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AN EMPIRICAL ASSESSMENT OF THE USEFULNESS OF WEAKNESS PATTERNS IN BUSINESS PROCESS REDESIGN

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Abstract

Business Process Management (BPM) is a topic with growing relevance for businesses as well as public organisations. Until today, the analysis part of a BPM cycle is mostly done manually. Process modelling methods are not designed to allow for automated analysis. Our aim is to show that meaningful weakness patterns that support semi-automatic analysis of business process diagrams (BPD) can be defined when a semantically enhanced modelling method is used. We derive exemplary weakness patterns by analysing literature and interviews from a business process redesign project. These are applied to a set of process models, in which occurrences of these weaknesses are being searched automatically. A comparison of achieved and expected results indicates that our approach helps to identify weaknesses within the processes and therefore supports business process analysis endeavours.

Keywords: Business Process Analysis, Weakness Patterns, (Semi-)Automated Weakness Detection, Semantic Business Process Management.

1 Introduction

In practical BPR projects, identifying weaknesses in as-is business processes as well as generating improved process designs is a manual task, typically performed by consultants (Vergidis, Tiwari, and Majeed, 2008). This task requires a profound understanding of the domain being analysed. First, any problems with current process designs must be determined. Second, possible solutions to such problems must be developed.

It is widely acknowledged that BPR is more an art than a science (Limam Mansar and Reijers, 2007). There is no clearly defined, technical procedure on how to do it. It requires, besides domain specific knowledge, a lot of creativity to identify problems and solutions. Consequently, it is not surprising that techniques which support business process analysis usually do not tackle this problem directly. Instead, their goal is to create an "analysis-friendly" environment, mostly through improving the quality of BPDs description processes.

Even though redesigning processes are highly creative, generic guidelines do exist. In a series of articles, Limam Mansar and Reijers (2007) as well as Reijers and Limam Mansar (2005a), (2005b) have identified a framework comprising several heuristics that are frequently applied in BPR projects. While the heuristics themselves (e.g. automate a formerly manual task) are not sufficient to identify improvement opportunities in a concrete case, they can serve as inspiration when combined with domain knowledge of analysts.

The purpose of this paper is to evaluate the possibility of extending the scope of BPD analysis techniques; from providing a high quality collection of BPDs towards supporting the actual act of BPD improvement itself. The starting point is to define weakness patterns. They represent typical problems a process may have together with ideas of how to address them. Searching for these patterns within BPDs constitutes a structured way of BPD analysis. Thus, weakness patterns could be interpreted as a reference model of process weaknesses and their remedies. As this requires domain knowledge, the pattern set is necessarily domain specific; in our case, specific to public administrations in Germany. Starting with results from a real world BPR project, we analysed which of the weaknesses identified by consultants during this project could be formulated as a generic pattern. Their definition is inspired by the above mentioned heuristics. In a subsequent step, pattern occurrences were searched within the BPDs of this project to assess the usefulness of this approach. Since patterns carry domain semantics and must be matched to the process with respect to their meaning, a domain specific modelling notation is used. This avoids the use of natural language processing techniques, which would strongly decrease the quality of the results.

The remainder of the paper is as follows. Section two elaborates on the research gap and briefly introduces the domain specific modelling notation used in the projects. Section three describes the data used in this study. In section four, the weakness patterns are developed. Insights from their application to the data are discussed in section five. Finally, section six contains concluding remarks.

2 Related Work

2.1 Business Process Redesign

Generally speaking, BPR is a field of research concerned with methodological support for the problem of changing organizational business processes from a current, as-is state into a desired, to-be state. A plethora of other terms have been used in the literature to describe such efforts (Zellner, 2011). Mainly, two areas can be distinguished, depending on the pace of change: radical change, associated with business process re-engineering, and incremental change, which corresponds to business process improvement. BPR relates to both of these areas (Valiris and Glykas, 1999).

