Demonstrating the Effectiveness of Process Improvement Patterns with Mining Results*

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Abstract. Improving the operational efficiency of processes is an important goal of business process management (BPM). There exist many proposals with regard to process improvement patterns (PIPs) as practices that aim at supporting this task. Nevertheless, there is still a gap with respect to validating PIPs in terms of their actual business value for a specific organization. Based on empirical research and experience from consulting projects, this paper proposes a method to tackle this challenge. Our approach towards *a-priori validation of process improvement patterns* considers real-world constraints such as the role of senior stakeholders and opportunities such as process mining techniques. In the sense of an experience report, our approach as well as results are illustrated on the basis of a real-world business process from human resources management, covering a transactional volume of about 29,000 process instances over the period of one year. Overall, our proposal enables practitioners and researchers to subject PIPs to a sound validation procedure before taking any process implementation decision.

Key words: Business Process Governance, Business Process Design, Business Process Optimization, Process Mining, Process Intelligence

1 Introduction

Research on business process management (BPM) and process-aware information systems (PAIS) has resulted in a multitude of contributions discussing options to improve the quality, performance, and economic viability of business processes. Examples range from individual "best practices" [1] to comprehensive business process quality frameworks [2]. In this context, we refer to *process improvement patterns (PIPs)* as abstract concepts to enhance particular aspects of processes. As an example, consider the "knock-out" re-arrangement of sequential appraisal tasks to reach a decision within a process as early as possible [3].

* This technical report constitutes an amended version of our BPMDS 2013 conference paper titled "'Demonstrating the Effectiveness of Process Improvement Patterns". Beyond the content presented there, it comprises an appendix with additional analysis results on the sample business process used, and additional illustrations.

To realize the full potential of PIPs in terms of practical relevance, it is necessary to demonstrate their actual *business value* to practitioners, thus enabling corresponding implementation decisions. To address this challenge, there exist many propositions to empirically establish the effectiveness of PIPs, including rather anecdotal evidence [4] as well as case studies [5] and survey-based research [6]. Commonly, these approaches are based on an *ex-post* appraisal of qualitative evidence given by process managers or other stakeholders to obtain general insights applicable to analogous cases.

However, there is still a notable gap with regard to *a-priori* validation of PIPs considering a *particular application context*, which ranges from an organization's strategy and goals to its existing business process and information systems landscape. In particular, this gap should be addressed for three reasons:

1. *Similar to design patterns* in software engineering [7], PIPs constitute abstract concepts which may or may not be useful in a particular context. Experience from other scenarios is thus not sufficient to take sound organizational or PAIS-related implementation decisions.
2. *Ex-post evidence* is usually obtained from persons involved in the corresponding implementation projects, which leads to a source of bias. In addition, a-priori evaluation allows addressing a far wider spectrum of PIPs since it is not necessary to conclude implementation projects before a PIP can be assessed.
3. *Contemporary technology*, combining PAISs with process intelligence and process mining tools [8–10], provides novel opportunities to quantitatively and qualitatively gauge actual business processes, which should be leveraged for scenario-specific PIP validation.

Reflecting these considerations, this paper contributes an approach towards a-priori evaluation of PIPs for specific application scenarios on the basis of today's technical means. This enables sound implementation decisions, and extends the relevance of corresponding propositions from BPM and information systems (IS) research. Our approach considers both scientific rigor and practical requirements, and is demonstrated through an experience report covering a substantial real-world business process. In particular when discussing the validity of our research design, execution and results with practitioners, we made a number of observations applicable to a-priori empirical PIP evaluation in general. Since these may be helpful as lessons learned for practical application as well as future research, they are highlighted as *key principles.*

The remainder of this paper is structured as follows: Sect. 2 describes the sample process we use to illustrate our approach and results. Sect. 3 illustrates our approach towards addressing the research issue. Sect. 4 describes the actual evaluation of PIPs and sample results. Sect. 5 and Sect. 6 discuss related work and conclude the paper.

2 Sample Case: Applications Management Process

The business process we use to illustrate the concepts presented in this paper stems from the field of human resources management. It addresses the handling of incoming job applications as implemented in a professional services firm. Fig. 1 describes the business objective of the process according to a notation developed in [11]. The objective of the process is to achieve one of two states for applications: either the application is to be declined or a job offer is to be sent to the applicant. A job offer can be sent if the following conditions are fulfilled: the application documents must have been accepted in terms of quality (e.g., with regard to the CV), an interview must have taken place with a positive feedback, basic conditions must have been agreed between both parties, and senior management approval must be given (cf. Fig. 1). If one of these requirements is not met, a letter of refusal has to be sent (see the OR node in Fig. 1).

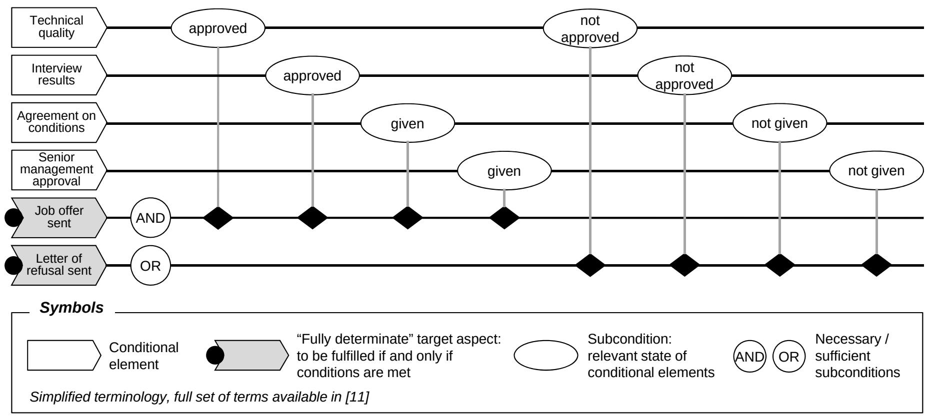

Fig. 1. Sample Business Objective

On the basis of discussions with stakeholders and the results of process mining, we can model the business process implementing the business objective described above as presented in Fig. 2, using Business Process Model and Notation (BPMN) symbols [12]. For reasons of brevity, we slightly simplify the model, and omit a detailed description of its elements.

