Categories of Change Triggers in Business Processes

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***Abstract*—Business processes need to constantly adapt due to changes in their environment and requirements. Therefore, one of the main activities in business process management is the management of changes. To effectively manage changes, there is a need for categorization of change triggers in business processes. However, existing categories of change triggers are limited to information systems and neglect the change triggers of business processes. We conducted a review with a well-defined methodology to identify categories of change triggers in business processes. This paper presents a generic categorization scheme of change triggers in business processes based on the results of the review. The new categorization scheme can serve as a checklist to elicit the possible future business process changes and, thus, support the process of change and risk management.**

***Index Terms*—Business Process, Evolution, Change Triggers, Change Management**

I. Introduction

Organizations are faced with several influencing factors such as new technologies or changes in requirements of stakeholders [1]. Thus, they have to continuously adapt their business processes to remain competitive [2]. The ability to manage changes efficiently is one of the most challenging tasks [3]. Further, the changes in business processes affect the product development and production activities [4]. Therefore, change engineering plays a major role in risk and cost management [4], [5]. To effectively manage changes, it is recommended to save triggers of changes in a database to identify patterns or categories of change triggers [6].

Software systems support business processes in organizations. Business processes can be considered as a set of activities to realize a business goal [7]. These activities can be divided into system steps (i.e., performed totally automatically by the software system) and actor steps (i.e., performed totally by a human actor) [8]. As a result, a business process and the corresponding software system affect each other in a mutual way. Thus, we cannot consider changes of business processes and software systems in isolation, as software systems and business processes co-evolve. During the co-evolution and the process of change management, change triggers in business processes lead to further changes in the corresponding software system [9].

Based on a discussion about change triggers, Swanson defined three categories (i.e., corrective, adaptive, and perfective maintenance) to describe software maintenance activities [10]. In the domain of information systems, Swanson's categorization or its adaptation is primarily used. In the domain of business processes, a change trigger can be defined as an "event or circumstance that can bring about changes in an enterprise" [11]. [12] lists examples of change causes in the business process (e.g., to become more competitive or to reduce costs) resulted from an empirical study (i.e., questionnaire). Based on a questionnaire, Write and Burns present a set of change triggers such as information technology or globalization in [13]. Another empirical study (i.e., structured interview) shows that social/economic transformation (e.g. from a centrally planned economy to free market economy) or leadership style can result in changes in business processes [14]. However, there is a lack of a comprehensive and systematic categorization of change triggers in the domain of business processes.

In this paper, we present the results of our literature review performed to identify categories of change triggers in business processes. Our review is based on a well-defined methodology. The overall objective was to answer the following **research question**: Which categories of change triggers can be identified in business processes? Based on these results, we built a generic categorization scheme of change triggers in business processes. The developed categorization scheme is hierarchical and allows the categorization of change triggers in business processes along the following dimensions: *participation*, *origin*, and *characteristics*. The structure of our categorization scheme is generic and does not depend on specific business process contexts. Thus, it is applicable to any kind of organization. Furthermore, by using such categories of change triggers, analysts can elicit possible business process changes and the resulting future requirements. Thus, it supports the process of change engineering in business process management and allows eliciting future requirements and risks for project planning. Supplementary material for the review study is given in [15].

The remainder of this paper is organized as follows: Sec. II gives an overview of the research methodology. We present the results of the study in Sec. III. Our categorization scheme based on these results is introduced in Sec. IV. The last section outlines the main conclusions and discusses future work.

II. Research Methodology

The review method is based on guidelines for performing evidence-based studies in software engineering research domain.

Based on the three-phase model of Kitchenham et al. 2007 [16], we used an iterative and incremental approach with regard to the three stages: planning by defining a review protocol, conducting, and reporting. Fig. 1 illustrates our review process including i) the pilot study and ii) the resulting review protocol. In the following, we describe the activities of the pilot study and the review protocol in more detail.

