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Business Process Redesign: A Systematic Review of Evaluation Approaches Prior to Implementation

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ABSTRACT

The continuous and systematic redesign of key business processes is very important for businesses and organizations that seek to achieve cost savings and efficiency enhancements. Selecting the most impactful processes and ensuring a successful redesign initiative remains an important topic that motivated the authors to conduct a Systematic Literature Review (SLR) on Business Process Redesign (BPR) Evaluation methodologies by applying an established eight-step SLR guide. The review sheds light on the current state of research and highlights the research gap by considering two dimensions of BPR artifacts: (a) the type of evaluation and (b) the generalizability of the existing approaches. The findings indicate that there is a lack of systematic methodologies in literature that properly evaluate the redesign capacity of models prior to implementation. Additionally, the existing methodologies do not cumulatively evaluate the quality characteristics that are necessary for BPR implementation or the applicability of BPR heuristics, and do not bear the generalizability to be readily used in a more general context. This paper aims to provide researchers with the necessary context and motivation to bridge this gap and further systematize BPR methodologies that can preselect the most suitable business processes for redesign.

1. Introduction

Despite the ambiguity of what types of processes and components fall under the Business Process (BP) umbrella, professional and research communities embraced the concept based on its premise for continuous improvement and redesign of critical parts of the organization [1]. One of the first academic works that helped to establish BPs was the work of Hammer and Champy [2]. BPs emerged as a concept that would transform the organization by providing the means to redesign and continuously improve its processes. It is important to recognize that BPs gained significant attention from both the academic and scientific communities because they embraced concepts such as transformation, redesign, and improvement.

Managing BPs has emerged as an advantage for every organization that adopts the BP outlook [3] and there have been reported a variety of approaches inspired by other management disciplines [4,5]. The common goal is to organize and implement BPs effectively, to complete them on time and

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within the specified resource constraints [6]. This viewpoint aims at improving overall performance by ensuring that business activities are better scheduled, executed, monitored, and coordinated [7].

Another important reason for the emergence of Business Process Redesign (BPR) stems from the need to be adaptable to the evolving organizational change by applying various techniques and approaches [8], towards modifying the process design depending on the feedback of the process run-time, and/or the performance attributes [9]. The prospect of continuously modifying and improving (i.e., redesigning) the various business operations played a central role in the emergence of BPs as a concept and is embodied in most Business Process Management (BPM) lifecycles, e.g., in [10,11]. As a structural model element, BPR is a first-class citizen in BPM lifecycles, even though it is incorporated into these models in diverse ways. The two principal non-mutually exclusive ways in which BPR is incorporated to the models are:

a. *Indirectly* through a feedback loop design approach. In such an approach, the phases of BP execution and design are called iteratively. In between these two phases, there may be additional phases, e.g., dedicated to monitoring and diagnosis. The main rationale is that metadata, new insights, and any kind of feedback generated during past executions can be leveraged to enhance the design of processes.
b. *Directly* through a specific component. In this approach, the process design component is explicitly mentioned to be activated and optimized periodically.

Although indirectly, BPR is implied by the iterative nature of phase sequence defined, most approaches opt to explicitly include redesign in their lifecycles and/or architectures with a view to emphasizing the significant role of BPR in BPM. It is important to note that, a detailed analysis of a BP typically sparks assorted ideas and perspectives for redesign, but it is usually conducted in a non-systematic way, and is considered a creative activity [12]. In this sense, parts of the wide-ranging spectrum of potential redesign options could be omitted, as in most creative techniques [13]. The latter enhances the need for narrowing the redesign perspective and specifying the aspects and capability of a method to yield better redesign options. For instance, a BP can be reformed to optimize metrics like resource utilization, maximal throughput, and flow time, and thus heuristics like task resequencing, parallelism, and task composition can be applied [14]. Given many such alternatives, there seems to be a lack of systematic ways to evaluate these heuristics and the tradeoffs among them.

What is also overlooked is the evaluation of the BPR impact prior to its implementation since most approaches deal with BPR at runtime. The redesign evaluation step is linked to the performance evaluation that provides feedback and revision-redesign options, which indicates that it is also conducted at runtime. What is overlooked in most existing redesign approaches is the consideration of the model type, its complexity level, the overall redesign feasibility, or, most importantly, the applicability of redesign heuristic(s). One of the obstacles for evaluating BPs is their complexity [15], and new methodologies are needed to manage this complexity, especially in terms of how to integrate process information into enterprise networks [16].

This paper aims to investigate the relevant literature in a systematic way for approaches that evaluate the redesign capacity of BP models prior to the implementation of BPR. To investigate the current level of knowledge in the form of proposed artefacts, existing redesign approaches are considered and analyzed in two dimensions: (a) the type of evaluation, and (b) their generalizability. The evaluation of BPR initiatives at design time is potentially a useful tool for practitioners towards increasing both the BPR effectiveness and the robustness of the varying methods.

It is important to note that evaluation is a critical step in the decision-making process. It involves assessing and judging the options or alternatives based on predefined criteria, which then informs the final decision. The distinction lies in the fact that evaluation is specifically focused on assessing the value, quality, or effectiveness of something, whereas decision-making involves choosing between alternatives based on a broader set of considerations.

The rest of the paper is organized as follows. Section 2 provides the adopted eight-step methodology for conducting the systematic literature review, while section 3 presents the literature review results and findings. Section 4 involves a discussion on the findings and the research landscape, based on answering the research question, while section 5 provides the conclusion of the work presented in this paper.

