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Two Problem Formulations for Process Innovation Based on Operations Sophistication

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ABSTRACT

Process innovation is assumed to require a more intrinsic rethinking of business processes, which is typically a creative process. Nevertheless, in this creative, prolific process, there can be artifacts derived from rational practices that are capable to provide insightful recommendations. In this work, the authors claim that an event log, a file that registers the execution of the relevant business processes, can be the source of such an artifact. They describe the fundamental elements of two problem formulations, namely the set of alternatives; the set of potential actions that the decision-maker may undertake; the set of points of view (dimensions) from which the potential actions are observed, analyzed, evaluated, compared, etc.; and the problem statement (what is expected to be done with the alternatives) for two cases.

KEYWORDS

Evaluation Models, Problem Formulation, Process Innovation, Process Mining

INTRODUCTION

Typical business processes in contemporary organizations can be defined as *a collection of inter-related events, activities, and decision points that involve a number of actors and objects, which collectively lead to an outcome that is of value to at least one customer* (Dumas, La Rosa, Mendling, & Reijers, 2018). To pursue the challenge of improved efficiency and effectiveness, organizations may follow a variety of options (Harmon, 2007), ranging from process innovation to process redesign and to process improvement. The seminal work of (Rosemann & vom Brocke, 2015) identifies process innovation within the core element of *Methods* as the stage that includes all methods which facilitate the development of improved business processes, as well as within the core element of *Information Technology* as the (semi-) automated support for the generation of improved business processes. There are of course different types of process innovation and a plethora of approaches towards it, however, arguably, among the factors that can stimulate and promote it, we find the reduction of innovation latency (Rosemann, 2014) (i.e., to timely anticipate what improves the process), and the mitigation of the organizational resistance towards a process change endeavor (W. M. P. van der Aalst, La Rosa, & Santoro, 2016).

The research aim of this work is to support an organization's decision on what elements of a business process should gain emphasis and priority during a process change project. In such a problem,

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there are several research questions that can be shaped: How organizations should proceed? What is the shape of a solution? Why such a solution should be preferred against another? In this context, this work contributes by defining two problem formulations that eventually allow the identification of the underlying structure of the relevant decision problem, and as such, they allow the re-use of procedures and models (Bouyssou, Marchant, Pirlot, Tsoukiás, & Vincke, 2006) forging a consistent process innovation technique.

Although it is typical to assume process innovation as a creative process (Figl & Recker, 2016), in this creative, prolific challenge there can be artifacts derived from rational practices that are capable to provide insightful recommendations. In this work, we claim that an event log, a file that registers the execution of the relevant business processes, can be the source of such an artifact. Therefore, we adopt a *process mining* perspective that commits to discovering process behavior (patterns) from the event log.

In this work, we propose a way to address the research questions we stated in the above paragraph by exploiting the outcomes of a process mining venture. We claim that this can be achieved by looking and taking action according to a metric that we call *Operations Sophistication*. This metric reflects how much diversified are the capabilities of an organization, and how difficult it is to deploy and apply those capabilities to the organizational operations. The core assumption is that a more versatile organization is expected to be able to demonstrate higher sophistication, manifest more complex sets of capabilities, and hence achieve better performance.

More specifically, we assume a tripartite network. The one part consists of the capabilities, the second of the organizations, and the third of the behaviors/ patterns they exhibit over their operations within a business process. Organizations are connected to their available capabilities, and patterns are connected to their required capabilities. Then, if a pattern is observed, we can assume that all the required capabilities are in place, therefore, we can reflect the tripartite network with a bipartite one, connecting organizations to patterns. In previous work (Delias, Acheli, & Grigori, 2019), we have shown that by analyzing the structure of such a bipartite network (an organizations-patterns network) and by iteratively considering the properties of the neighboring nodes of each part, it is possible to derive several metrics that reveal the potentials of the patterns to contribute to higher sophistication for the organizations. However, even after deriving several relevant metrics, it is not clear how a problem situation can be shaped and how a corresponding decision model can be formulated. This is exactly the topic that we address in this work.