Fig. 3 provides an overview on the distribution of termination states for our sample process covering a time period of one fiscal year, i.e., the frequency of possible states an application process instance might terminate in. We will refer to this overview when discussing our research execution in Sect. 4. A corresponding data sample obtained from the log database tables of the corresponding PAIS (in this case, a SAP ERP system) was used for our analyses. The data sample includes 27,205 cases (i.e., process instances) traceable in the PAIS. The 1,972 cases not included comprise, for example, cases handled in the business units without involvement of the human resources (HR) department.

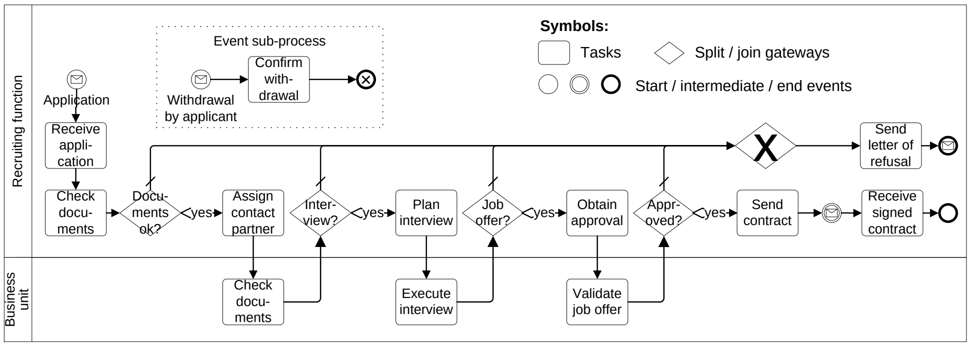

Fig. 2. Sample Process: Handling Incoming Applications (BPMN Notation)

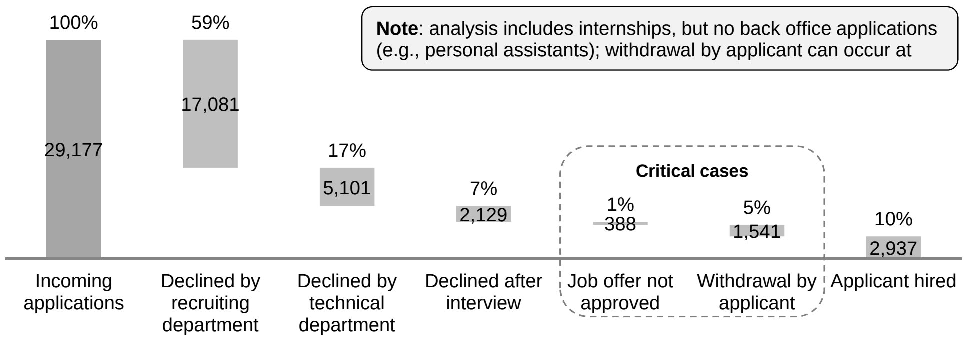

Fig. 3. Termination States of the Application Process: One Fiscal Year Sample

The appendix of this paper comprises additional facts and empirical analyses generated in the process mining tool Disco and the statistical tool Minitab for the data sample. Note that Disco and Minitab were selected as examples of tools available to practitioners, alternatives might be employed as well.

3 Methodology

Like other IS artifacts, PIPs constitute *goal-bound artificial constructs* in the sense of the design science paradigm [13] to be evaluated in terms of "value or utility" [14]. In our context, this results in a particular challenge: while PIPs constitute abstract concepts applicable to a broad range of scenarios, their *business value* must be determined with regard to a particular case to enable actual implementation decisions. To this end, we employ an extended conceptual framework summarized in Fig. 4.

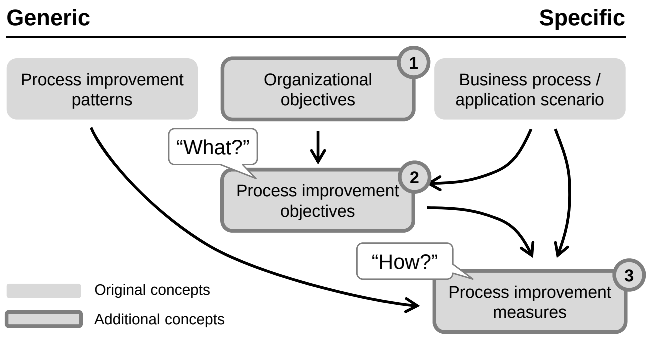

Fig. 4. Extended Conceptual Framework

Beyond the concepts of PIPs and business processes or application scenarios, we introduce organizational objectives, process improvement objectives, and process improvement measures:

1. ***Organizational objectives*** **reflect strategic goals an organization wants to achieve**, like, for example, cost savings. In principle, respective objectives are generic, but how they are prioritized against each other is specific to an organization's strategy.
2. ***Process improvement objectives (PIOs)*** **comprise characteristics that enhance a process considering organizational objectives.** PIOs may be evident, like lowering cost, or they may require additional validation. Consider, for instance, short cycle times: while it is not necessarily a strategic goal to enact processes as fast as possible, this may be a PIO if a link between cycle times and cost can be demonstrated. PIOs provide an additional layer of abstraction as a "shortcut" between improvement measures

and organizational objectives. For the above example, measures might be validated by demonstrating a positive impact on cycle times instead of overall cost. Note that the concept of PIOs corresponds to the requirement to identify stakeholders' goals as demanded in [15].