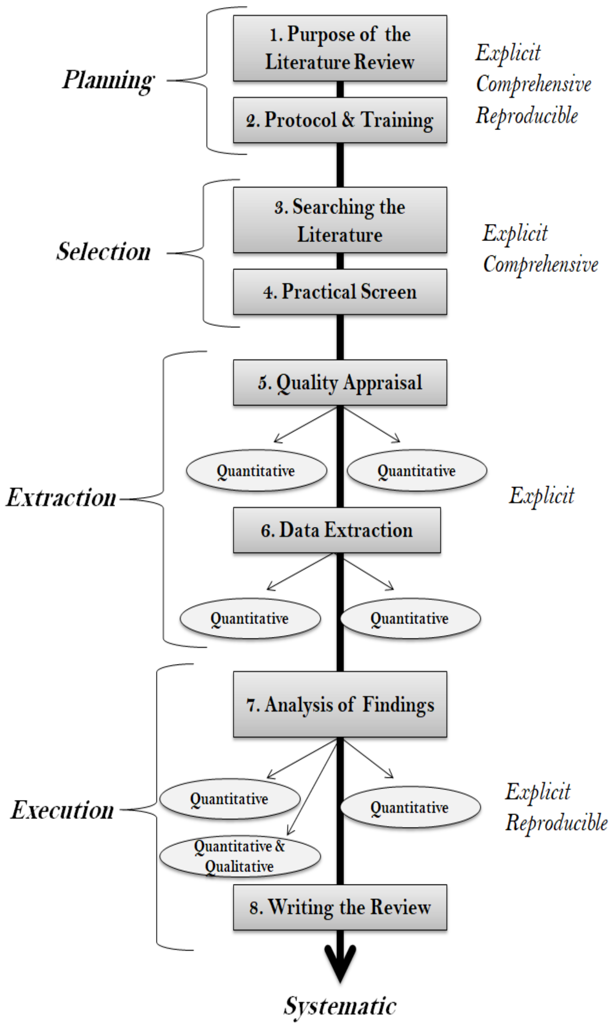

Fig. 1. Eight-step SLR guide [19]

2. Systematic Literature Review Methodology

To identify the research gap, the authors conducted a Systematic Literature Review (SLR) on BPR evaluation frameworks and methodologies. This section presents the adopted literature review methodology that facilitates the the research question formulation that will in turn highlight the research gap. According to Fink [17] an SLR is "a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners". A SLR aims to present a fair evaluation of a research topic by using a trustworthy, rigorous, and auditable methodology [18].

There is an abundance of guides to conducting SLRs in varying research fields. This research is based on the methodology proposed by Okoli and Schabram [19] that has been conceived with a particular emphasis on SLR conducted within the Information Systems (IS) domain. The authors consider it suitable and applicable for the research works under the topic of BPR as it falls within the IS domain. According to Okoli and Schabram [19], conducting a SLR is based on eight steps that are included in four phases: namely *Planning, Selection, Extraction* and *Execution*. Figure 1 presents the eight-step guide, and each step is further discussed.

Planning

The first step in the review process requires to clearly identify the purpose and intended goals. In this aspect, the particular review is intended to provide an insight into established BRP evaluation methodologies (or frameworks) and identify which aspects are researched until now and what is missing from literature. To properly ground the research, the authors conducted an SLR which entails that the review is exhaustive in terms of literature searching and extraction. Since formulating the research question guides the design of the review process, its specification is the most important part of any literature review [20]. In view of the SLR the research question is formulated as follows:

RQ: Are there any systematic methodologies in scientific literature that evaluate the redesign capacity of models prior to BPR implementation? And how the evaluation is performed?

Once the question has been formulated, the research protocol serves as a roadmap and includes the following steps:

a. The sources and search strings for searching literature.
b. The practical screen criteria (content, language, year range, etc).
c. The quality appraisal criteria (methodological quality, argumentation analysis).
d. The data extraction method for storing details of the final list of articles.
e. The method for the analysis of findings.
f. The process of writing the SLR, using the comprehensive and polished synthesis of information from the previous stage.

Selection

The strategy employed in this phase is to find as many scientific publications as possible and, subsequently, narrow down the results by applying predefined criteria. The first action in the search strategy is the selection of the search sources. Table 1 presents the selected search sources that were employed to conduct the search. These databases were chosen in an effort to traverse the majority of scientific publications. The search in each database was applied to the full text of the publications.

Table 1
Literature Databases

Database	Institution	Abbr.
Google Scholar	Google	GS
ACM Digital Library	ACM	ACM
IEEE Xplore	IEEE	IEEE
ScienceDirect	Elsevier	ELSV
SpringerLink	Springer	SPRG

The authors submitted a set of search strings for the RQ but in some databases the search string had to be adjusted due to Boolean restrictions (the adjustments are shown in detail later). The main search string is the following:

*("process redesign" OR “process re*design” OR "process improvement" OR "process optimization") AND ("framework" OR "methodology") AND ("assessment" OR "evaluation") AND ("before implementation" OR "before application" OR "before execution")*

After searching through the literature, the authors retrieved large sets of related research works. In this step the authors include articles based on whether the study is digitally accessible (IC-A1), whether the study's content is applicable to the research question (IC-C1), and, according to explicitly defined paper specification criteria (IC-P1 IC-P2 and IC-P3) aiming to restrict the total number of articles to a set that is practically manageable. The selected criteria (see Table 2) are subjective but are clearly defined for the resulting literature review to be reproducible. Regarding content, the exclusion/inclusion of studies was based on reviewing the title and the abstract of each study.

Table 2
Practical Screening Criteria

Criteria		Description
Accessibility	IC-A1	The full text of study should be digitally accessible.
Content	IC-C1	The studies should have bearing on the specific RQ.
Language	IC-P1	The studies should be written in English.
Publication Date	IC-P2	The studies are restricted to date ranges from 2000 to 2022.
Publication Type	IC-P3	The studies should be books, book chapters, journal articles, already published literature reviews or conference papers.