More specifically, the focus of this work is to formally describe two relevant problem situations (one at the level of organizations, and one at the level of human resources) that will enable the stakeholders who will be involved in process improvement projects, to have a clear picture of what is at stake, and to shape solution paths. In the next section, we try to give an overview of the related work and of the concepts related to the Operations Sophistication notion. In the methodology section, we position our work on a process mining project. Although this work focus on a particular phase of process mining projects, with a rather conceptual nature, we try to put our contribution in a more applicative context. Therefore, in the next section (Business understating through problem formulation in context), we present the two problem formulations along with all the required definitions, and their implications. A fictional example is used for illustrated purposes to demonstrate the practical potential of the conceptual contributions that lead to the forging of the corresponding artifacts. A short discussion concludes the paper.

BACKGROUND

Related Efforts

The concept of *Process Innovation,* since its introduction four decades ago by (Utterback & Abernathy, 1975), and after having been pursued by an abundance of organizations, has been revived in 1993

by (Davenport, 1993) to subsume new work strategies and business process changes to generate more beneficial outcomes for process stakeholders. To survey the process innovation capability of an organization, (Hogan, Soutar, McColl-Kennedy, & Sweeney, 2011) operationalized process innovation as the ability to overpower competition in applying collective knowledge, skills, and resources to create added value for the organization. To reflect contemporary advances of the concept, M. Roseman, prefacing (vom Brocke & Schmiedel, 2015), provides a comprehensive and rather aphoristic definition about innovation as the "*idea-to-execution process, i.e., the conversion of emerging insights, opportunities, and creative designs into new products, services, process or business models"*.

Business Process Management and Business Innovation are two fields notably intertwined: BPM plays an important role in fostering innovation as well as BPM can get improved by accepting innovation (Schmiedel & vom Brocke, 2015). In this work, the relevant strand is the former, since we plan to exploit business process execution footprints to deliver recommendations on how process innovations can be reached. Indeed, to reach process innovations, a meaningful prerequisite that is suggested in (vom Brocke, Debortoli, Müller, & Reuter, 2014) is the identification of value-creating potential. On top of this inference, (Lehnert, Linhart, & Roeglinger, 2017) advocate that it is not sufficient to examine the range of process improvement opportunities in a disconnected way, and that relevant decisions require *a detailed analysis of the* (process innovation) *projects' effects on the process performance instead of a high-level abstraction*.

Two compatible research questions addressed in (Lehnert, Linhart, Manderscheid, & Svechla, 2016; Manderscheid, 2016) are about *i)* which projects should an organization implement to improve a distinct process, particularly accounting for process characteristics that reflect how work is performed and organized, and *ii)* how to provide useful and easy-to-use tool support for value-based innovation portfolio management.

To respond to the issues described in the previous paragraphs, an analytical, data-based approach appears to be a prominent paradigm. Khanbabei et al. (Khanbabaei, Alborzi, Sobhani, & Radfar, 2019) exploited data-mining techniques (clustering and classification) to identify the behavior (in terms of patterns on numerous process characteristics) of knowledge-intensive processes that compete each other for improvement. As a more detailed thread, we pinpoint the field of *business process analytics*, which as (Dumas & Maggi, 2015) suggest, could be exploited for process innovation through monitoring and analyzing process performances based on digital processes (real-time deviance mining).

Process analytics can also be coupled with Big data (Mikalef & Krogstie, 2018) to lead to varying levels of process innovation. In their survey on how Big data can enable process innovation, they conclude that process innovation capabilities are commonly identified as combinations of factors (including resources, skills, environmental attributes, and behaviors). Considering capabilities that could further support process transformation, (Bruin & Rosemann, 2005) identified such factors within strategic alignment, governance, people, and culture. Focusing on strategic alignment, (Oliveira, Lima, & Reijers, 2015) present a BPM-based approach to support a manager to ensure that employees are aligned with the company's strategy. They introduce strategy awareness as an information system's capacity to influence users to work towards the strategic priorities of the organization, an approach based on the relevant capability of *line of sight*, a concept that designates the alignment of organizational capabilities and culture, group competencies and norms, and individual knowledge, skills, and abilities (KSAs), motivation and opportunity with one another and with the organization's strategy (Buller & McEvoy, 2012).