Numerous methodologies for redesigning business processes are can be found in literature. Their aim is to structure the entire endeavour of actually doing BPR within an organization. Kettinger, Teng, and Guha (1997) synthesize the literature and extract a generic six step framework: *Envision*, *Initiate*, *Diagnose*, *Redesign*, *Reconstruct* and *Evaluate*. In the context of BPR, the approach of this paper can be interpreted as a technique for supporting business analysts during the *Diagnose* and *Redesign* phase of BPR endeavours, as it is concerned both with weakness identification and best practice suggestion.

As discussed in the previous section, the transition from as-is towards to-be process design is a task demanding a lot of creativity combined with extensive knowledge of the domain under analysis. Thus, techniques proposed by BPR methodologies to support analysts are of a general nature. Kettinger et al. (1997) surveyed consultancy firms and found that the main tools are conceptual models combined with creativity techniques. A more recent literature review on methodologies for improving business processes confirms these results (Zellner, 2011). Among the 14 approaches discussed in that study, only seven explicitly name techniques to support redesign. Again, with brainstorming (Harry and Schroeder, 2006), cause-effect diagrams (Lee and Chuah, 2001) and creative silence workshops (Adesola and Baines, 2005), generic creativity techniques are proposed. An exemplary exception is Varghese (2004), who proposes quantitative measurement, for instance by means of activity based costing. However, while these quantitative techniques might serve as inspiration for problem identification, they do not relieve the analyst from the burden of generating ideas for process improvement.

2.2 Business Process Analysis

Even though business process analysis is considered to be a creative task in BPR literature, there still are numerous techniques for supporting analysts in analysing BPDs. These techniques, however, do not directly address process redesign. Rather, they aim, for instance, at validating a process design, managing large collections of process models, facilitating process modelling, or providing quantitative evidence for redesign decisions.

With respect to validation, it is possible to verify automatically that a business process design is sound (van der Aalst, 1997), provided that the execution semantics are well defined. Thereby, certain mistakes can be avoided, such as incorporating an activity into a process that can never be performed. Originally defined for petri nets, soundness has been transferred to many different modelling notations, including BPMN (Dijkman, Dumas, and Ouyang, 2008) and EPC (van der Aalst, 1999).

With ongoing business process initiatives in companies, BPD collections can grow to considerable sizes. There are various techniques which support their maintenance (La Rosa et al., 2011). Among them are searching similar BPDs (see e.g., Dijkman, Dumas, van Dongen, Käärik, and Mendling (2010) or Kunze, Weidlich, and Weske (2011)), merging two BPDs into one integrated version (e.g., see Mendling and Simon (2006)), and abstracting irrelevant parts of a process while maintaining its important components (see e.g., Polyvyanyy, Smirnov, and Weske (2008)).

Process mining is another popular area in business process analysis; the goal of which is to leverage data collected from information systems to extract knowledge about a process. Tiwari, Turner, and Majeed (2008) provide an overview of methods applied to tackle this problem. Process mining complements modelling as it provides insights into how processes are actually performed in the organisational environment as opposed to how a designer planned them to be.

Quantitative analysis of business processes can be accomplished by means of simulation, which deals with formalizing a process in its entirety to make it amenable to mathematical optimization (Greasley, 2003). A problem with simulation is that the mathematical model must represent all possible decisions that could be made in reality. Analysts instead tend to use simplified or unrealistic models to handle the enormous complexity (van der Aalst, 2010).

The main purpose of the analysis techniques presented so far is, on the one hand, to support business process analysis in constructing and maintaining a set of accurate, high quality business process models that reflect the current situation or describe to-be processes. This is in line with the roles such models have in BPR, which is being a data base for identifying improvement potential. The actual step from current towards improved process design, however, is a creative task left completely to the analyst. On the other hand, already identified possibilities to improve a process can be evaluated if an appropriate simulation model is formulated. Thus, simulation does not help the analyst in generating ideas for improvement. What can be achieved by means of simulation is constrained by the ideas already built into the simulation model. Our approach aims at filling this gap of idea generation.