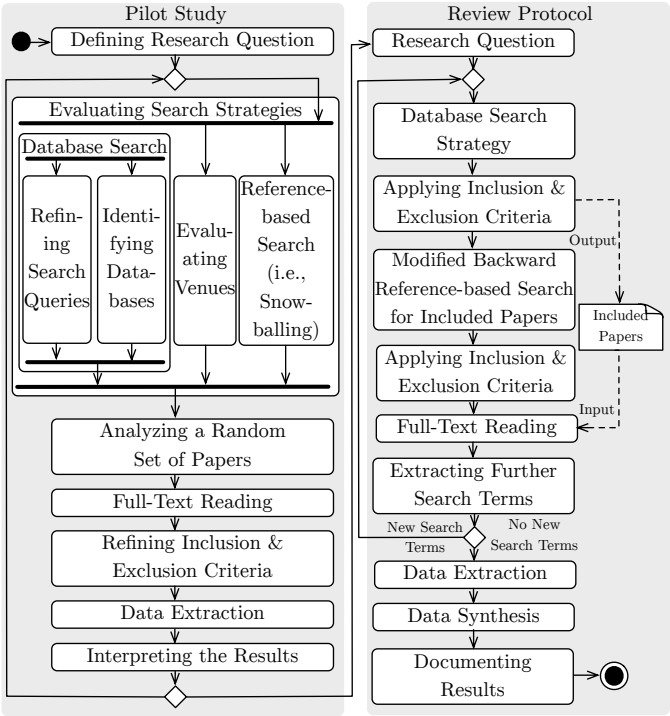

Fig. 1. The activity diagram of our review process

A. Pilot Study

We conducted a pilot study to define our review protocol. In the pilot study, an iterative approach was used i) to define research question, ii) to identify the best search strategy, iii) to refine inclusion and exclusion criteria, and iv) to formulate the data extraction form. First of all, we defined the initial research question referred to our overall objective and evaluated several search strategies. As we did not use an initial set of papers, we initially used the database search strategy. Thus, we examined the reference-based search strategy in further iterations. As the research question is multidisciplinary, we could not limit the review only to a set of venues for manual search. Analyzing random sets of papers from several venues showed that a set of venues may lead to biased results.

Our pilot study was composed of four iterations. In the first two iterations we used a keyword and a descriptor-based approach to identify the search terms. However, these iterations resulted in a very high number of hits in the database search strategy (e.g., in some cases more than 3000000 hits) and did not contain relevant results in terms of categories of change triggers. Thus, based on the results of the first two iterations, we used structured and generalized search queries in the last two iterations to improve the results of the database search. In the following, the last two iterations (i.e., 3. and 4. iteration) are described:

1) 3. Iteration: A so-called *change facet* is defined in the following as a general term referring to all aspects of a change for example change trigger or change impact. In this iteration, we narrowed the change facet in the search term to only "change trigger" and its synonyms. As a consequence from the first two iterations, we used general search queries. The general search queries are independent of a special context or a specific subdomain in the business process (e.g., business process flexibility). In this iteration, we examined two types of a search query: A search query is a cross product of three or four search terms: i) synonyms of the research domain (i.e., "business process" or "workflow"), ii) "change", iii) synonyms of "trigger", and optional iv) synonyms of classification scheme (e.g., "category"). We used cross product instead of AND and OR concatenation, as several databases support concatenation up to a certain input length (e.g., the search of IEEE Xplore is limited to a maximum of 15 search terms).

However, the results of the database search showed a high number of hits. Thus, we analyzed random sets of the search results for both search query types. The analysis showed that the results do not contain research papers with focus on change triggers, as AND operator does not result in a strong connection between "change" and synonyms of "trigger". To overcome this problem, we semantically merged the second and the third search terms using the following techniques: i) using the proximity operators (e.g., change* NEAR/5 trigger*) and ii) merging the two search terms to one term and use a phrase search (e.g., "change trigger*" or "trigger* for change*"). However, analyzing random sets of search results for each technique showed that the proximity operators are not supported by all electronic databases. Thus, we used the second search strategy in 4. iteration.

2) 4. Iteration: As a consequence from the 3. iteration, we merged the synonyms of "trigger" and "change" in a phrase search (e.g., "change trigger*" or "need for change*") for a search query. Thus, a new search query is either i) synonyms of research domains and the phrase search of synonyms of "trigger" and "change" or ii) synonyms of research domains, the phrase search of synonyms of "trigger" and "change", and synonyms of classification scheme. The goal of this iteration was to identify the best search query. Thus, we analyzed and compared the results of both search queries. The analysis of a random set of resulted papers of each search query type showed that the first search strategy contained more relevant research papers. Additionally, the analysis showed that a full-text reading of the random set of papers needs to be conducted. The full-text reading of the included papers in the random sets allowed extracting further synonyms for search terms.