There is a common ground between our work and the capability development approaches (Forstner, Kamprath, & Röglinger, 2014) that support the decision about which organizational capabilities should be developed, yet there are two fundamental differences between those approaches and this work. Capabilities development efforts obviously focus on capabilities, which in our work constitute a latent layer, since our focus is on lower-level behaviors. Secondly, models for capabilities development

decisions are created by an essentially deductive approach (Forstner et al., 2014), while this work embraces the inductive paradigm.

Regarding capabilities, there are, of course, several prominent works in the fields of maturity models and frameworks (e.g., the seminal work of (Rosemann & vom Brocke, 2015) or the innovation-focused capability framework of (Hosseini, Kees, Manderscheid, Röglinger, & Rosemann, 2017)). However, these works are holistic approaches that abstract from the low-level task execution.

At this low-level, authors of (Dreiling & Recker, 2013) conceived a framework to examine processes in terms of events during organizations' attempts to innovate, an effort that was utilized as an argument in shaping the term "Evidence-based Process Innovation" by (Recker, 2015). It is under this label that we position our work, since the management decisions that are highlighted in (Recker, 2015) as the ones that can benefit from evidence-based process innovation (e.g., evaluation of ideas, trajectories to solutions, feasibility of options) are highly relevant to the questions we phrased in the introductory section, and additionally, we base our work on evidence data (in the form of an event log) that we plan to input to an analytic method that relies on process mining and bipartite network analysis, after having shaped the relevant problem situations.

The Concept of Operations Sophistication

In this section, we briefly describe the related concepts and terms. Since only the basic justifications and information are provided, the interested reader is redirected to (Delias et al., 2019; Hidalgo & Hausmann, 2009) for a more detailed description. First, we assume that there is an available event log (W. van der Aalst, 2016, p. 128) which contains the execution logs of the business process for which the innovation project is initiated. In (Delias et al., 2019), we describe analytically how this event log can produce a bipartite network. This bipartite network can take two shapes, as we will explain in the next sections. The one set of nodes will always represent patterns (process behaviours like batch processing, involving multiple resources, balancing workload, etc. that are routinely followed during the process execution). The second set will reflect either the resources that are performing the relevant process tasks, or it will comprise organizations that are performing the same process. Without loss of generality, to convey the notion of Operations sophistication, in this section we will describe the concepts based on the second option.

We define *versatility* as the number of the different patterns that an organization demonstrates. In addition, we define the *pervasiveness* of a pattern as the number of organizations that exhibit it. We expect that patterns that require complex combinations of capabilities to be less pervasive, or in other words, the pervasiveness of a pattern signals the number of capabilities that are required for its application. Therefore, we claim that the performance of an organization resides in the diversification of the patterns it can demonstrate. Sophistication is expressed in the assembly of the exhibited patterns and reflects the mechanisms that are needed to exploit different sets of capabilities.

By using versatility to correct pervasiveness and vice versa, through a set of recursive equations (see (Hidalgo & Hausmann, 2009)) we can capture a metric that reflects the degree of sophistication that each organization exhibits during the process execution (we shall call this the *Operations Sophistication Index-OSI*) and a similar metric that reflect how much sophisticated every pattern is (let us call this *Patterns Sophistication Index – PSI*).

Using the structure of the bipartite network, as well as the above basic metric, we can ramify the outputs and construct a set of additional insightful metrics. By calculating the probability of co-occurrence in the same organization between every two patterns, we can calculate a kind of similarity (*proximity)* over them. Then, exploiting this proximity metric among patterns, we can calculate the distance of every organization to every pattern as the normalized sum of the proximities of all the patterns that are proximate to the relevant pattern but that are not yet exhibited by the relevant organization.