3. ***Process improvement measures (PIMs)*** **are bundles of actions considered jointly for implementation.**[1] They reflect the application of PIPs to a specific process to realize PIOs. Note that, in many practical cases, multiple PIPs are bundled into one PIM to be jointly implemented, depending on the application context. Accordingly, a PIM is a set of one or more PIPs associated with a specific business process to address one or more particular PIOs. A-priori validation of PIPs for a particular application context thus amounts to assessing the business value of the corresponding PIMs considering relevant PIOs.

Note that, following the arrows, Fig. 4 can also be read as a methodological *top-down approach* for process improvement that has proven its value in practice, and is applied in Sect. 4: General organizational objectives are refined to PIOs specific to the business process or application scenario. Then, corresponding PIPs are selected from a generic set to be bundled into concise PIMs, again under consideration of specifics of the business process or application scenario.

Key Principle 1 (Top-down Process Improvement Methodology). Top-down methodologies aiming at process improvement have proven as most stable in terms of change management. In principle, this paradigm is based on an early senior management agreement on the general "call for action" (see the concept of organizational objectives), which is then refined into process-related objectives (see the PIOs concept), and finally into individual improvement measures. PIPs or industry-specific "best practices" (e.g., [16]) can be leveraged to identify appropriate improvement measures. The advantage of this top-down approach lies in focusing the discussion of individual measures on *how* things are to be achieved instead of *what* to achieve in general, and in facilitating change management through an early agreement on basic principles.

In the sense of this paper, business processes and PIMs as our unit of study are implemented by means of PAISs. To maintain scientific rigor, their assessment should take into account requirements posed towards the empirical evaluation of propositions in software engineering or IS research. In [15], Wieringa et al. subsume methodological considerations on scientific evaluation in IS engineering. Accordingly, this section proceeds by aligning the basic requirements described in [15] with regard to *problem statement* and *research design* to the conceptual framework of Fig. 4.

[1] In this context, the term "measure" is *not* to be understood as an means of measuring something (e.g., a performance indicator) or as an unit of quantity.

3.1 Problem Statement

Our problem statement (cf. Fig. 5) is structured along the requirements towards effective empirical research [15]. It refines general principles for empirical validation of PIPs as appropriate for our sample case, and describes relevant key success factors. Note that the research question refers to PIMs instead of PIPs. This characteristic reflects our goal of *scenario-specific* validation.

Components of the problem statement	Research Question *"What do we want to know?"*	Unit of Study *"About what?"*	Relevant Concepts *"What do we know in advance?"*	Research Goal *"Why do we want to know?"*
Application to empirical validation of PIPs	> Should PIMs be implemented to improve on organizational objectives?	> The business process in question > Proposed PIMs comprising PIPs	> Related work: conceptual work on the PIPs, case studies for other processes etc.	> Implementing PIMs will result in cost and risks incurred (e.g., process disruptions). Thus, implementation decisions should be based on sound investigation
Sample Case-specific refinement	> Should PIMs be implemented to reduce cost per hire (cf. Section 4.1)?	> Application management process (cf. Section 2) > Selected PIMs (cf. Section 4.3)	> Cost per hire benchmark (cf. Section 2) > Available research on "knock-out" processes	
Key success factors	> Proper demonstration of the relevance of organizational objectives to be addressed	> Proper selection of relevant PIPs to be bundled into scenario-specific PIMs	> Proper research into available literature > Use of available organizational knowledge	> Proper consideration of related investments, transactional volume etc.

Fig. 5. Problem Statement: Structure and Application

3.2 Research Design

Proper research design is the second requirement towards any scientific evaluation [15]. Fig. 6 summarizes our considerations in this regard.

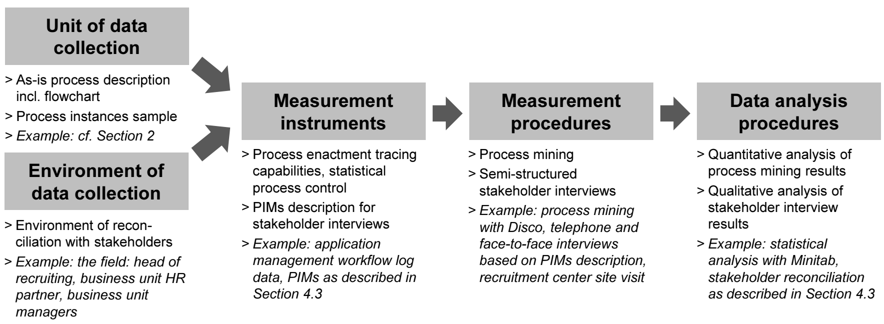

Fig. 6. Research Design

As discussed, in practical scenarios, PIPs are bundled into PIMs addressing PIOs. Accordingly, the scenario-specific business value of PIPs can be demonstrated by validating the respective PIMs' positive impact on PIOs which are, in turn, desirable with respect to organizational objectives. Our research design seeks to establish these characteristics by combining quantitative analysis based on, for example, process enactment logs, and qualitative discussion with stakeholders. Selected methods must be properly aligned to the application context:

Key Principle 2 (Appropriate Qualitative or Quantitative Demonstration of Business Value). For each PIO to be addressed by PIMs, the underlying business value must be empirically demonstrated based on proper qualitative or quantitative analyses with respect to organizational objectives. Likewise, the business value of PIMs must be made transparent through appropriate analyses. While applicable methods are summarized in Fig. 6, the specific approach for individual PIOs and PIMs must consider the actual application context in order to balance expected insights against analysis effort. For example, the omission of obviously redundant tasks not contributing to the business objective of the process can be justified by a short qualitative description. In contrast, the introduction of additional control tasks to diminish defects later on in the process will require careful quantitative weighing of pros and cons.

Note that, regardless of the appropriate method of demonstrating business value, all types of PIOs and PIMs require the context of a concise description and a well-understood business process, and the cooperation of knowledgeable stakeholders in the field as unit and environment of data collection (cf. Fig. 6).

Key Principle 3 (Identifying Relevant Stakeholders as Interview Partners). To ensure the validity of measurement procedures, proper selection of interview partners is of particular relevance for PIOs and PIMs that should be validated qualitatively. For BPM scenarios, it is important to interview experienced senior personnel overlooking the end-to-end business process, and to represent both the "supplier" and the "customer" perspective to avoid lopsided optimization. For our sample process, we interviewed the head of recruiting operations and the administrator of the application management workflow from the "supplier" side, and the HR partner of a business unit as well as team managers from the business unit from the "customer" side.

4 Sample Case: Process Improvement Patterns Validation

We now apply the conceptual framework from Fig. 4 and our research design from Sect. 3.2 to the process described in Sect. 2.

4.1 Organizational Objectives

As discussed in Sect. 3.1, obtaining clarity about the content and business value of organizational objectives is an important prerequisite to ensure relevance of PIP validation. For our process, the following considerations apply:

Reducing Cost per Hire as Organizational Objective. In our sample application field (i.e., recruiting), organizations aim at filling vacant positions quickly, cost-effectively, and with suitable candidates. To achieve this goal, personnel marketing is tasked to generate a sufficient number of suitable candidates while the purpose of our sample process, application management, is to convert applications into actual hires. In this context, the *cost per hire* key performance indicator captures the total cost of both personnel marketing and applications management. While recruiting cost spent per application is proprietary data, based on client projects experience we may assume an amount of about 400 Euros. In our sample scenario, generating and managing 29,000 applications per year would thus sum up to 11.6m Euros total cost. Accordingly, cost per hire may be assumed to be around 4,000 Euros. Since hiring cost for talent in professional services will be higher than in, e.g., manufacturing, this value corresponds well to the average of 4,285 USD reported as cost per hire for larger organizations by a benchmarking organization [17], and seems rather conservative considering that professional recruiting consultants commonly charge half a year's salary for successful hires, depending on industry. This calculation demonstrates the relevance of reducing cost per hire through an improved application handling process.

4.2 Process Improvement Objectives (PIOs)

PIOs pertain to characteristics of the business process that affect the organizational objectives we want to improve on. Thus, they serve as a "shortcut" to facilitate the discussion of the business value of PIMs without reverting to fundamental objectives. In our sample case, cost per hire is driven by the general efficiency of the application management process, but also by its effectiveness with regard to avoiding the termination states marked as "critical" in Fig. 3:

- *Not approving a job offer* after a successful interview may be caused by defective steering of capacities (i.e., job vacancies), defective communication of terms to be offered, or defective review of application documents.
- *Job offers declined by applicants* means that the applicant does not approve of conditions offered, did not have a good impression during the application process, or has decided to take another job offer.

Since terminating the process in these states means that significant effort has been incurred with no business value in return, organizational objectives are clearly violated: On average, only one out of six applications will successfully pass interviews. However, considering defective termination events (cf. Fig. 3), only one out of ten applicants can be hired. In other words, if the process enactment defects lined out could be fully eliminated, only about 18,000 applications would have to be acquired and managed to cover demand. This would reduce total hiring cost by about 4.6m Euros. Accordingly, we seek to identify PIOs as process characteristics which are apt to reduce the probability of the defective cases described. Table 1 describes our results in this respect.

PIOs	Rationale
Reducing processing cost	Emerging potentials in terms of reducing process enactment effort per instance should be addressed.
Reducing failed approvals	Final approval of job offers by senior management fails if there are issues regarding vacancy management, reconciliation of terms, or checking of documents. The probability of these “late defects” should be addressed.
Reducing cycle times	The probability of applicants’ obtaining and taking alternative job offers increases with time. Therefore, cycle times between applications being received and job offers made should be as short as possible.

Table 1. Sample Case: Process Improvement Objectives

Note that for the first PIO, *Reducing processing cost*, there is an evident link to our organizational objective of reducing cost per hire. However, the second and third PIOs, *Reducing failed approvals* and *Reducing cycle times*, are based on hypotheses on how process enactment defects which affect the organizational objective can be reduced. Accordingly, they require qualitative or quantitative evidence with regard to their relevance in terms of reducing enactment defects and thus, in the end, improving cost per hire.