Extraction

In the extraction phase, the eligible studies are examined more closely to assess their quality and extract the information from the final list of studies. The primary studies have varying quality in terms of methodological support and in many cases propose artefact approaches; thus, it is important to characterize studies according to the extent to which they meet basic standards of quality. Moreover, artefacts were repetitively used by the same or different authors. In this research, the authors define the quality inclusion criteria by focusing on approaches that: (a) propose artefacts related to each RQ, (b) are based on a clearly defined methodology for the introduction of the artefact and, (c) are the primary proposed artefact. The inclusion criteria IC-A2, IC-M and IC-P4 are presented in Table 3.

Table 3
Quality Appraisal Criteria

Criteria		Description
Artefact Proposal	IC-A2	Has the study proposed an artefact for the purpose of the RQ?
Methodological support	IC-M	Is the proposed artefact based on a clearly defined methodology?
Primary Artefact	IC-P4	Is the proposed artefact the primary approach in literature?

The extraction of the final list of studies related to the RQ was performed by excluding duplicate ones and orderly applying the inclusion criteria of the practical screening and quality appraisal sub-phases. At this point, critical information was systematically extracted from each paper to serve as the raw material for the synthesis stage. The type of extracted data is based on the RQ established during the protocol phase. In this research, the authors focused on the generalizability of the approaches, the applicability of artefacts to varying process types and models, the consideration of different BPR evaluation methods and the focus on performance criteria.

Execution

This phase involves the combination of knowledge through the synthesis of studies to produce concrete evidence. The articles for the review have been practically screened and selected based on quality criteria, while the relevant data for answering the RQ have been extracted. The next requirement is to combine the extracted data to produce knowledge out of many studies through a polished synthesis of information. In this research, the synthesized studies are qualitative, and the synthesis stage follows the methodology proposed by [21]. Thus, the synthesis has a clear concept-centric focus, the extracted information is effectively mapped to optimally evaluate the data and they are incorporated within the theory of the authors' review.

The final sub-phase of developing the SLR is writing the review and reporting the findings. The process of conducting the SLR has been intricately documented for it to be reproducible by other researchers. This means that by following the same exact steps, one can reproduce the same results of this review. Lastly, the review concludes by highlighting the findings that indicate a research gap in literature for artefacts pertaining to the defined RQ.

Table 4
Search results after practical screening and duplicates removal

			After Practical Screening	
Source	**Search String**	**Initial Results**	**IC-A1, IC-P1, IC-P2, IC-P3**	**IC-C1**
Google Scholar	("process redesign" or "process improvement" OR "process optimization") AND ("framework" OR "methodology") AND ("assessment" OR "evaluation") AND ("before implementation" OR "before application" OR "before execution")	329	23	
	("business process redesign" OR "business process improvement" OR "business process optimization") AND ("framework" OR "methodology") AND ("assessment" OR "evaluation") AND ("redesign capacity" OR "redesign capability" OR "ability to be redesigned")	12	4	
	("business process redesign" OR "business process improvement" OR "business process optimization") AND ("framework" OR "methodology") AND ("model assessment" OR "model evaluation")	419	7	
IEEE Xplore	("process redesign" OR "process improvement" OR "process optimization") AND ("framework" OR "methodology") AND ("assessment" OR "evaluation")	56	8	67
ACM Digital Library	("process redesign" or "process improvement" OR "process optimization") AND ("framework" OR "methodology") AND ("assessment" OR "evaluation") AND ("before implementation" OR "before application" OR "before execution")	85	2	
Elsevier Science Direct	"business process redesign" AND ("framework" OR "methodology") AND ("assessment" OR "evaluation") AND ("before application" OR "before execution" OR "before implementation")	308	26	
SpringerLink	("process redesign" or "process improvement" OR "process optimization") AND ("framework" OR "methodology") AND ("assessment" OR "evaluation") AND ("before implementation" OR "before application" OR "before execution")	165	11	
Number of research items:		1374	81	67

3. Literature Review Results

In view of the SLR, the authors conducted searches on the literature databases towards answering RQ: *Are there any systematic methodologies in scientific literature that evaluate the redesign capacity of models prior to BPR implementation? And how the evaluation is performed?*

3.1 Practical Screening

For the review to be comprehensive and given the fact that the search engines and capabilities are different in each database source, the search strings were customized to produce as many relevant results as possible (Table 4). Moreover, in BPR the terms ‘evaluation’ and ‘assessment’ are frequently used interchangeably and were both included in the literature review search strings.

The authors further selected to include the term “business process” to the search query of the IEEE Xplore database, due to fact that from the 232 initial studies retrieved, 176 of them related to the software process optimization. Regarding the SpringerLink database, the authors excluded the subdisciplines "Software engineering" (forty-nine studies) and "software engineering/Programming and Operating Systems" (forty studies) to acquire a list of 165 studies.

After the initial search, the authors retrieved 1,374 papers. Consequently, the inclusion criteria IC-A1, IC-P1, IC-P2, IC-P3 were applied, and eighty-one studies were good candidates for the next round of reviews. Regarding the criterion IC-C1 the authors identified the relevant studies by reading the title and abstract of the retrieved papers. To determine the relevancy of each paper, the title and abstract indicate whether the study introduces or applies an artefact, methodology or set of activities, towards assessing the BPR (or related discipline) capacity of input models. This process and the exclusion of duplicate papers resulted in sixty-seven studies.

3.2 Quality Appraisal

In the next review step, the quality appraisal criteria IC-A2, IC-M and IC-P4 are applied. The authors included studies that (a) propose an artefact for the evaluation of redesign capacity, (b) the artefact is based on a clearly defined methodology, and (c) the proposed artefact is the primary approach. The quality appraisal step resulted in the exclusion of studies, and the final number of included studies after each criterion is presented in Table 5.