Accounting not only for the distance between an organization and patterns but for the level of patterns' sophistication as well, we could calculate the sophistication prospects of the organization.

This kind of weighting results in a metric which we call *Opportunity Value* for an organization and it is very important because when we create differences between the opportunity value of an organization and its twin that does not apply a distinct pattern, we can calculate the *Opportunity Gain* that every organization has from the adoption of that distinct pattern.

METHODOLOGY

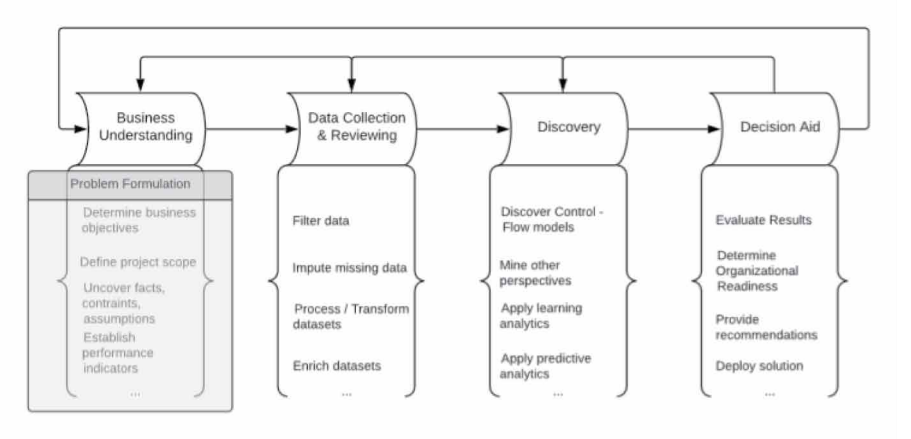
Process Innovation projects typically start with envisioning the change, initiating the project, and then proceed with a diagnosis stage (Harmon, 2007). It is in this stage that process mining enters, mainly due to its capacity to document and analyze the existing process. Process mining activities comprise a project on their own, principally instructed by a guiding methodology. Figure 1 illustrates such a methodology that exhibits a phase of *business understanding* as to the initiating phase. The rationale of this phase is to help the analyst arrive at a stage of reflection where she has a clear understanding of the business context, and where she can assess how alternative actions can contribute to the business objectives (Delias, Doumpos, & Matsatsinis, 2015).

Unlike the original methodology - which by its turn adopts the paradigm of (Chapman et al., 2000)- which considers that determining business objectives implies informally describing the problem to be solved, in this work, we propose to treat formally the relevant tasks by assimilating a *problem formulation* definition into exactly this stage, as the shaded rectangle-container suggests in Figure 1.

In particular, following (Bouyssou et al., 2006), we will take the view that a decision aiding process is a process "*in which different agents endowed with cognitive capabilities have to share some information and knowledge in order to establish some shared representation of the process object*". During the first steps of the process, these pieces of information of knowledge take the shape of two major deliverables, namely the problem situation and the problem formulation. The former boils down to a representation that will ultimately aid the client to better arrange herself regarding the decision procedure for which she asked the analyst's recommendation. The latter (problem formulation), is actually a task of translating the client's interest into a format that decision support techniques and methods can address. This is reached by using a formal decision support language, however since this will inevitably lead to a reduced reality, we ought to point out the following pitfalls: A problem formulation is not neutral to the final recommendation (solution), indeed a different formulation is very likely to lead to a different recommendation. The analyst's defense of this is that following a problem formulation, the client will eventually be able to anticipate the possible conclusions and check whether these are compatible with her expectations. It is quite clear that the analyst shall not continue the decision aiding process unless the problem formulation is validated by the client.