Final Search Queries: The resulted search queries in this iteration is the cross product of: i) the synonyms for the first search term: "business process" and "workflow" and ii) the second search term is a combination of the change facet (i.e., "trigger", "reason", "force", "driver", "cause", "need", "origin",

"source", and "lever") and "change" in a phrase search (e.g., "change trigger*") as a consequence of the 3. iteration.

Electronic databases: In the next phase, random sets of papers for the search queries of the multidisciplinary resource databases Google Scholar (GS), Scopus, Web of Science (WoS), BASE, ACM DL, IEEE Xplore, AISeL, and SpringerLink were analyzed. Based on this analysis and the multidisciplinary characteristic of the research query, we used only the four electronic databases GS, Scopus, WoS, and BASE for the further analysis. Additionally, the results of the four databases contain the results of the remaining databases (i.e., ACM DL, IEEE Xplore, AISeL, and SpringerLink).

Further Search Strategies: In addition to the database search strategy, we used a modified snowballing method for the included papers. Therefore, we conducted a reference-based search in one iteration due to inefficiency of this method in our case. In this context, efficiency is defined as "the number of included papers in relation to the total number of candidate papers examined" [17].

B. Review Protocol

Based on the pilot study, we present the review protocol for the **research question**: Which categories of change triggers can be identified in business processes?

1) Search Strategies: The results of the pilot study showed that the database search is the appropriate search strategy. Based on the results of the 4. iteration, the search query consists of the cross product of the research domain (i.e., "business process" and "workflow") and the phrase search of synonyms of "trigger" and "change" (e.g., "change trigger*", "trigger* for change*", "trigger* of change*", and "trigger event*" for trigger). We used the multidisciplinary databases GS, Scopus, WoS, and BASE and adapted the search queries based on the syntactical characteristics of each database (i.e., using database search helps). Exact search queries for each database and the number of hits for each search query are given in [15].

2) Analysis Strategies: Based on a full-text reading of the papers, we could extract further synonyms for the change trigger. If a new synonym is identified, a new cross product with the synonyms of research domains is used for further search process. In general, we analyzed the first 20 hits of each search query (i.e., each cross product for each database). The number of results for each query from WoS, Scopus, and BASE is less than 220. However, due to the high number of papers resulted by GS we applied two methods to systematically analyze the subset of papers while avoiding publication bias (e.g., a higher ranking of a paper due to the year of publication, as the older papers have more citation and are higher ranked): i) decomposing the second search term and ii) using a modified search strategy, if the number of papers is still too high. The goal of both methods is to systematically identify a representative subset of the GS results. We combined both methods depending on the number of papers in the result of a search query. Both methods are described in the following in more detail:

a) Decomposition of the Second Search Term: We divided the search queries depending on the initial number of papers resulted by GS search: If the number of papers is less than 1000, we analyzed the first 20 papers for this search query. If the number of papers is more than 1000, we decomposed the second part of the search query (i.e., the phrase search for the change facet) and analyzed the first 10 papers. For example, the number of results for the second part of the search query "driver* for change*" was at approximately 2110. We decomposed this search query to the following search queries: "driver for change", "driver for changes", "drivers for change", and "drivers for changes". Consequently, we proportionally analyzed more papers for a search query, if it has more hits in the GS search result.

b) Modified Search Strategy: The second method aims at avoiding the publication bias, as older publications have more citations and can be ranked as more relevant. In this phase, if the number of the papers of a search query is less than 500, we analyzed the first 20 papers. If the number of papers is more than 500 but less than 1000, in addition to the first 20 hits, we sorted the papers by time, and analyzed the first 20 papers between the years 2011 and 2017. If the number of papers is more than 1000, in addition to the first 20 hits, we analyzed the first 20 papers between the years 2011 and 2017, and the first 20 papers between the years 2006 and 2011. Besides avoiding bias, this method gives the search queries with more hits a higher priority, as more papers for such search queries are analyzed. Analyzing more papers since 2006 gives the current research a higher priority. The search queries and the number of hits for each database are given in [15].