Table 5
Number of included Studies after each criterion.

	Practical Screening	After IC-A2	After IC-M (& IC-C1)	After IC-P4
Number of included Studies	67	44	36	32

Initially, the IC-A2 criterion was applied by reviewing each of the sixty-seven studies. This step resulted in excluding twenty-three studies as in these cases an artefact or concrete methodology was not introduced or applied. The data set of forty-four studies is presented in detail in the supplementary material, where in Section 1 each study is enumerated, and basic information (year of publication, authors, title, and source) is presented. In the supplementary material, the authors present further demographic statistics pertaining to the year of publication, number of publications per author, type, outlet, and discipline. What is evident is that an increase of interest on the research topic can be observed after 2012, and that Hajo A. Reijers [27,56] and Paul Harmon [1,29] are the authors most frequently introducing evaluation methodologies (three studies) for BPR implementation.

The publication type is most frequently scientific journals (73%) and the publication outlet that most frequently appeared is the Business Process Management Journal (five studies). Lastly, the analysis of publications per discipline resulted in BP improvement (nineteen) as the most frequent discipline. In many studies, the three major disciplines (improvement, redesign, and reengineering) referred to in nineteen, twelve and twelve studies respectively, were used interchangeably for similar BPR initiatives.

The next quality appraisal criterion (IC-M) involved further reviewing the studies to exclude the ones that are not based on a concrete methodology, either pre-existing in literature or new. This analysis resulted in excluding the studies [12] and [18] for proposing artefacts that are not based on a concrete methodology. It is important to mention that since each of the forty-four studies was meticulously reviewed, the authors also excluded six more methodologies from the initial set of forty-four studies (i.e., the studies in papers [14, 20, 23, 30, 34, 43]), since they proved irrelevant to the purposes of the RQ (Practical Screening criterion IC-C1).

The last quality appraisal criterion (IC-P4) involved examining whether the implemented artefact in each study is the primary approach in literature, or it is reused in studies of the list. This analysis resulted in excluding papers [26, 38, 31, 28] since they reuse previously introduced methodologies in papers [8, 24, 25]. The final list following the practical screening and the quality appraisal phases includes thirty-two (32) studies that propose primary artefacts for BPR evaluation and are methodologically sound, i.e., they are based on a concrete pre-existing or new methodology. The selected studies were stored using the Mendeley Reference Manager software and in pdf format for data extraction and further investigation.

3.3 Data extraction and Execution

During the data extraction phase, critical information was systematically extracted from each paper to serve as the raw material for the synthesis stage and the answer to RQ. The authors considered two dimensions of BPR evaluation artefacts: (a) the type of evaluation, and (b) the generalizability of the approaches. The combination of knowledge through the synthesis of studies for the two dimensions, aims to produce concrete evidence for answering the RQ. The recorded elements, phases or steps followed in each methodology and the extracted information regarding generalizability and inclusiveness, are presented in the supplementary material.

Type of Evaluation

Each of the thirty-two artefacts is reviewed to extract the type of evaluation, the evaluation characteristics (organizational aspects, performance, quality) and the BPR characteristics (type and whether the methodology proposes the “TO-BE” BP model). The selection of evaluation characteristics is rationalized by the vital role of the organizational aspects, the external quality and performance of models for the application of BPR.

Table 6 presents the reference of each artefact and the type of evaluation. The latter proved to vary between model characteristics (e.g., quality), the impact of different activities on process performance, critical-to-quality (CTQ) and critical-to-business (CTB) factors, process performance indicators (PPIs), critical success factors (CSFs), etc. In AS MDs [15, 16, 18, 19, 25, 30], the artefacts evaluate process improvement, BPR and reengineering projects based on success factors, desirable organizational, lean capabilities, project goals or organization's goals priorities. Hence, they focus on a distinct perspective since they evaluate projects or initiatives instead of processes.