For the second PIO, *Reducing failed approvals,* we obtained qualitative evidence by interviewing responsible managers, which confirmed the underlying topics described in Table 1. Since the reasons for failed approvals are not captured in the applications management PAIS, quantitative evidence is not available. For the third PIO, *Reducing cycle times,* the causal link to its underlying defect of applications withdrawn by candidates is not as obvious. However, the correlation can be quantitatively demonstrated:

Correlation between Job Offers Declined and Cycle Times. We want to determine whether there is a significant influence of cycle time between application receipt and job offer in weeks on the probability of an applicant accepting or declining a job offer. Accordingly, we use a binary logistic regression test to evaluate the influence of a metric independent variable on a binary dependent variable. For the test, we use a sample of 2,721 job offers representing about 70% of the annual volume (cf. Fig. 3), and consisting of instances fully covered in the PAIS (not all interviews and feedbacks are documented in the PAIS). The sample contains 261 cases where the job offer was eventually declined by the applicant. This is the latest point in the process where withdrawal by the applicant is possible, and a significant amount of effort will have been spent on each respective case. Both independent samples have a size of more than 100 cases. Thus, the binary logistic regression can be applied. Fig. 7 shows an excerpt from the output of the statistical software package we used (Minitab). The p-value of less than 0.05 indicates sufficient evidence to assume a significant impact of cycle time. According to the “Odds Ratio” column, a one week delay can be expected to increase the probability of an applicant declining a job offer by 16%.

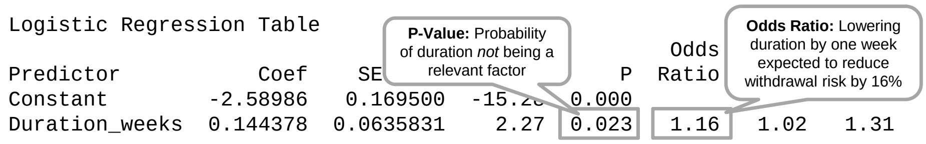

Fig. 7. Minitab Output Excerpt: Binary Regression Test

Key Principle 4 (Considering Labor Relations and Restrictions in Quantitative Analyses). Quantitative analyses to support PIO and PIM validation like, for example, the use of process mining requires the collection of data on actual process enactment. However, it is not a research objective to assess individual performance of employees. In Germany, for example, intentions in this respect are subject to worker participation regulations according to the *Betriebsverfassungsgesetz* (the federal code on co-determination). Thus, researchers must be careful when designing quantitative analyses and the respective data collection procedures. Otherwise, organizations may refrain from providing relevant data.

4.3 Process Improvement Measures (PIMs)

To address the PIOs described in the previous section, relevant PIPs are bundled into PIMs specific to the application scenario. In our case, PIPs have been selected from a framework by Reijers & Liman Mansar [1] on process redesign practices (these are marked with an asterisk “*”) as well as from our ongoing research on improving business process quality [18, 19]. Accordingly, as a mental technique to identify propositions applicable to our application scenario, we reflect available results on PIPs against our PIOs to obtain PIMs (cf. Fig. 4). Table 2 summarizes PIOs and corresponding PIMs as bundles of PIPs.

Key Principle 5 (Prospective and Retrospective Identification of Potential PIOs, PIMs, and PIPs). Potentially applicable PIMs and PIPs should be identified not only by prospectively considering the process model, but also by retrospectively analyzing empirical data on process enactment. This is crucial to focus on topics of actual value potential. For example, consider the selection of critical cases in Fig. 3 that is reflected in the PIOs for our sample case.

PIOs	Applicable PIMs with Comprised PIPs
Reducing processing cost	*PIM 1 (Application Management Automation):* Task automation*, routing automation
Reducing failed approvals	*PIM 2 (Utilization and Capacity Management):* Empowerment*, knock-out* *PIM 3 (Standardized Terms and Conditions):* Triage*, buffering*
Reducing cycle times	*PIM 4 (Managing Interview Feedback Cycle Times for Successful Applicants):* Control addition*, routing automation, escalation procedure *PIM 5 (Improving Application Routing):* Case manager*, knock-out*, mitigation of repetitive loops

Table 2. Defining Process Improvement Measures for Process Improvement Objectives

In actual design and implementation projects, it is common to document and track individual PIMs through *measure cards*. As an example of this practice, we choose two PIMs from Table 2 and describe them in more detail. For each PIM, we give a short content description – with PIPs involved marked as *italic* – and required implementation effort. On that basis, we appraise the business value considering the impact on PIOs as well as implementation effort. Results of our appraisal are validated through interviews with respective stakeholders.

Key Principle 6 (Considering Implementation Effort in Business Value Appraisal). When discussing the business value of particular PIMs for a business process, the respective implementation effort, including measures required, cost, time, and change management issues (e.g., training personnel to enact new activities), must be taken into account. Accordingly, a PIM will provide business value only if implementation effort is justified by realized process improvement potentials. For example, an organization may demand that the required investment may not exceed three times the projected annual cost savings when appraising operational cost optimization measures.

Note that, in addition to the scope presented here, actual *measure cards* comprise additional information relevant to project management such as project planning, project organization, key milestones with "traffic light" status, risks, next steps, and decision requirements. Reporting on measure cards usually takes place in steering committee meetings of senior management.