In this work, and in accordance with (Bouyssou et al., 2006; Stamelos & Tsoukiàs, 2003), we define a problem situation $\mathcal{P}$ to be a triplet $\mathcal{P} = \mathcal{A}, \mathcal{O}, \mathcal{S}$ where $\mathcal{A}$ are the actors involved in the process, $\mathcal{O}$ are the objects (problems, interests, opportunities) introduced by each actor (for instance a manager of an organization may be concerned with the organizational change that an innovation will bring, while shareholders may be concerned with the expected profits it will bring), and $\mathcal{S}$ are the resources (monetary or not) committed by each actor to each object of her concern. Another triplet representation is employed for the problem formulation. In particular, we define a problem formulation Γ to be a triplet $\Gamma = \mathbb{A}, \mathbb{V}, \Pi$ where $\mathbb{A}$ is the set of alternatives, the set of potential actions that the client may undertake, $\mathbb{V}$ is a set of points of view (dimensions) from which the potential actions are observed, analyzed, evaluated, compared, etc., and Π is the problem statement (what is expected to be done with the elements of $\mathbb{A}$ - some common problem statements are choice, ranking, rejection, etc.).

Figure 1. The problem formulation takes place during the business understanding phase. Adopted from (Delias et al., 2015).



BUSINESS UNDERSTANDING THROUGH PROBLEM FORMULATION IN CONTEXT

Formulation at the Level of Organizations

This is the case where multiple organizations are performing the same business process (in parallel, not collaboratively), and they are interested in improving their relevant performance. This scenario is typical in the case of public organizations, or in branches of multinational companies. Following the definitions of the previous section, we postulate that:

- $\mathcal{A}_{org}$ is the set of actors that will get affected by the consequences of the decision, as well as the actors that are influencing the decision. This set comprises *i*) representatives from each organization: the CEO; the process owner (the person who is responsible for the efficient and effective operation of the relevant business process); the process participants (the persons that are performing the process) and *ii*) the process analyst; the process methodologist; a higher authority that is the actor who initiate the process innovation project.
- $\mathcal{O}_{org}$ comprises a performance metric that is the target of improvement (typically throughput time, customer satisfaction, etc.), the process behaviors that are routinely followed by the process participants during the process execution, and the organizational resistance to change.
- $\mathcal{S}_{org}$ consists besides of the implicit elements (the labour, the knowledge, etc.), of an event log (a flat-file that registers the traces of the process execution) and of a set of *patterns*, i.e., process behaviors (e.g., batch processing, workload balancing) which organizations demonstrate during the process execution.
- $\mathbb{A}_{org}$ is a set of patterns that can be adopted in order to improve the performance of organizations. We should emphasize two important issues: *i*) we assume that the process innovation project consists of the adoption of a subset of those patterns for the process execution; *ii*) patterns are meant as the elements of the final solution as a reflection of the capabilities that are required to perform them.
- $\mathbb{V}_{org}$ the evaluation dimensions include the potentials of improvement that each pattern brings, the feasibility of its realization in terms of the organizational resistance that it will meet, and the suitability of the pattern for the particular organization.

Table 1. Interpretation of the degrees of the bipartite network and of their subsequent refinements at the level of organizations

Outcome	Description
$v_{org,0}$	Versatility. Number of patterns exhibited by organization org
$p_{pat,0}$	Pervasiveness. Number of organizations exhibiting pattern pat
$v_{org,1}$	Average pervasiveness of the patterns exhibited by organization org
$p_{pat,1}$	Average versatility of the organizations exhibiting pattern pat
$v_{org,2}$	Average versatility of organizations with a pattern profile similar to organization org
$p_{pat,2}$	Average pervasiveness of the patterns exhibited by organizations that exhibit pattern pat

- Π_{org} is the problem statement which we suggest being non-purposeful, i.e., to describe the patterns under the points of view established in $\mathbb{V}_{org}$.