Table 6
Type of Evaluation of each Artefact

No	Reference	Type of Evaluation
AS MD 1	[22]	Evaluation of organizational knowledge.
AS MD 2	[23]	Evaluation of model characteristics.
AS MD 3	[24]	Evaluation of enlightened performance measures.
AS MD 4	[25]	Evaluation of process performance.
AS MD 5	[26]	BP evaluation and decision.
AS MD 6	[27]	Evaluation of process performance (service times, lead times, arrival rate of new cases, work-in-progress, resource Utilization).
AS MD 7	[28]	Evaluation of process performance (resource capacity, service time characteristics, etc.).
AS MD 8	[29]	Evaluation of existing process in the "Analyze Process". The procedure involves identifying any "disconnects" or deficiencies in the current As-Is process and recording findings on a process analysis and improvement worksheet.
AS MD 9	[30]	Evaluation of process performance, choosing better-designed processes to get better-results, cost evaluation, determining bottlenecks and wastage.
AS MD 10	[31]	Understand the "AS-IS" process and measure the variation that takes place in key performance measures.
AS MD 11	[32]	Evaluation of process performance (Cycle Time, Process bottleneck, Cycle cost and Resource utilization).
AS MD 12	[33]	Evaluation of process performance (Time, quality, cost, service, and environment).
AS MD 13	[34]	Evaluation of component's importance, BP's popularity, BP's qualitative impact, BPs relationship to BPR goal and BP's impact on project risk.
AS MD 14	[35]	Evaluation of performance measures (cost, performance, and reliability) by identifying the impact of Non-Value-Added Activities (NVA) risk factors.
AS MD 15	[36]	Evaluation of desirable organizational capabilities (DOCs) for BPR projects.
AS MD 16	[37]	Evaluation of process improvement initiatives using time-driven activity-based costing (TDABC) in a Preoperative Assessment Center (PAC).
AS MD 17	[38]	Evaluation of effectiveness, efficiency, and adaptability of existing processes.
AS MD 18	[39]	Evaluation of BP reengineering projects based on success factors (such as driving BPR projects using customer demand, competitive pressures, and financial performance).
AS MD 19	[40]	Evaluation of BPI projects by measuring project goals from a customer and business perspective and performance indicators.
AS MD 20	[15]	Selection of processes for redesign through multi-criteria analysis and supply chain operations reference (SCOR) model performance attributes and metrics.
AS MD 21	[41]	In phase "Evaluate Current State", the process is mapped, and Lean tools are implemented (i.e., VSM current state, 5Why's, Work sampling, etc). In the next phase, visual/performance management is implemented.
AS MD 22	[42]	The a priori evaluation of process improvement patterns (PIPs) is based on process improvement objectives (PIOs) and measures (PIMs).
AS MD 23	[43]	BPMIMA measures input models by using BPMMETool and evaluates external quality measures to propose specific redesign practices.
AS MD 24	[44]	The framework includes process performance indicators (PPIs) and indicators to assess whether process redesign best practices have been applied and to what extent.
AS MD 25	[45]	Analytic Hierarchical Processing (AHP) is used to identify the BP priority based on the organization's goals priorities.
AS MD 26	[46]	The Khan-Hassan-Butt (KHB) method identifies process interdependencies and used them as decision-making tools to increase productivity.
AS MD 27	[12]	The assessment mechanism evaluates the model type, complexity metrics, normalization, and optimization capability of candidate process models.
AS MD 28	[47]	The KPI4BPI approach defines Key Performance Indicators (KPIs) target values within the process model.
AS MD 29	[48]	IBUPROFEN assesses model quality prior to applying BP refactoring.
AS MD 30	[49]	This study suggests that leanness assessment is essential to identify the current lean capability of a health-care organization. The enablers of lean performance indicators are

No	Reference	Type of Evaluation
		Process flow, Workforce, Sustainability, Management, Technology, Service strategy and Operational leanness.
AS MD 31	[50]	The Process redesign framework (PRF) was deployed to develop the Standard process model (SPM). The identified activity attributes were Calendar Time and Effort Time.
AS MD 32	[51]	The BP-RCA Framework assesses the redesign capacity of a BP model based on: (i) the available redesign technique, (ii) the specified performance criteria, (iii) the applicable redesign heuristics and (iv) the values of complexity metrics.

Table 7 presents further information and characteristics of the evaluation methodologies. Initially, specific evaluation characteristics of the approaches are examined, to highlight their differences and level of abstraction. In twelve out of thirty-two methodologies (AS MD 1, 2, 3, 5, 6, 10, 13, 15, 17, 25, 28 and 30), the artefacts evaluate organizational aspects and how these aspects affect the application of BPR. These approaches examine human factors, strategy formation, planning, target values and building organizational ontology in the act of BPR. The approach in [36] further examines 21 desired organizational capabilities (DOCs) in aspects of BPR, while [49] study suggests that leanness assessment is essential to identify the current lean capability of a health-care organization, thus, leading to a more focused BPR implementation. Also, Mohapatra [38] suggests that developing the business vision and business objective is a key feature for the identification of the BPs to be redesigned.

The next evaluation characteristic of the approaches is BP performance. In twenty-eight out of thirty-two methodologies the artefacts evaluate the process performance by measuring performance indicators related to time (e.g., service times, lead times, arrival rate of new cases, calendar time, effort time), cost (e.g., activity-based costing, cycle cost), resource utilization, KPIs, PPIs, etc. In these cases, process performance is assessed based on statistical data that have derived from prior process execution or simulation. This means that the selection of processes for BPR or the evaluation of redesign capability of each model is not performed before implementation, i.e., at design time, process discovery or during strategic analysis.

Another subset of artefacts (AS MD 17, 22, 26, 29) involves the evaluation of distinctive characteristics of input models. The AS MD 17 provides the evaluation of effectiveness, efficiency, and adaptability of existing processes in general. AS MD 22 involves the a priori evaluation of process improvement patterns (PIPs) which is based on process improvement objectives (PIOs) and measures (PIMs). The AS MD 26 proposes an artefact that identifies process interdependencies and employs them as decision-making tools to increase productivity.

Maintenance and quality assurance of candidate process models are considered critical [52], since poor model quality can affect the development effort and/or result in a process or product with defects [53]. This importance of external model quality has motivated the authors to review selected studies regarding the evaluation of model quality characteristics. In AS MD 3, Brown *et al.* [24] argue that the bases of performance measurement for operations are speed, flexibility, price, reliability, and quality. More specifically, they define quality as the act of “making products or providing services to provider and user specifications” and argue that it is the fundamental measure in a performance measurement system towards identifying where to target its performance improvement efforts. In AS MD 17, the performed process implementation activities involve piloting and implementing new processes or changes to existing ones across an organization [38].

In the act of planning the piloting procedure, the one implementing the reengineering framework defines the objectives for pilot (like quality, productivity, and cycle time improvements). In the AS MD 19, Johannsen and Fill [40] determine the BPI goals through the critical-to-quality (CTQ) factors that capture the customers' requirements on a process. Through the BPI roadmap, performance indicators are used for measuring specific project goals derived from customer requirements.