3) Inclusion and Exclusion Criteria: In this section, we describe the inclusion and exclusion criteria. Additionally, we consider papers published until 31.12.2017.

The **inclusion criteria** were defined for the research question as follows:

- The paper relates to one of the aspects of the business process domain. The title, abstract, (author) keywords or descriptors, and introduction have to have a reference to the business process domain. Typical indicators of this domain are the terms and their synonyms such as change management, process management, business process change, business process modeling, business process management, business process flexibility, or workflow management.
- The paper explicitly mentions a change category or class in the business process with focus on change triggers. Additionally, the categories semantically aggregate examples and rationales referring to change triggers. Typical indicators are terms such as class/es, category/ies, or type/s and so on. Additionally, they can be part of a taxonomy or a framework. We consider only change trigger as a change facet. Other change facets, for example, change impact are not considered. The inclusion considers all contexts in the business process domain (e.g., "business process flexibility"). We consider only universal and not branch-specific categories for change triggers.
- Conferences, symposiums, journals, workshops, and magazines are considered.

TABLE I
DATA EXTRACTION FORM

Data Item	Description
ID	Unique reference ID for the publication
Title	Title of the publication
Year	Calendar year of the publication
Context	Research context or domain
Venue	Conference, journal, symposium, workshop, or magazine
Name	Name of the specific venue
Category	Categories of change triggers in the domain of business processes

The **exclusion criteria** are formulated as follows:

- The paper does not relate to the business process domain.
- Duplicates are excluded. If the same paper is published in several venues, we considered the paper including a more complete categorization.
- The number of pages of a paper is less than 7 (i.e., short papers are excluded).
- Gray literature (e.g., theses, presentation slides, technical reports, white papers, or books and book chapters) is excluded, too.
- We only consider papers written in English.
- The paper is not available for (free) download.

4) Reading Strategies: If a paper was resulted from the database search, we used the following reading strategy: A local reading of the title, abstract, conclusion, and the sections, in which the search query was found, were used to initially exclude the papers. For the further inclusion we skimmed the papers. As the next step, we used intensive reading in the phase of the data extraction. If the paper was identified using the reference-based search strategy, a local reading of sections was not possible. In this case, we conducted a full-text reading of the entire paper.

5) Data Extraction: Table I presents the data extraction form used in our review.

III. FINDINGS

In the following, we present the major results obtained from the review. We applied the inclusion and exclusion criteria to the papers. One of the exclusion criteria was the gray literature (e.g., [18] in spite of reference to categories of change triggers in business processes). If a paper references a categorization of the change triggers in business processes from another literature, the referenced paper was analyzed. If the referenced paper is gray literature, we also excluded the paper. Further, the papers, that are not directly related to the business process domain, were excluded. These papers are usually sector-specific (e.g., in the health care or finance sectors) and, thus, have no generic categories with regard to business processes. Another example of excluded papers, which do not contain generic categories, are papers in the context of requirement engineering (e.g., [19]) or papers referring to only a specific subdomain such as supply chain management. Further, the papers, that do not explicitly refer to a category, were excluded (e.g., [20] refers to source of change without referring to the categories). The explicit reference to categorization is particularly important for the objectivity of the review process in order to avoid different interpretations of the reviewers regarding the categories. Furthermore, we excluded the papers that only refer to the categories of changes in the business processes without discussing the change triggers (e.g., [21] focuses on change strategies). Additionally, we eliminated the duplicates regarding the content (e.g., [22] and [23]).

After analyzing the relevant content of the included publications, we conduct data synthesis, which involves collecting and summarizing the results of the included papers (cf. [16]). Therefore, we chose a descriptive (i.e., non-quantitative) synthesis according to our defined data extraction form in Sec. II-B. The information extracted from the studies is illustrated in Table II. Although the research question was generally defined, we divided each paper into the specific context of the business process (e.g., business process flexibility).

