatori. 2010. "Managing Regulatory Compliance in Business Processes." In *Handbook on Business Process Management 2*, edited by Jan vom Brocke and Michael Rosemann, 159–75. Berlin, Heidelberg: Springer Berlin Heidelberg. [https://doi.org/10.1007/978-3-642-01982-1\\_8](https://doi.org/10.1007/978-3-642-01982-1_8).
- Schumm, David, Oktay Turetken, Natallia Kokash, Amal Elgammal, Frank Leymann, and Willem-Jan Van Den Heuvel. 2010. "Business Process Compliance Through Reusable Units of Compliant Processes." In *Current Trends in Web Engineering*, edited by Florian Daniel and Federico Michele Facca, 6385:325–37. Berlin, Heidelberg: Springer Berlin Heidelberg. [https://doi.org/10.1007/978-3-642-16985-4\\_29](https://doi.org/10.1007/978-3-642-16985-4_29).
- van der Aa, Han, Henrik Leopold, and Hajo A. Reijers. 2017. "Comparing Textual Descriptions to Process Models – The Automatic Detection of Inconsistencies." *Information Systems* 64 (March): 447–60. <https://doi.org/10.1016/j.is.2016.07.010>.
- Van Der Aalst, Wil. 2018. "Spreadsheets for Business Process Management: Using Process Mining to Deal with 'Events' Rather Than 'Numbers'?" *BPMJ* 24 (1): 105–27. <https://doi.org/10.1108/BPMJ-10-2016-0190>.
- Vanderfeesten, Irene, Hajo A. Reijers, and Wil M. P. Van Der Aalst. 2011. "Product-Based Workflow Support." *Information Systems* 36 (2): 517–35. <https://doi.org/10.1016/j.is.2010.09.008>.
- Viriyasitavat, Wattana. 2020. "Blockchain-Based Business Process Management (BPM) Framework for Service Composition in Industry 4.0." *Journal of Intelligent Manufacturing*.
- Viriyasitavat, Wattana, Li Da Xu, Gaurav Dhiman, and Zhuming Bi. 2023. "Blockchain-as-a-Service for Business Process Management: Survey and Challenges." *IEEE Trans. Serv. Comput.* 16 (3): 2299–2314. <https://doi.org/10.1109/TSC.2022.3199232>.
- Vo, Ngoc Phuoc An, Irene Manotas, Octavian Popescu, Algimantas Cerniauskas, and Vadim Sheinin. 2021. "Recognizing and Splitting Conditional Sentences for Automation of Business Processes Management." arXiv. <https://arxiv.org/abs/2104.00660>.
- Zasada, Andrea, Mustafa Hashmi, Michael Fellmann, and David Knuplesch. 2023. "Evaluation of Compliance Rule Languages for Modelling Regulatory Compliance Requirements." *Software* 2 (1): 71–120. <https://doi.org/10.3390/software2010004>.