Table 7

BPR and BPR Evaluation Characteristics

	Evaluation Characteristics			BPR Characteristics	
No	Organizational Aspects	BP Performance	BP Quality	Type	Proposes "TO-BE" BP
AS MD 1	X			Reengineering	
AS MD 2	X	X		Reengineering	
AS MD 3	X	X	X	Improvement	X
AS MD 4		X		Reengineering	X
AS MD 5	X			Reengineering	
AS MD 6	X	X		Improvement	
AS MD 7		X		Redesign	
AS MD 8		X		Redesign	X
AS MD 9		X		Reengineering	X
AS MD 10	X	X		Improvement	X
AS MD 11		X		Improvement	
AS MD 12		X		Continuous Improvement	X
AS MD 13	X	X		Redesign	
AS MD 14		X		Improvement	
AS MD 15	X			Reengineering	
AS MD 16		X		Improvement	
AS MD 17	X	X	X	Reengineering	X
AS MD 18		X		Reengineering	X
AS MD 19		X	X	Improvement	X
AS MD 20		X		Redesign	X
AS MD 21		X		Improvement (Lean)	X
AS MD 22		X		Improvement	X
AS MD 23		X	X	Improvement	X
AS MD 24		X	X	Redesign	X
AS MD 25	X	X		Reengineering	X
AS MD 26		X		Reengineering	X
AS MD 27		X	X	Redesign	X
AS MD 28	X	X		Improvement	X
AS MD 29			X	Refactoring	X
AS MD 30	X	X		Improvement (Lean)	
AS MD 31		X		Redesign	X
AS MD 32		X	X	Redesign	

In the AS MD 23, Sánchez-González *et al.* [43] demonstrate the usability of BPMIMA framework; composed of empirically validated measures related to quality characteristics of the models, a set of indicators with validated thresholds associated with the 7PMG guidelines and the prototype BPMMETool. In AS MD 24, the authors define Process Performance Indicators (PPIs) in four perspectives: time, cost, quality, and flexibility. Regarding quality, the PPI metrics evaluate the extent of standardization on process flows or time-related values. This means that they focus on internal process quality, in the sense that improved internal quality will most probably lead to improved customer satisfaction.

Tsakalidis *et al.* [12] propose the AS MD 27 in which the structuredness of the model and an indication of its overall complexity is evaluated prior to BPR. Given that the overall complexity is an external quality measure of models, it is assumed that the proposed approach provides an indicative evaluation of model's quality for BPR. The IBUPROFEN framework (AS MD 29) calculates well-proven measures (such as size, connectivity, separability, and density) to assess the understandability and modifiability (external quality) of input models and apply refactoring operators. The AS MD 32 evaluates the model complexity as a critical characteristic of BP models that signifies their understandability and modifiability. In this sense, model complexity is considered by the authors as a measurable property of quality.

Table 7 also presents a categorization of the approaches based on the type of the BP change that the authors of each paper claim to evaluate and whether the approaches further propose the "TO-BE" BP models. It is important to mention that the authors of this paper consider Business Process Redesign (BPR) to be an umbrella term encompassing the different disciplines, since it is extensively used in practice nowadays and referred to in literature. Based on the findings, ten out of thirty-two approaches refer to the evaluation of BP Reengineering (BPReng); a more radical type of change that can produce quick and substantial gains in organizational performance by starting from scratch in designing the core BPs.

Thirteen approaches refer to BP Improvement (BPI); a more incremental type of change, encompassing disciplines like Continuous Process Improvement, TQM, Lean and Six Sigma. The remaining nine approaches refer to BPR and related disciplines of this BP change category (Refactoring, BP Adaptation and Optimization). Lastly, twenty approaches are extended to also apply the BPR and propose the "TO-BE" BP models, apart from evaluating the BPR capacity.

As a result, the studies refer to artefacts that evaluate: (a) BPR initiatives or projects based on the organizational priorities, capability or success factors, (b) the applicability of initiatives based on process improvement objectives and measurement or process interdependencies, (c) candidate process models based on measurable performance indicators like time, cost and resource utilization, (d) candidate process models based on more qualitative indicators like effectiveness, efficiency, adaptability and quality. In eight out of thirty-two artefacts, quality characteristics of the models like internal process quality and critical-to-quality factors were assessed before applying a BPR initiative. It is also important to mention that none of the reviewed papers introduce or apply an artefact that provides evaluation of the model's redesign capacity prior to implementation.

Generalizability

Generalizability or generalization, is an act of reasoning that involves drawing broad inferences from a set of observations and, is widely acknowledged as a quality standard in research [54]. In practice, generalizability is the extent to which the findings of a study can be applied to other situations and can be divided into population, environmental and temporal generalizability. In this subsection the authors investigate the population generalizability of the artefacts, meaning the extent to which the approaches can be applied to a broader population of BP cases from the ones that are being used. There is also a particular focus to this quality characteristic, due to research work in progress by the authors to create a more generalizable BPR evaluation and application framework. For deriving rational inferences, the authors determined five generalizability criteria and investigated how each artefact fulfills them. The criteria are:

1. Whether the artefact can be applied to BPs in general.
2. Whether the artefact supports different BPR methods (BPReng, BPI, BPO, etc).
3. Whether the artefact supports different process model notations.
4. Whether the artefact supports the selection of different objectives.
5. Whether the artefact supports the selection of different redesign heuristics.

The authors focused on critical redesign components and the analysis aims to draw a conclusion on whether the artefacts can be used in a more general context and to varying BPs. Table 8 presents the extracted information. As it is evident, four artefacts use specific BP models to serve as inputs. AS MD 2 focuses on Industry BPs, AS MD 16 and AS MD 30 on BPs from Health Care and AS MD 20 on Supply Chain processes. The focus and application of BPR on particular domains does not guarantee that the artefacts can be generalized and be applied to BPs from other domains.