Analyzing the categories in the identified papers showed that the *internal* and *external* categorizations of change triggers are implicitly or explicitly named in several papers, as they are based on system theory. One of the first general approaches can be found in [29]. Additionally, the most categorizations are hierarchically structured using subcategories. This recurring pattern and the hierarchical conception are also a part of our categorization scheme concept in the next section.

IV. CATEGORIES OF CHANGE TRIGGERS IN BUSINESS PROCESSES

During the review, we created a "state-of-the-evidence" and "state-of-the-art" based on a well-defined methodology as provided in the evidence-based guidelines in software engineering. We could identify research activities in terms of change categories in business process domain focusing on change triggers. To this end, we followed the guidelines of Kitchenham et al. 2007 (i.e., [16]) and the database search helps of the digital libraries. Based on the results of our review study (cf. Table II), we derive a categorization scheme for change triggers in business processes in Sec. IV-A (cf. Table III). The categories of change triggers in business processes are explained in more detail in Sec IV-B. Sec. IV-C provides the benefits and purpose of the categorization scheme. Design decisions are described in Sec. IV-D. Finally, the threats to validity of the results are given in Sec. IV-E.

A. Concept and Terminology

Using the results in Sec. III and the underlying question "*Why* is there a change in business processes?", we developed a multidimensional categorization of change triggers by formulating the following questions:

- *Who or What?* refers to the *participation*. It mainly describes a role in the considered business process.
- *Where?* relates to the *origin* of a change trigger. To build this dimension, it is necessary to regard the process or the business domain in general as a system. Therefore, we consider at least three subsystems: economy, sociology, and technology.

TABLE II
OVERVIEW OF PAPERS INCLUDING CATEGORIES OF CHANGE TRIGGERS IN BUSINESS PROCESSES

ID	Title and Reference	Year	Categories	Context*
[P1]	Drivers and Tracers of Business Process Changes [24]	1999	1. Internal inefficiency 2. Changed customer/supplier requirements 3. External changes uncontrollable, unpredictable to the industry	BPR
[P2]	Dealing with Workflow Change: Identification of Issues and Solutions [3]	2000	1. Developments outside the system 1.1. Changing business context 1.2. Changing legal context 1.3. Changing technological context 2. Developments inside the system 2.1. Logical design errors 2.2. Technical problems	WfMS
[P3]	Integrated Enterprise Transformation: Case Application in Engineering Project Work in Belgian Armed Forces [25]	2003	1. Internal (relating to personnel, culture, technology, etc.) 2. External (relating to customers, competition, etc.)	OC
[P4]	Compliant and Flexible Business Processes with Business Rules [26]	2006	1. Internal policies 2. External regulations	BPC BPF
[P5]	A New Framework for Managing Change [1]	2007	1. Internal drivers 1.1. Improving operational efficiency 1.2. Need to improve the quality of products and services 1.3. Process improvement 2. External drivers 2.1. Customer requirements 2.2. Demand from other stakeholders (e.g., government) 2.3. Regulatory demand 2.4. Market competition 2.5. Shareholders/city	OC CM
[P6]	Conceptual Dependencies between Two Connected IT Domains: Business/IS Alignment and IT Governance [27]	2008	1. Internal origin of change 2. External origin of change	B/ISA
[P7]	Life Cycle for Change Management in Business Processes Using Semantic Technologies [22]	2008	1. Automatically based on 1.1. Measurement of key performance or quality indicators 1.2. Reasons for inefficiencies 2. Manually by the administrator due to 2.1. Technology changes 2.2. Changes in the environment 2.3. Change/shift in the goals of the company	CMS IT/BA
[P8]	Engineering Change: An Overview and Perspective on the Literature [5]	2011	1. Emergent (e.g., error correction, safety, change of function, or product quality problems) 2. Initiated (e.g., stakeholders such as customers or legislators)	EC
[P9]	Efficient Change Management in Long-term Composed Services [28]	2011	1. Top-down change 1.1. Business-centric changes 1.2. Regulation-centric changes	CM
[P10]	Timeline Visualization for Documenting Process Model Change [2]	2012	1. Triggers (or reasons) for change from external factors 2. Triggers (or reasons) for change from internal factors 3. Triggers for evolutionary changes	BPM
[P11]	Engineering Changes in Product Design - A Review [4]	2016	1. Emergent changes (product design error) 2. Initiated changes (external sources)	ECM

* Legend: B/ISA: Business/IS Alignment, BPC: Business Process Change, BPF: Business Process Flexibility, BPM: Business Process Modeling, BPR: Business Process Reengineering, CM: Change Management, CMS: Change Management System, EC: Engineering Change, ECM: Engineering Change Management, IT/BA: IT/Business Alignment, OC: Organizational Change, WfMS: Workflow Management System.