Idea generation requires a huge amount of contextual knowledge far beyond that what is explicitly modelled in a BPD. Hence, success critically depends on the skill of the analyst. For this reason, techniques for supporting this task must focus on a particular domain. Patterns that represent weaknesses, accompanied with a suggestion how to improve the process, can serve as the domain specific knowledge base for process analysis. Weakness patterns provide analysts with reference ideas for process improvement. Formulating them in terms of a business process modelling notation allows for identifying, semi-automatically, which part of a process needs improvement. The accompanied solution specifies how to redesign it. This idea has recently been applied in the banking sector (Winkelmann and Weiß, 2011).

2.3 PICTURE

As mentioned before, patterns carry domain semantics and must be matched onto a BPD with respect to these semantics. Using natural language processing to interpret the meaning of modelling elements comes along with significant problems. Erroneous results are likely to occur and much effort is required to enforce language standardization. To circumvent this, a domain specific modelling notation can be used. In the BPR project we analysed, PICTURE was used to document BPDs. It is a notation developed specifically for the domain of public administrations. For methodological details, we refer to Becker, Algermissen, Pfeiffer, and Räckers (2007).

The main modelling constructs of PICTURE are process building blocks (PBB). They are predefined modelling elements, each representing a reoccurring activity in the application domain. For instance, this could be “Print Document” (cf. Figure 1). Thus, the set of PBBs serves as a categorization of activities (Becker, Bergener, Breuker, and M Räckers, 2010). To further detail the meaning of a PBB, a corresponding set of attributes is assigned. Such attributes have clearly defined domains describing possible values. For instance, an attribute of the PBB “print document” could be “Page Number,” with the domain being positive integers. The set of PBBs, together with the accompanying attributes and their values, constitutes all information that should be used for pattern search. An accompanying natural language description of a PBB (e.g., Print document A 38) merely provides further description to make a process understandable by humans, but is not used in automatic analysis. When defining weakness patterns only in terms of PBBs and their attributes, one can circumvent the need for natural language processing and can easily detect these patterns automatically in a process repository. The information required to find a pattern is accessible in a structured, machine-readable form.

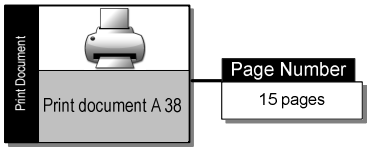

Figure 1. Example of a PBB with attribute

In this paper, we use PICTURE for representing weakness patterns. Our approach can, however, be used with any other process modelling notation as well. The only requirement is that modelling elements are annotated with the domain-specific constructs as used in the patterns that are to be

searched. For example, if applying BPMN, BPMN activities could be annotated with categories and further attributes (in analogy to PBBs).

3 Case Background – Data from a BPR Project

The aim of our study is to evaluate how useful weakness patterns could be for process analysts. To this end, we analysed real world data from a completed BPR project, which has been conducted by a consulting company at a German district administration. The aim of this project was to establish ongoing business process management within the district administration. To this end, a total of 32 processes were documented and analysed for possible weakness and potentials for improvement.

The BPDs were captured in interviews between consultants and officials responsible for conducting the respective process. Besides a description and the flow of process activities, the interviews recorded additional information like customers of the process, internal and external organizations involved, working documents, and software used. Furthermore, weaknesses and potentials for improvement were explicitly enquired during the interviews. Based on the interviews, the consultants modelled the processes with the PICTURE notation in the company's self-developed modelling tool.

For our study, the weaknesses and potentials for improvement identified in the interviews are of special interest. In a first step, we evaluate which of them could have been represented in form of a weakness pattern in the PICTURE modelling notation. Subsequently, searching the BPDs created in the project for these patterns allowed for assessing their usefulness. For all 32 processes, a total of 81 different items of weakness/improvement potential could be identified. To provide an overview, we classified them using the BPR framework presented by Reijers and Limam Mansar (2005a). It is designed to help practitioners in BPR projects to identify relevant areas and their interdependencies. The categories are as follows: *customers*, *products, process operation*, *process behaviour*, *organization*, *information*, *technology*, and *environment*. In line with Reijers and Limam Mansar, no items are assigned to the *product* category, since decisions about the product portfolio are not part of BPR. Note that the categories are not mutually exclusive. For example, information used by a process might also be related to the information system (technology) which holds it. We classified each item with respect to what we perceived as the dominant aspect. The following presents typical items found in the project data, structured along the above mentioned categories.