PIM Card 2 (Utilization and Capacity Management). Among other reasons, senior managers refuse to approve job offers when the business unit wishing to hire a candidate cannot fully utilize present capacity. While refusal reasons are not tracked in the PAIS, stakeholder interviews resulted in an estimate of about 30% of total refusals

to be caused by this issue. Since candidates' qualifications, in particular in graduate recruiting, are mostly not specific to particular business units, the recruiting department can be *empowered* to route applications to more appropriate teams from the start on. This results in an early *knock out* of applications that would, in the end, be declined because of low utilization.
Implementation. To enable utilization-based routing decisions, a new report on utilization per team must be integrated into the application management workflow. Since relevant data is available, and is routinely checked at other spots, the corresponding implementation effort has been estimated to be 25 consultant days or 27,500 Euros. In addition, relevant utilization thresholds must be agreed and communicated. The recruiting center routes about 12,000 applications per year. If the additional operating effort for the utilization check can be assumed to be 10 minutes per application, this results in an overall additional capacity requirement of about 1.2 full time equivalents (FTEs), resulting in approximately 84,000 Euros annual cost.
Business value. The PIM is expected to reduce the "late refusal" rate by about 30% or 120 cases per year. Assuming a rate of job offers declined by the applicant of 7% (cf. Sect. 4.2), this would reduce the number of applications to be generated and managed to achieve a constant volume of hires by about 1,200. As we assumed the cost per application to be about 400 Euros, an annual savings potential of 480,000 Euros compares to 27,500 Euros one-off cost and 84,000 Euros operating expenditure per year.
Stakeholder verification. When discussing the PIM with senior stakeholders, its business value appeared as rather clear. However, the distribution of utilization data emerged as a "political" issue. Considering present organizational culture, the PIM will not be implemented, but the basic capability to add utilization control functionality to the PAIS will be included with the requirements definition for the new PAIS solution to be completed by early 2013.

The abbreviated measure card presented above exemplifies how PIM implementation benefits can be projected and matched against expected implementation effort. However, beyond this quantitative reasoning, qualitative (or "political") topics can play a role in implementation decisions as well.

PIM Card 4 (Managing Interview Feedback Cycle Times for Successful Applicants). The time span between successful interviews and job offers can be reduced by implementing a *control addition*, i.e., additional control flow elements to ensure the correct enactment of the process. Triggered through *routing automation*, the recruiting department will call the interviewer directly when feedback is not available five business days after an interview. If the interviewer cannot be reached within two business days, an *escalation procedure* will take place by calling the respective supervisor. If no feedback can be obtained through these PIPs within ten business days, a letter of refusal will be sent.
Implementation. To implement the PIM, comprehensive tracing of interview dates and an additional workflow with corresponding triggering mechanisms must be implemented in the PAIS. This results in an estimated cost of approx. 38,500 Euros for 35 consultant days. In the data sample used for the binary regression test in Sect. 4.2, about 51% of cases would fall under the proposed regulations. Accordingly, a total volume of 7,000 interviews conducted annually (cf. Fig. 3) would result in about 3,600 escalation procedures. On the one hand, this number can be expected to decline over time. On the other hand, multiple phone calls might be necessary for one escalation case. Hence, we assume that 20 escalation procedures can be handled in one person

day. This means that an additional 0.9 FTEs are required, resulting in about 63,000 Euros annual cost.
Business value. Based on our binary logical regression analysis (cf. Sect. 4.2), we reconciled with stakeholders that the maximum interview feedback time can be reduced to two weeks based on an escalation process. Applying the corresponding odds ratio (cf. Sect. 4.2) to all cases in our sample which exceed this timeframe results in a reduction of 39.2 cases of "late withdrawals" (cf. Fig. 3). This would reduce the number of applications to be generated and managed by about 390 per year, corresponding to 156,000 Euros in annual savings. Considering additional operating expenditures of 63,000 Euros results in a total annual cost reduction of 93,000 Euros versus a one-off cost of 38,500 Euros.
Stakeholder verification. During stakeholder interviews, we validated implementation cost with the application workflow administrator, additional processing effort at the recruiting center with the head of recruiting, and overall viability of the new process with the head of recruiting and the business unit HR partner. The escalation procedure to provide timely feedback was challenged by the business unit HR partner, but not by team managers. Final consent on the positive business value of the PIM could be achieved by discussing the quantitative analysis of the underlying PIO (cf. Sect. 4.2).

Note that the PIMs presented exhibit a fairly positive business case with implementation cost to total annual savings ratios below two years. They constitute good examples of a phenomenon often encountered in practice: in many cases, it is interesting to first identify and resolve existing process defects within the framework of available technology before additional process automation is implemented at huge cost.

Key Principle 7 (Leveraging "Quick Win" Potentials). In many practical scenarios, it is possible to identify "quick win" PIMs that can be implemented with limited effort and should thus be prioritized, in particular in comparison to full-scale PAIS implementation measures which are typically very costly. Examples include the elimination of process defects caused by process participants' behavior, interface issues between departments, or issues with respect to master data quality. Note that these topics are often identified through empirical analyses (e.g., using process mining).

5 Related Work

Approaches aiming at empirical validation of PIPs can be traced back to quality management and business process reengineering approaches which have evolved since the 1950s and the early 1990s, respectively.

In terms of quality management, Six Sigma [20] is of particular interest because it aims at eliminating errors in manufacturing processes. While the scope of BPM usually lies in administrative processes instead, there are interesting analogies since Six Sigma is based on step-by-step optimization of production processes through a-priori experimental changes to parameters.

Business process reengineering, as exemplified in [4, 21], aims at optimizing processes "in the large" instead of implementing incremental PIPs. Transferring process enactment to an external supplier or customer constitutes a good example of this paradigm. While the potentials of this disruptive approach may seem tempting, more recent empirical evaluation has shown that the risk of projects failing is substantial [22]. Thus, incremental implementation of individual PIPs may still be a valid approach.