Table 8
Generalizability of Artefacts

No	1. Can the artefact be applied to all BPs?	2. Does the artefact support different BPR methods?	3. Does the artefact support different process model notations?	4. Does the artefact support the selection of different objectives?	5. Does the artefact support different redesign heuristics?
AS MD 1	X	X			
AS MD 2					
AS MD 3	X	X		X	
AS MD 4	X				
AS MD 5	X				
AS MD 6	X			X	
AS MD 7	X			X	X
AS MD 8	X				
AS MD 9	X	X	X	X	
AS MD 10	X				
AS MD 11	X			X	
AS MD 12	X			X	
AS MD 13	X			X	X
AS MD 14	X			X	
AS MD 15	X				
AS MD 16				X	
AS MD 17	X	X	X	X	
AS MD 18	X			X	
AS MD 19	X				
AS MD 20				X	
AS MD 21	X			X	
AS MD 22	X			X	X
AS MD 23	X				X
AS MD 24	X			X	X
AS MD 25	X				
AS MD 26	X				
AS MD 27	X				
AS MD 28	X				
AS MD 29	X				
AS MD 30					
AS MD 31	X				X
AS MD 32	X	X	X	X	X

The second criterion to be considered is whether each artefact supports the application of different BPR methods. The authors discovered that for most studies, the evaluation artefacts were implemented for a particular BPR method. In the AS MDs 1, 3, 9, 17 and 32 the application of different BPR methods is either explicitly or implicitly supported. Specifically, in AS MDs 1 and 9 the applicability of varying BPR methods is implicitly denoted. The AS MD 3 can be applied for continuous improvement, BPReng and benchmarking methods, while in AS MD 17 BPR is implemented using tools such as flowcharts, histograms, Pareto charts, control charts, scatter plots, and fishbone diagrams. The AS MD 32 explicitly supports the application of varying BPR methods.

The third criterion refers to the capability of the artefact to use input models in different process model notations. In most cases, there is no discussion related to the selection of varying model types for the candidate input models. It appears that in some of the cases, the artefacts could support different model types, but there is no such definite consideration. In the AS MDs 9 and 17, it is implicitly presumed that the artefacts are applicable for different input model types, while the AS MD 32 explicitly supports the usage of input models in varying notations.

The next generalizability criterion examines whether the artefacts support the selection of different improvement objectives. Sixteen out of thirty-two artefacts focus on the improvement of specific objectives. For instance, AS MD 19, concentrates on the reduction of cycle time as a performance indicator, the AS MD 26 on time-related aspects of performance, like lead time, cycle time, maintenance time and bottlenecks, and the AS MD 23 on the improvement of quality. The AS MDs 3, 6, 7, 9, 11, 12, 13, 14, 16, 17, 18, 20, 21, 22, 24 and 32 support the selection of different performance objectives. AS MD 3 provides business analysts with the capability to select different objective between speed, flexibility, reliability, and price, while in AS MD 6 the selection is also feasible but is limited to lead time, service time, wait time and utilization of involved human resources.

The AS MD 11 focuses on cost reduction, quality improvement, service improvement and process time reduction and the AS MD 12 proposes a performance evaluation technique that considers the performance indicators of time to market, quality, cost, service, and, environment. The AS MDs 7, 9, 13, 22, 24 and 32 provide the capability of selecting among the performance objectives of time, cost, quality, and flexibility, introduced in [55]. These performance criteria are the most established in the BPM community and are interrelated in the devil's quadrangle that demonstrates the inevitable trade-offs among them. Finally, in some cases (AS MD 17, 21) the consideration of different performance criteria is implicitly denoted.

The last criterion is the degree to which the applicable BPR method in each artefact supports the application of different heuristics (i.e., practices). This criterion is fulfilled in the case of artefacts that either explicitly support Heuristic Process Redesign or the BPR method resembles the application of different redesign heuristics from [56]. What is concluded from the analysis of studies is that most artefacts (twenty five out of thirty-two) do not support the application of redesign heuristics. The AS MDs 7, 13, 24 and 32 support the application of the full set of 29 redesign heuristics in [56], while the AS MD 31 further extends the list of applicable heuristics to 49 by including the rules in [57,58].

Lastly, the AS MD 29 is used towards assessing the Quality (Understandability and Modifiability) of BPMN models and applying a subset of refactoring operators to optimize them. A subset of these refactoring operators are the 7PMG guidelines in [59] which in turn resemble some of the redesign heuristics.

In summary, the overall degree of generalizability is different among the artefacts. In twenty five out of thirty-two cases, two or less generalizability criteria are fulfilled, meaning that the artefacts are more case-specific and are not considered suitable for BPR application in a wider context. In the AS MDs 3, 13, 22 and 24 three out of five criteria are fulfilled.

The AS MD s 13, 22 and 24 are more generic in the sense that there is no limitation regarding the type of BPs serving as inputs and they support the selection of different objectives and redesign heuristics, while the AS MD 3 supports different BPR methods, but there is no explicit selection of redesign heuristics. The AS MDs 9 and 17 fulfil four out of five generalizability criteria since they do not support the explicit selection of redesign heuristics. Lastly, the AS MD 32 fulfils the full set of predefined generalizability criteria and is considered as the most inclusive artefact, incorporating critical redesign aspects like the selection of BPR method, performance criteria, heuristics, and overall complexity of the input model.

4. Discussion

The conducted review is based on the proposition that the evaluation of redesign capacity of input models should be a compound of: (a) evaluating essential characteristics related to organizational aspects, BP performance and quality that are necessary for BPR implementation, and (b) evaluating the applicability of redesign heuristics, through measurable indicators. Moreover, for a redesign capacity evaluation artefact to be more contributing, it should bear a certain degree of generalizability for critical to BPR components, as case-specific artefacts are less useful to most domains.