Items of the *customer* category are related to contacts with the customer, information provided or not provided by the customer, and actions which a customer should or should not perform. For example, in one process, a large number of queries from citizens are received in response to letters sent by the administration. Items concerning activities which are felt to be redundant (e.g., double checking of the same information) or missing (e.g., an organizational unit not informing another) are assigned to the *process operation* category. *Process behaviour* items typically relate to timing and scheduling issues. For instance, in some cases of one process, a notification is sent to a citizen before the data on which it is based has been corrected, resulting in a mistake that must be dealt with later on. Items of the category *organization* are personnel allocation problems. In the analysed BPR project, complaints about insufficient staffing at peak times were recorded. Also, the need to move certain parts of process activities to another organizational unit has been identified. *Information* items are related to missing or incomplete information and the actions necessary to acquire this information. For example, in several processes, certain legal texts are required but not always directly available, which results in laborious investigations. This category also includes problems with handling or interpreting information (e.g., inconsistent interpretation of certain regulations by different officials resulting in confusion among citizens). *Technology* category items describe either problems with a certain system that is not working properly (e.g. because of missing functionality or a confusing GUI) or situations in which certain technological measures are perceived as helpful to improve the process, such as an electronic fax solution. Finally, items in the *environment* category describe problems or suggestions regarding the work place environment. One example is the insufficient availability of vehicles for on-site

inspections. Table 1 shows how many items mentioned in the interviews have been assigned to each of the categories (row "Number of items").

4 Definition of Weakness patterns

Based on the weaknesses and improvement potential items from the interviews, we defined weakness patterns. They are constructed using the same PICTURE PBBs used in the BPDs. We define that a pattern matches a certain BPD if the sequence of PBBs in the pattern is found in the BPD. In order to enrich patterns, one can specify constraints on the attributes that must be fulfilled. To further enhance the expressiveness of weakness patterns, they can also contain so called wildcards between two pattern PBBs. A wildcard denotes that, in the BPD, an arbitrary number of PBBs can be positioned between those two PBBs that are matched into pattern PBBs separated by a wildcard. As an example, consider the pattern *Document request causing consulting need* in Figure 2. The first pattern PBB is *Send Document*, which also has an attribute constraint assigned ensuring that the recipient of the information is not an employee of the administration. The second PBB is P*erform Consultation*, and it is separated from the first by a *wildcard*. Any BPD containing PBBs of these types in correct order, separated by any number of arbitrary PBBs, and with the first PBB having an attribute *recipient* with the value *external*, would contain a match for this pattern.

The goal during the pattern definition stage of this study was to express as many items as possible in form of a weakness pattern. However, this was not possible for all weakness items. First, none of the items from the *process behaviour* category had a pattern assigned. This is because they deal with problems in scheduling the execution of process instances (e.g., a certain data repository is not updated often enough), which cannot be detected in individual, static BPDs. Also, we were not able to find any pattern corresponding to an item of the category *organisation* as, for instance, a lack of personnel resources cannot be inferred from a BPD. Similarly, one cannot see without further contextual knowledge that a certain process could be better handled by another organizational unit. Finally, items in the *environment* category do not have patterns assigned as they address external circumstances (regulations, work place equipment, etc.) not captured in BPDs.

Category	Customer	Process Operation	Process Behaviour	Organi-sation	Infor-mation	Tech-nology	Environ-ment	**Total**
Number of items	7	11	4	7	15	31	5	**81**
Number of patterns	2	1	0	0	4	22	0	**30**