In contemporary BPM, [6] proposes a framework to select and implement redesign practices. As opposed to our research, this approach does not aim at evaluating individual PIPs, but at efficiently appraising a broad framework of practices. However, we use earlier results from the same authors as a source of PIPs to be assessed in more detail [1]. Note that research on PIPs addresses the quality of process models and process implementations in the sense of business content. In contrast, [23–25] exemplify propositions addressing process model quality in terms of structure, i.e., the proper partitioning of actual business content into model elements.

In IS research, there have been diverse propositions to ensure common standards of scientific rigor in empirical research such as field experiments or case studies [26, 27]. As a basis of this paper, we chose the requirements summary by Wieringa et al. [15] due to its concise, checklist-based character, which makes it readily applicable to research as well as discussion with practitioners.

6 Conclusion

This paper described a methodology for a-priori, scenario-specific validation of process improvement patterns based on organizational objectives, process improvement objectives, and process improvement measures. In our methodology, we leveraged available work on generic requirements towards empirical research in IS engineering [15], thus demonstrating how these principles can be applied to practical cases while ensuring the general appeal of our approach.

We reported on the application of the methodology to a real-world business process, including validation of the respective results with practitioners. The organization hosting our sample application scenario is currently implementing a new application management PAIS to be completed in 2013. The agreed PIMs have been included in the requirements definition for this project.

In particular when discussing research design and execution with stakeholders, we identified a number of key principles useful as lessons learned for subsequent work which we included at appropriate spots in this paper. The key principles generally relate to which aspects should be considered when planning and executing process improvement projects. Fig. 8 provides a respective overview.

Fig. 8. Summary: Key Principles for PIP Validation

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Appendix: Process Mining Results

This appendix includes additional illustrations on the topics presented in the preceding sections. Its purpose is to further clarify the sample case we used as an example for our approach.

First, Fig. 9 shows a process map generated in the process mining tool Disco for the data sample. Note that, for the sake of readability, this process map has been filtered to comprise only the most frequent part of actual paths and the most relevant events for our analyses. The process map needs to be interpreted with the support of experienced stakeholders. In our sample case, for instance, application refusal events are also used to purge the database to comply with privacy regulations, and not all hirings are handled through the corresponding end events. Accordingly, more detailed analyses must draw on methods and tools beyond process mining.

Second, Fig. 10 exhibits the corresponding statistics for the data sample as provided in the Disco tool. Note that the distribution of events over time reflects weekends and bank holidays.

Third, Fig. 11 shows a process map generated by applying additional filters. It corresponds to the data sample used to test for a correlation between cycle times and job offers declined by applicants (cf. Sect. 4.2). The respective analysis constitutes an example of the mix of tools and methods often encountered in practice: Initially, the appropriate sub-process view is filtered in the process mining tool. Then, the filtered data sample is re-extracted and imported into a spreadsheet application where the event log is converted into a "case log", i.e. an array of events for each case. On that basis, case attributes like cycle times between particular event categories can be computed. These case attribute sets