- *When or How?* describes the *characteristics* of change triggers. These questions can define the properties and the occurrence of a change trigger.

Based on the *w-questions*, we developed a new categorization of change triggers in business processes. The categorization scheme can be divided into four **abstraction layers**, as illustrated in Table III. The abstraction layers define the degree of specialization regarding the specification of a change trigger. The highest abstraction layer (i.e., Layer 1) is divided into three **components**: i) *participation* (i.e., *who or what?*), ii) *origin* (i.e., *where?*), and iii) *characteristics* (i.e., *when or how*). A component can be considered as self-sufficient. Each component can be subdivided into further fine-grained subcomponents in the next lower abstraction layer. Additionally, it is possible to classify a specific change trigger along several components (i.e., *participation*, *origin*, or *characteristics*) or its subcomponents. In the following, the categorization scheme is introduced in more detail.

B. Dimensions of Categorization Scheme for Change Triggers

This section represents the main components relevant to specify a change trigger in business processes. As discussed in [5], a change can start a chain of changes. The proposed categorization scheme can also support the classification of change triggers in a chain of changes. The components *participation*, *origin*, and *characteristics* in Layer 1 represent the *w-questions*. In the following, the refinement of each component in subcomponents in next lower layers is described.

1) Component 1: The component *participation* (cf. Layer 1) includes three role descriptions in Layer 2: two antagonistic subcomponents *initiators* (e.g., [P8], [P11]) and *reluctant participants* as well as *further participants* with a neutral or passive role description. Based on the change model of Kurt Lewin (1947) [30] regarding the derivation and restraint of forces, the defined antagonistic principle is an important element to describe a change trigger. The subcomponents *initiators* and *reluctant participants* are indicators for identifying a change

TABLE III
CHANGE TRIGGERS IN BUSINESS PROCESSES

Layer 1	Layer 2	Layer 3	Layer 4
participation	*initiators*	legal entities	internal and external stakeholder
		non-legal entities	control and monitoring systems key performance indicator further systems (e.g., hardware, software, infrastructure) methods of communication
	reluctant participants	– " –	– " –
	further participants	– " –	– " –
origin	*internal origin*	person-related influence	skills and expert knowledge culture and ethical reasons leadership style internal stakeholder requirements
		business domain (process and structure)	business strategy, business goals business rules quality and performance organizational structure and further events
		technology and IT	logical design errors in business process model inefficient business model design (performance, benchmarking) hardware failure and technical problems safety
	external origin	person-related regulations	external stakeholder requirements
		socioeconomics	demography culture and ethical reasons
		politics	national legislation international agreements and conventions
		further regulations	standards and norms certification, seal/label (seal guarantees)
		economy	inflation globalization characteristics of economic systems
		location	climate natural disaster and hazards competing conditions referred to economic system
		technology	data communication and IT infrastructure data storage and processing IT security hardware evolution new production methods, working techniques and methods, materials
characteristics	*degree of urgency*	reactive proactive	
	degree of intensity	low medium high	
	degree of complexity	low medium high	
	degree of prediction	predictable unpredictable	
	degree of hierarchy	top-down change bottom-up change hybrid change	

process with regard to the business process domain. Layer 3 refines the established role description. Participation of a change trigger can be specified as a single person or as a group of persons according to group dynamics (cf. *legal entities* in Layer 3). The subcomponents of *legal entities* describe the *internal and external stakeholders* (e.g., [P5], [P8]). They are not specified in more detail to keep the developed categorization scheme more generic (in contrast to stakeholder analysis in [5]). The separation of *non-legal entities* contains methods or technical systems, which can act as (intelligent) decision support, communication medium (e.g., [14]), or technical support for stakeholders (e.g., [P2]).