Table 1. Number of Weaknesses with Number of Patterns Assigned per Category

For all other categories, at least some of the items were amenable to weakness pattern formulation. The number of items that could be addressed can be seen in Table 1 (row "Number of patterns"). Patterns are inspired by the heuristics that Reijers and Limam Mansar (2005a) provided along with their BPR framework. For each of the categories (except *product*), they identified numerous generic heuristics for business process improvement. Our patterns can be interpreted as particular instances of these heuristics, expressed in the simple pattern notation described above. They add domain specific knowledge to the generic heuristic to make it applicable to concrete BPDs. As such, BPDs created with the PICTURE notation can be searched automatically for occurrences of these patterns. However, not all pattern occurrences represent actual weaknesses. Hence, they must be evaluated manually. However, patterns provide process analysts with ideas on what could be done to improve the processes. Occurrences of these patterns provide a list of processes to which these ideas could be applied. This way, process analysts are supported during the act of process improvement. In the following, we discuss the ten weakness patterns we defined based on the data. A graphical

representation, using PICTURE and including attributes constraints, is provided in Figure 2. Table 2 lists the pattern's names, the category they belong to, and the heuristics which inspired their definition.

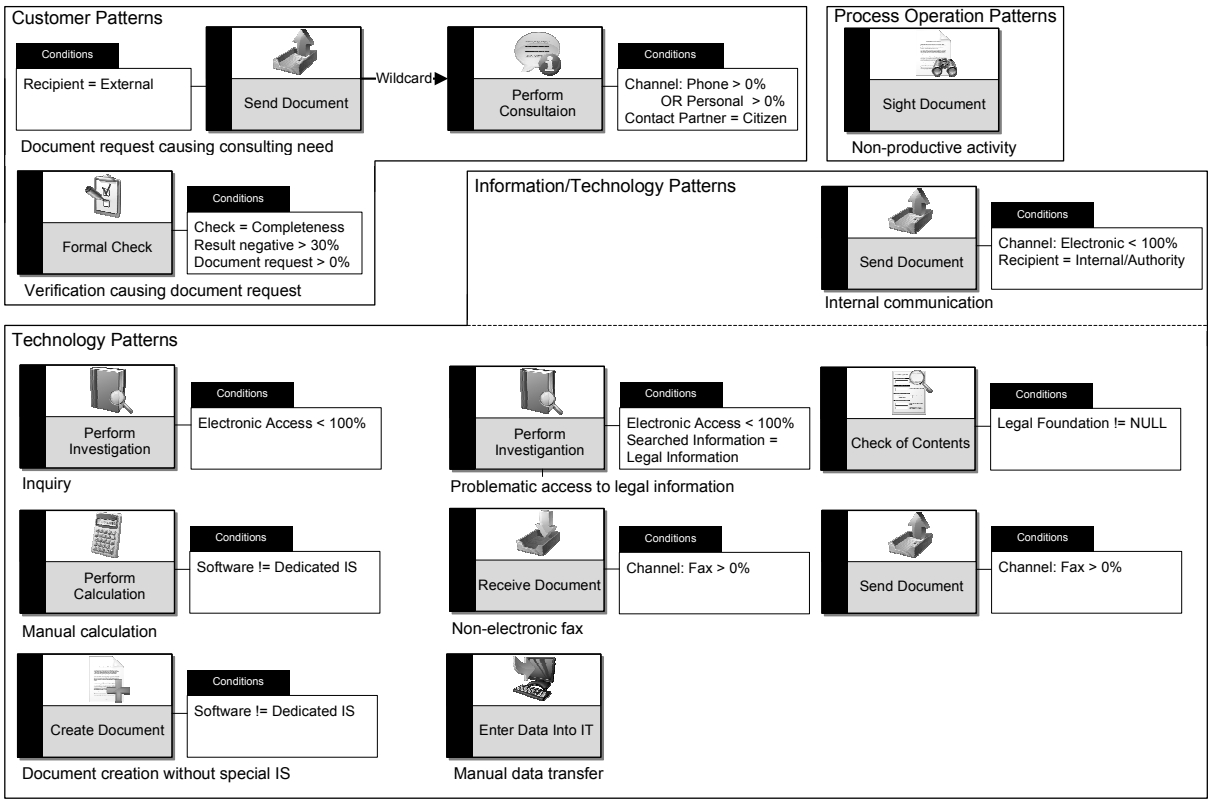

Figure 2. Graphical Representation of Deduced Patterns

For the Customer category, a pattern called *Document request causing consulting need* was identified. It describes a situation in which, after requesting documents from a citizen, the need for a consultation is raised. The resulting call or visit by the citizen costs time and disrupts the official's current workflow. Contact reduction is the corresponding improvement heuristic. It suggests avoiding such communication; for instance, redesigning the request such that customers understand it better. *Verification causing document requests*, the next pattern, should help to identify situations in which checks for completeness reveal a relatively high proportion of incomplete data. As a result, additional documents have to be requested frequently from citizens. This causes disruptions in the process and extra effort for requesting and repeatedly checking information. Again, the corresponding heuristic is contact reduction, e.g., providing better information about the required documents. Other items from this category could not be expressed as patterns as they are concerned with customer behaviour that is not part of the BPDs.

Only one pattern could be identified for items of the Process Operation category. *Non-productive Activity* describes cases in which superiors inspect documents only for informational purposes, thereby delaying the process execution. Consequently, the heuristic to apply is task elimination. Other weaknesses in this category could not be assigned to patterns. They were either too specific, referring to a missing activity whose need naturally cannot be detected in BPDs, or referring to a lack of entire processes.

Several patterns could be derived from items in the Technology category. *Problematic Access to Legal Information* captures situations in which an activity requires looking up legal information available only on paper. This may cause problems with the topicality of the information and the time needed to find it. The heuristic to apply is Integral Technology which, in this case, means querying a digital library. *Non-electronic Fax* should find activities for which an ordinary fax solution is used. Again, the