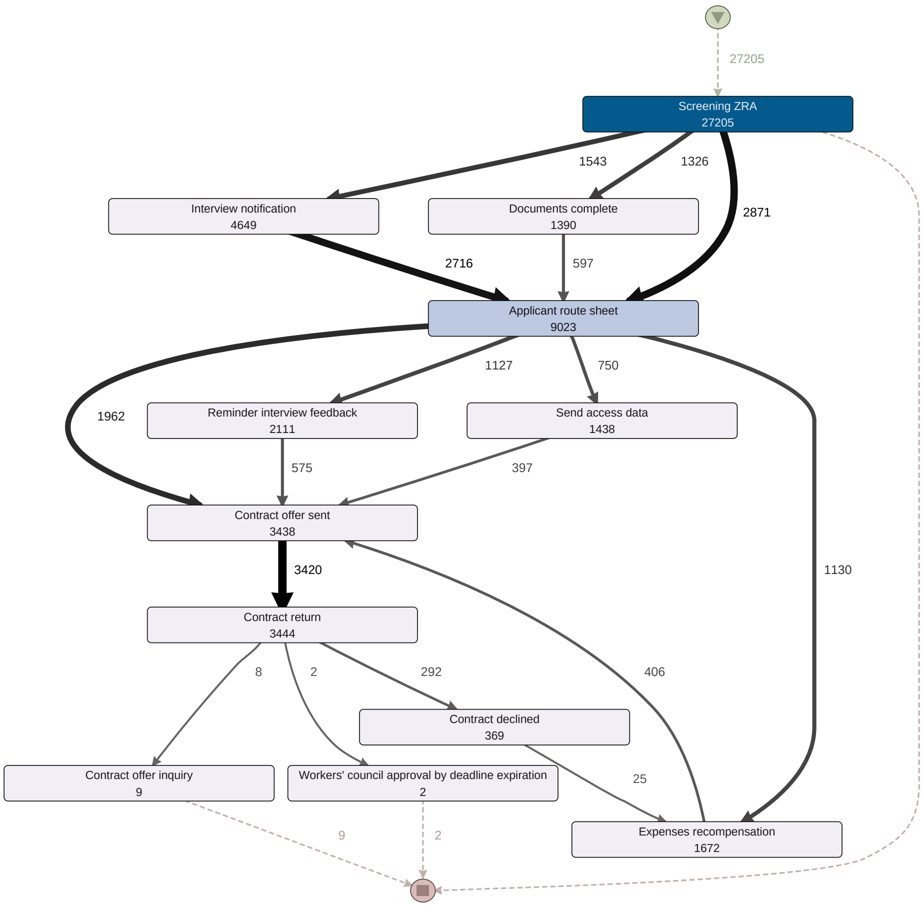

Fig. 9. Filtered Process Map: One Fiscal Year Data Sample

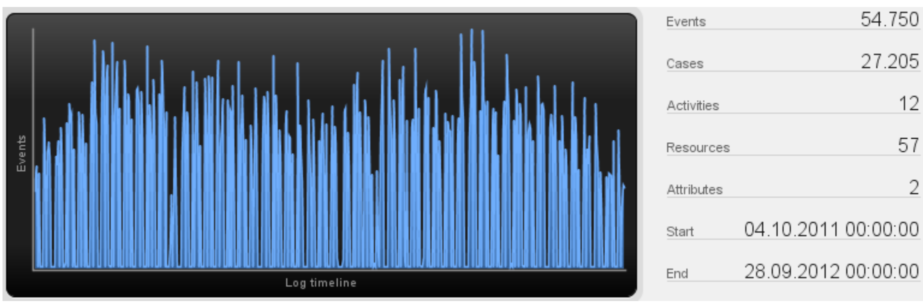

Fig. 10. Filtered Process: Log Statistics

can be used as data samples for statistical analysis with appropriate tools such as, in our case, Minitab. Accordingly, improved integration between tools, for example by providing functionality for case variant attribute analysis in process mining tools, would be desirable.

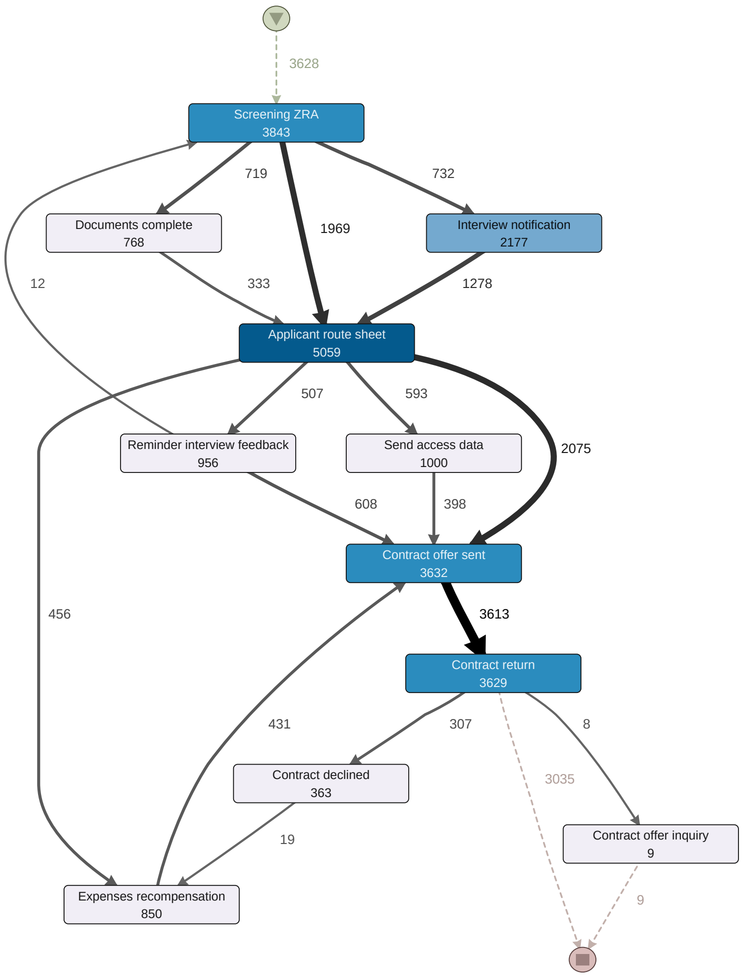

Fig. 11. Filtered Process Map: Job Offers

Fourth, Fig. 12 compares cycle times for the sub-sets of applicants accepting and declining job offers. Note that, in this case, the significance of the impact of cycle time on job offer acceptance probability is not as obvious when just considering the boxplot in comparison to the binary logic regression test. This observation stresses the necessity to employ appropriate statistical methods when dealing with empirical data on process enactment.

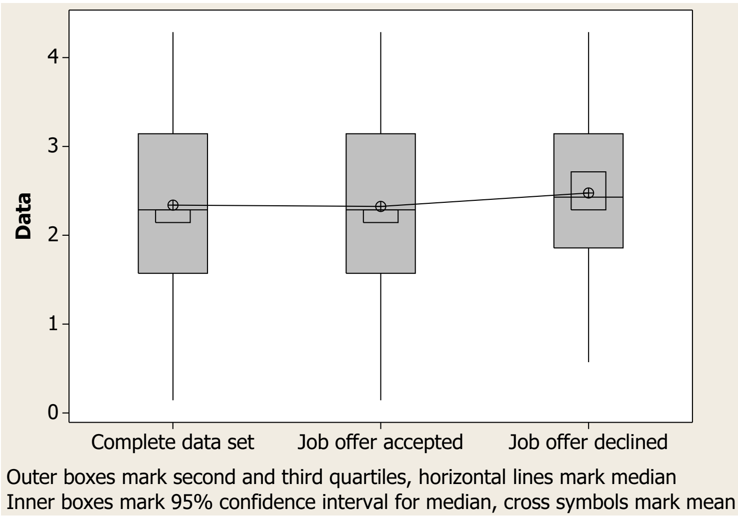

Fig. 12. Boxplot: Cycle Times vs. Acceptance of Job Offers