In this sense and to answer the formulated RQ, the authors investigated the types of evaluation and the generalizability of each artefact. In total, the studies refer to artefacts that evaluate: (a) BPR initiatives or projects based on the organizational priorities, capability or success factors, (b) the applicability of initiatives based on process improvement objectives and measurement or process interdependencies, (c) candidate process models based on measurable performance indicators like time, cost and resource utilization, (d) candidate process models based on more qualitative indicators like effectiveness, efficiency, adaptability and quality.

In this work, we employed BPR as an umbrella term based on the Redesign Orbit [60]. The artefacts refer to different BPR disciplines, which can also be attributed to the time of publication. Ten out of thirty-two approaches – most of which were published until 2013 - refer to the more radical BPReng that currently is not considered very popular amongst practitioners. Thirteen approaches refer to the more incremental BP Improvement while the rest nine cases refer to BPR and related disciplines like refactoring and adaptation. Twenty approaches are extended to also apply the BPR discipline and propose the "TO-BE" BP models, apart from evaluating the BPR capacity.

From the analysis of the evaluation type, we found that very few approaches took into consideration all three critical characteristics as suggested by the authors. Regarding organizational aspects that affect BPR, twelve out of thirty-two approaches considered aspects, like human factors, strategy formation, planning, target values, organizational capabilities, and ontology. What was also unveiled is that ten out of these thirteen approaches were published before 2013, meaning that recent approaches tend to give less attention to strategic organizational aspects when evaluating the applicability of BPR schemes. Regarding BP quality, the review highlighted a critical characteristic in eight out of thirty-two artefacts: In these approaches, quality characteristics of the models, such as internal process quality and critical-to-quality factors were assessed before applying a BPR initiative.

Despite the small number of proposed approaches in literature, seven were introduced after 2013. Regarding the BP performance, twenty eight out of thirty-two approaches assess process performance by measuring performance indicators related to time, cost, resource utilization, KPIs, PPIs, etc. This signifies the importance of BP performance indicators for the application of BPR.

Nonetheless, all the approaches were based on statistical data that have derived from prior process execution or simulation. This means that the evaluation of redesign capability of BPs in all cases is not performed before implementation, i.e., at design time, process discovery or during strategic analysis. None of the reviewed papers provides an evaluation of how a BPR initiative would perform, e.g., by measuring the applicability of selected BPR heuristics.

The authors also investigated the generalizability of the approaches to investigate the extent to which the approaches can be applied to a broader population of BP cases. To do so, the authors determined five generalizability criteria, and checked the degree to which each of the approaches fulfils them. It is shown that in twenty-five out of thirty-two cases, two or less generalizability criteria were fulfilled. That means that the artefacts are not considered suitable for a BPR application in a broader context. Moreover, in four cases, three out of five criteria were fulfilled, while two other cases fulfilled four out of five criteria since they do not support the explicit selection of redesign heuristics. Only one artefact fulfilled the full set of predefined generalizability criteria, proving a useful methodology for a broader context. In summary, the approaches proved to bear a limited generalizability and were mostly tailored for input processes and custom methods. This fact potentially delimits their usability.

In conclusion, none of the thirty-two artefacts introduces or applies a methodology that cumulatively: (a) evaluates organizational aspects, BP performance and quality characteristics necessary for BPR implementation (b) evaluates the applicability of BPR heuristics, through measurable indicators, (c) includes all the necessary redesign components and (d) bears the generalizability to be readily used in a more general context. Hence, the answer to the RQ is that there are no methodologies – and as a logical inference, none of them systematic - in literature for evaluating the redesign capacity of models prior to BPR implementation.

The contribution of this review lies in the fact that there is a considerable gap in literature regarding contemporary approaches that assess BPR prior to implementation. This inference can serve as a direction for future research in the Business Process Management community because it highlights the necessity for an inclusive BPR assessment methodology. The authors are already pursuing to address this gap by producing the *BPR Assessment Framework*, initial work of which can be found in [61,62].

The framework is based on the AS MD 32 [51] and incorporates critical redesign components (Objectives, Method, Heuristics, Input Model, Plasticity and Quality) to properly evaluate the redesign capacity of BPs through investigating the suitability of BP models. The novelty of the approach lies to the introduction of BP model Plasticity, a concept that conveys the ability of the model to be redesigned in terms of BP behavior, as a measurable index of the applicability of BPR heuristics (Resequencing, Parallelism, etc).

As a further extension of the *BPR Assessment Framework* in [61,62], the authors conduct research on the introduction of a *BPR Application Framework*, which is designed to apply BPR to feasible models and be incorporated to a comprehensive methodology that: (a) initially assesses the redesign capacity of models through the *BPR Assessment framework* and (b) applies BPR to feasible models through the *BPR Application framework*. This unified methodology shares common components and phases between the two frameworks, providing a considerable advantage to practitioners that intend to apply any of the two frameworks or both for feasible models. The contribution of the combined methodology lies to the interoperability with the two proposed frameworks and its generalizability.

5. Conclusion

The systematic literature review presented in this paper traversed the state of research regarding BPR evaluation methodologies. The review was conducted through a systematic methodology to be inclusive and comprehensive. The research results highlight that there are zero BPR evaluation methodologies in literature that evaluate both critical characteristics necessary for BPR implementation and the applicability of BPR heuristics, through measurable indicators. The research findings indicate a considerable research gap in a research domain that is very important for the implementation of effective and value-adding BPs. The evaluation of the redesign capacity of BPs prior to implementation provides multiple advantages to businesses varying from quantitative ones (e.g., reduction of execution time and monetary costs) to qualitative in terms of BP quality improvement that in turn improves the quality of the corresponding services and products. Further research in BPR evaluation methodologies can focus on more categories, characteristics, benefits and/or challenges that can amplify the current state of knowledge and provide new directions for enhancing BPR effectiveness.

Author Contributions

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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