heuristic is Integral Technology which suggests applying an electronic solution to reduce costs in terms of money and time. *Manual Calculation* should identify activities where calculations are performed by hand or using self-made spread sheets, possibly causing quality problems and additional effort. Applying the heuristic Task Automation here means to properly automate these tasks, for instance with specialized IS. *Document Creation without special IS* captures similar situations in which documents are created by hand or using standard text processors instead of dedicated software. This may result in inconsistent documents and extra effort. Again, Task Automation can be a remedy. Finally, *Manual Data Transfer* captures situations in which data is transferred manually into an IT system (e.g., from a document or another IT system). In this case, the heuristic to apply is also Task Automation which can be accomplished by providing appropriate interfaces to connect the IT systems. *Inquiry* captures activities in which a search for missing information is necessary and this search cannot be performed purely electronically. Large effort for searching paper-based files may be the result. This could be avoided by applying the heuristic Integral Technology, i.e., by providing an electronic database with sophisticated search functionality. Weaknesses that could not be matched are those where particular functionality of IT systems was missing or perceived to be poorly usable. Such problems are not detectable in process models.

Internal Communication is designed to identify internal communication or communication with other authorities which is not performed electronically and might therefore be time-consuming. This type of pattern cannot be assigned to a single category. Rather, it belongs to *Information*, if information is pulled via an IS (buffering heuristic), or to *Technology*, if communication is performed via fast electronic channels such as email instead of ordinary mail (integral technology heuristic). Weaknesses from *Information* category which could not be assigned to patterns deal with structure or quality of certain pieces of information and, thus, are not directly process related.

Pattern	**Category**	**Heuristic**
Document request causing consulting need	Customer	Contact reduction
Verification causing document request	Customer	Contact reduction
Non-productive activity	Process Operation	Task elimination
Internal communication	Information/Technology	Buffering/Integral Technology
Inquiry	Technology	Integral Technology
Problematic access to legal information	Technology	Integral Technology
Non-electronic fax	Technology	Integral Technology
Manual calculation	Technology	Task Automation
Document creation without special IS	Technology	Task Automation
Manual data transfer	Technology	Task Automation

Table 2. Patterns deduced from interview protocols with corresponding heuristics

5 Assessment of Weakness patterns

To evaluate our set of weakness pattern from the previous section we made use of the PICTURE process models from the consulting project. We were able to automatically search for matches of patterns in the process database of the consulting company's modelling tool. To this end, the patterns were transformed into SQL statements which were run on the modelling tool's database. All matches found by theses statements were manually inspected.