2) Component 2: The second component of Layer 1 describes the *origin* of a change trigger. Based on the concept of system theory (cf. Sec. III), we define the subcomponents *internal origin* and *external origin* in Layer 2 (e.g., [P5], [P6], [P10]). This concept is applied to three subsystems: economy, sociology, and technology (i.e., subcomponents of *internal origin* and *external origin*). It is also possible to define hybrid-approaches like socio-economics, which increases the degree of complexity for a component term (e.g., subcomponents of *external origin*). Thus, we define the separation of the components in Layer 3 according to these described subsystems.

The subcomponent *internal origin* is divided into subcomponents *person-related influence*, *business domain (process and structure)*, and *technology and IT*. The subcomponents of *person-related influence* in Layer 4 are *skills or expert knowledge* (e.g., optimization of the business process due to new knowledge), *culture and ethical reasons* (e.g., culture of an organization [P3]), *leadership style* (cf. [14]), and *internal stakeholder requirements* (e.g., [P8]). The second branch of *internal origin* is related to the business domain involving the following four subcomponents in Layer 4 *business strategy/goal*, *business rules* (e.g., [P4]), *quality and performance* (e.g., [P1], [P7]),

and *organizational structure and further events*. Particularly, the intent of business rules can be described as "to assert business structure or to control or influence the behavior of the business" (cf. [31]). Thus, they are important change triggers due to their regulation nature (e.g., [P9]). The *quality indicators* such as *performance* or *cost* of products or services (e.g., [P7]) can trigger changes in processes. The subcomponent *organizational structure and further events* summarizes different occurrences like introducing new organizational forms (e.g., [14]). The *technology and IT* define three main separations. The first separation refers to change triggers, which come from developments inside technical systems [3]. *Inefficiencies* or *logical errors in business design model* (e.g., [P2]), *hardware-related problems* (e.g., [P2]), or *safety* (e.g., [P8]) are further change trigger categories with an *internal origin*.

In *external origin*, regulations have an important impact (e.g., [P7], [P9]). They set boundaries regarding the ability to act and determine the frame of processes. *Person-related regulations* are based on stakeholder requirements (e.g., due to contracts) (e.g., [P5]). The same applies to *politics* (i.e., *national legislation* (e.g., [P2], [P11]) or *international agreements/conventions* (e.g., [P4]) depending on the location of a company). The subcomponent *further regulations* aggregates any circumstances, which cannot be allocated to the subcomponents described above (e.g., *standards* and *norms* (e.g., [P4], [P8]) like quality DIN EN ISO 8402 [32]). The subcomponents of *economy* (e.g., *globalization* [13]) and *location* (e.g., *competing conditions regarding economic systems* [P3], [P5]) represent the business domain from an external perspective in system theory. Similar to *internal origin*, *technology* (e.g., *new production methods or techniques* [P11]) can also be a change trigger with an *external origin*. Dividing *technology* into five subcomponents in Layer 4, results from several concepts (e.g., Moore's Law [33]).

3) Component 3: The *characteristics* is the last component of Layer 1. It has five subcomponents in the next lower abstraction layer. In contrast to the two components described above, the classification of *characteristics* ends in Layer 3.

The first subcomponent *degree of urgency* (e.g., [P8], [P11]) represents a certain kind of action or behavior. The first subcomponent *reactive* has a forcing nature, while the second one *proactive* has a preventive intention according to changes. *Proactive* can introduce innovations and has a creative character.

The second subcomponent in Layer 2 *degree of intensity* refers to the last item of *w-questions* (i.e., *when or how*). It describes the immediate impact of a change trigger and has three classification level (i.e., *low*, *medium*, and *high*).

Degree of complexity (e.g., [P8]) represents the *degree of intensity* over time. We consider not only the effects of the initial change trigger, but also the effects of the following change triggers caused by the initial change trigger. Consequently, it has the following subcomponents: *low*, *medium*, and *high*.

The subcomponent *degree of prediction* (e.g., [P8]) defines the probability of a change trigger's occurrence. The occurrence can be *predictable* and *unpredictable*.

Degree of hierarchy (e.g., [14]) is the last subcomponent in Layer 2 reflecting the organizational structure and the ability of an enterprise regarding flexibility. Its subcomponents are *top-down change*, *bottom-up change*, and *hybrid change*. While a *top-down change* can be caused at a management level, a *bottom-up change* can have its origin at the employee level.