Table 3 provides an overview of the results. The first column shows the name of the pattern, the second contains the overall number of processes in which a pattern match was found. The third column shows the number of matches that were expected to be found based on the analysis of the interview protocol. The fourth column contains the number of expected matches found, while the fifth column contains this number compared to the number of expected matches, as a percentage value.

For all patterns, the total number of matches found is greater than the number of expected matches. Hence, a number of unexpected matches were found. The assessment of these unexpected matches is not straightforward. On the one hand, they could be an indicator of weaknesses or improvement potentials not mentioned during the interviews. Reasons for this might be that the official was not aware of them, did not regard them as important, forgot to tell about them, or the actions implied by them were immediately considered to be impossible to implement. On the other hand, there might not be a weakness or improvement potential at all. This can only reliably be assessed with detailed knowledge about the processes. The aim of our approach is to generate suggestions for improvement potentials which have to be inspected manually by a process expert anyway. Hence, we regard a relatively large number of total matches not as problematic per se. They still filter the process database and direct the analyst's attention to potential points of interest which thereby provides inspiration for process improvement. In the following, we will elaborate on the results for every pattern, including our insights from manually inspection of found and missing matches.

Pattern	Total Processes with Matches	Expected Matches	Expected Matches Found	% Expected Matches Found
Document request causing consulting need	4	1	1	1.00
Verification causing document request	4	1	1	1.00
Non-productive activity	1	1	0	0.00
Internal communication	11	9	6	0.67
Inquiry	9	2	2	1.00
Problematic access to legal information	3	5	2	0.40
Non-electronic fax	6	5	4	0.80
Manual calculation	5	3	3	1.00
Document creation without special IS	13	2	2	1.00
Manual data transfer	18	1	1	1.00
Totals	74	30	22	0.73

Table 3. Results from the automated pattern search

The pattern *Inquiry* was designed to detect information deficits inducing the need to search for this information without technical support. Both expected matches for this pattern were found. Manual inspection of the remaining, unexpected matches suggests that many, but not all of them indicate improvement potentials as missing information is searched manually, e.g., in files or by requests at other organizational units. So in this case, officials were not aware of these improvement potentials and pattern search support further improvement. Additionally, in some cases, this pattern found creative tasks like creating a market review for procurement purposes.

Verification causing document request should detect formal verifications (e.g., verifying completeness of applications) which deliver negative results frequently and lead to requests for further information. The expected match for this pattern was found. The remaining matches seem to represent similar situations, although their small number might indicate a more infrequent problem.

With *Non-productive activity* pure sighting or double checking of documents by a superior is captured. The expected match was not found. Inspection of the corresponding BPD revealed that the part of the process performed by the superior was not modelled, which is why the pattern was not matched. The match that was found represented a check for completeness instead of pure sighting, suggesting a different understanding of the PBB by the modeller. Consequently, the pattern did not find any useful potential improvements.

The *Internal communication* pattern should detect internal communication or communication with other public authorities which could be enhanced through electronic data exchange. Two thirds of the expected matches were found. For the three missing cases, the internal communication was – in our understanding – wrongly modelled with a different PBB intended to describe consultations with citizens. All other matches found depicted situations similar to the expected ones.

The pattern *Problematic access to legal information* should help finding situations where extensive inquiries for legal information must be performed without digital access to this information. Only two of the five expected matches were found. This is due to the fact that legal information requirements were rarely annotated in the BPDs as capturing this information was not in the focus of the consulting project. The additional unexpected match also described a situation with an extensive legal examination.

Electronic Fax should help to identify potentials to use electronic fax as substitution for normal faxing. Out of the expected five matches, four could be identified with the pattern. In the process that was not found, a request for information via fax was only mentioned in the textual description and not modelled as an attribute. The unexpected matches delivered similar activities in which the application of an electronic fax solution appeared feasible in principle.

The *Manual calculation* pattern was designed to identify activities in which manual calculations without dedicated IT support are performed. All expected matches were found. The additional two matches also revealed activities in which calculations are performed by hand, although the complexity of these calculations could not be judged.

The pattern *Document Creation without Special IS* should detect activities in which documents are created using just office software, possibly leading to inconsistencies and quality problems. All expected matches were found. However, among the relatively large number of unexpected matches, there are many activities in which documents are created using office software and templates or text modules and where the use of these systems seems appropriate. Consequently, the pattern appears to be too imprecise and needs further refinement in further evaluation steps.

With the *Manual data transfer* pattern, activities in which data is entered manually into IT systems should be identified. The expected match was found. Again, however, the large number of other matches suggests that this pattern might be too coarse. Paper based forms, and hence the manual entry of information into IT systems, is common in public administrations and, therefore, not as easy to change;even so, it represents a potential opportunity for improvement: for instance, online application forms could be used instead.

The *Document request causing consulting need* pattern should help finding activities in which document request to citizens cause queries interrupting the official's work. The expected match was found. Of the three additional matches, two turned out to be simple appointment request not in line with our understanding of the PBB. Thus, they could be classified as modelling mistakes. Further, with only one match, this pattern might also represent a rather uncommon problem. Another possible explanation is that queries by citizens are often not explicitly represented in process models, as they only occur in some cases and outside of the normal flow of activities.

6 Conclusion

6.1 Implications and Limitations

Based on the findings presented above, we regard our pattern based approach as suitable to support process analysis. We deem the percentage of matches found to be satsifactory, especially since most of the missing matches are, from our point of view, caused by modelling mistakes or missing information not included in the BPDs because it was not necessary to accomplish the project's goals. However, the results demonstrate that not all patterns proved equally useful. Most of them, like *Internal Communication* or *Non-electronic fax* provided promising results. Others, like *Manual data transfer* and *Document creation without special IS*, appears to be too unspecific. Furthermore, patterns like *Non-productive activity,* for which almost no matches were found at all, seem to represent very specific and thus uncommon situations.

It might appear as if searching for local weaknesses in BPDs can only deliver local suggestions for improvements, while redesigning a business process if often concerned with large-scale change. Associating our weakness patterns with the process optimization heuristics of Reijers and Limam Mansar (2005a) establishes this link from local weaknesses (micro-view) to high-level improvement measures (macro-view). For example, a weakness of type *Non-electronic fax* can be addressed by implementing an electronic fax solution; since such an investment will not only be used in a single process. The set of all (local) matches for this pattern as a whole may allow an analyst to quickly estimate the potential of this (global) improvement measure.

These findings do have certain limitations. In particular, they are based only on data collected from a single case. However, other studies indicate that the type of weaknesses and improvement potentials found in this paper are typical for public administrations (Algermissen, Delfmann, and Niehaves, 2005). Thus, the patterns derived from these problems are likely to applicable in other public administrations. Nevertheless, further studies are necessary to create an exhaustive set of weakness patterns and determine how common and useful specific patterns are.

6.2 Implications for future research

From a theoretical perspective, this paper filled, to some extent, a gap in the existing BPR literature. Weakness patterns can provide automatic support for process analysts during process improvement; a task currently perceived to be entirely manual and highly dependent on creativity. Ideas how to improve a process design can be given to the analyst. The patterns, which are based on a semantically enhanced modelling notation, also have the advantage of avoiding the use of natural language processing techniques. We hope to stimulate more research on the role such semantically enriched modelling approaches could assume in supporting BPR as well as other analysis techniques.

For practitioners in the field of BPR, our approach could provide a useful tool in BPR projects. As mentioned above, it can, to some extent, automate a previously manual step by providing suggestions for possible process weakness and improvement potential. Via the link to the process enhancement heuristics, suggestions on how these problems could be tackled can be provided as well. Our findings also highlight the importance of ensuring and maintaining high model quality. Most of the missing matches were not found due to missing information or incorrect usage of modelling constructs.

The results of this paper represent a starting point for a comprehensive BPR approach. Further steps in our research process will be to verify the developed approach with additional project data, to evaluate the overall usefulness of the concept, and to refine and expand the set of weakness patterns. Furthermore, we will examine in detail the unexpected matches and to identify reasons for this. This may allow cementing patterns such that they deliver more precise results.

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