The categorization scheme (cf. Table III) is based on the aforementioned *w-questions* and the idea of system theory applied to different subsystems (e.g., technology). It can be considered as generic and is, thus, not limited to a specific context of business processes. A specific change trigger can be classified under one of the subcomponents along the layers for each component.

C. Benefits

In the following, we discuss the benefits and the purpose of the developed categorization scheme in research and practice:

i) As a business process can be considered as a set of actor steps (i.e., performed by human) and system steps (i.e., performed by information systems), there are mutual dependencies between both domains. Information systems and business processes are in operation over decades while being continuously modified. Consequently, change management with focus on a single domain (i.e., information system) is not sufficient [9]. A systematic categorization of change triggers for business processes aims at supporting change management not only in the business process management, but also in information systems, as it helps early estimation of changes caused by the corresponding business process and the resulting impact of information systems.

ii) The proposed categorization scheme can serve as a checklist when eliciting possible changes, future requirements, and risks for project planning.

iii) In addition to change management, the categorization scheme can be used as a framework for specifying description or modeling languages to support activities such as documentation, risk or statistical analysis, business process optimization, and controlling. It allows defining the semantic and syntax according to requirements of different focus groups and practitioners (e.g., business analysts). Further formalization can be done based on the proposed categorization concept.

iv) The proposed categorization scheme can be considered as generic, as it does not depend on specific economic sectors or contexts. As the categorization scheme allows categorization along several dimensions and layers, it can be applied to any organization and economic sectors.

D. Design Decisions and Assumptions

In the following, we discuss the design decisions regarding the categorization scheme. It is structured hierarchically in layers and components. This allows keeping the categorization scheme flexible according to future changes. Thus, extensions based on new knowledge (e.g., new change triggers) can be considered and added to the structure easily. We recommend to keep the degree of specialization of layers stable, as having a higher number of layers makes the categorization scheme inflexible, too complex, and not clear to users. We developed universal and not branch-specific change trigger categories. As

the categorization scheme allows to classify a change trigger along *participation*, *origin*, and *characteristics*, it is possible to specify an individual change trigger in different ways depending on the users' requirement or business process view.

E. Threats to Validity

In the following, we discuss the threats to validity of our review results and summarize the taken steps against limitations. To conduct our review, we used database search strategy as recommended in the evidence-based guidelines in software engineering. To decrease the risk of an incomplete keyword list of change trigger synonyms, we extract authors' synonyms from relevant papers during the conduction phase. This procedure helped to develop new search queries and enhanced the data to be analyzed. In spite of decreasing the hits in the database search and refining the search strategy during the pilot study, it was not possible to investigate every single publication of the search results (i.e., more than 50000 hits). Thus, the gained evidence is mainly limited to this constraint. A modified search strategy with a well-defined method was conducted for the database GS in order to decrease the risk of bias (i.e., regarding the time aspect in the paper ranking). While developing this strategy, we found out that it is only possible to investigate the first 1000 hits even if GS displays more results (i.e., if GS shows a number of hits over 1000 for a search query). In general, this might be a fundamental limitation for systematic studies. To avoid subjective bias in the final data selection phase, we necessarily discussed and evaluated our initial inclusion and exclusion criteria. Further, to reduce interpretations of different reviewers, we included only papers that explicitly mention the categories of change triggers. The data selection and data extraction phase was performed using peer review.

V. Conclusion and Future Work

In this paper, we presented the results of our review using a well-defined methodology. The main goal was to identify categories of change triggers in business processes. We used a pilot study to define our review protocol. The results show that several papers explicitly define categories of change triggers in the business processes. Based on these results, we built a generic categorization scheme according to change triggers in business processes along of the following dimensions: *participation*, *origin*, and *characteristics*. We also provided a fine-grained categorization scheme for each dimension. The categorization scheme aims at supporting comprehensive requirements elicitation and serving as a checklist for supporting the process of change and the risk management.

As future work, we aim at extending the review study to other change facet categories (i.e., change resistance) in order to proof and to consolidate the antagonistic principle in our categorization scheme.

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