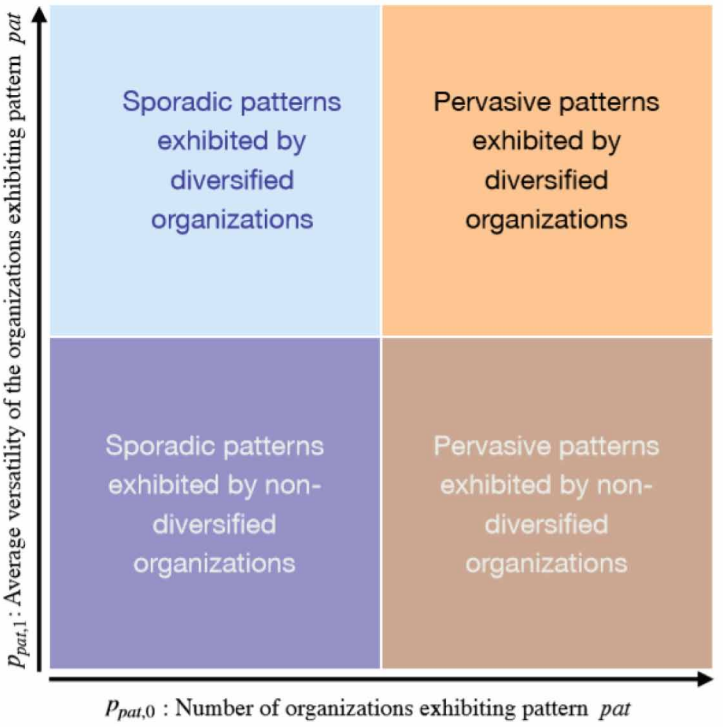
Based on the above formulation, we are able to construct a bipartite network through an event log, as it is described in (Delias et al., 2019), and deliver the following template outcomes, artifacts that are capable to support the decisions in context:

A. The degrees of the network and their refinements through subsequent recursive iterations, following the method of reflections (Hausmann & Hidalgo, 2011). In particular, in the context of this problem formulation, these take the shape of the metrics presented in Table 1.

These metrics are useful for the business understanding challenge on their own, but there is an additional potential for insights if we combine them. In Figure 2, we illustrate the insights that we can infer by combining the first two iterations of the pervasiveness metric. We construct a 2×2 matrix where patterns can be plotted using their $p_{pat,0}$ value as the x-coordinate and their $p_{pat,1}$ value as the y-coordinate. Assuming that the sophistication metrics are indeed relevant for the business case, we expect a negative correlation between those metrics (Hidalgo & Hausmann, 2009). That will highlight the elements of the top-left square (sporadic patterns exhibited by diversified organizations) as the most interesting elements of the set of patterns.

B. Sophistication indices: The *Operations Sophistication Index* will indicate how sophisticated are the operations that every organization applies to perform the specific business process, and the *Pattern Sophistication Index*, which will indicate how sophisticated each pattern (process behavior) is within the context of the specific business process.
C. A perception of "similarity" among the patterns, by calculating their *proximity* as the probability of co-occurrence in organizations (how any pair of patterns appear in different organizations). It is also useful to consider a "reverse" interpretation, namely, to consider that if an organization exhibits one pattern, then, it is more probable that it will also exhibit other patterns that are "proximate" to the first one rather than patterns that are "distant" to it. Likewise, we expect to

Figure 2. A visual aid by plotting the first two iterations of the pervasiveness of the patterns



get a perception of "similarity" between organizations and patterns by constructing a metric that will yield a low distance between an organization *org* and a pattern *pat* when the organization exhibits most of the patterns that are proximate to *pat*, and the inverse. The intention of these *similarity* metrics is to supply the process change champions and the involved decision-makers with recommendations on the feasibility of the changes since proximate patterns are expected to be easier to implement.

D. Recommendations on which patterns should be prioritized, in terms of the benefits they are able to commit. The two relevant metrics are *opportunity value* (what patterns and at which level of sophistication are proximate to the organization), and the *opportunity gain* (what improvement on its *Operations Sophistication Index* a pattern counts for a particular organization).

Formulation at the Level of Human Resources

In this case, we twist the main idea and modify the objects of the bipartite network. Actually, we modify just the objects of the one set of nodes, the one with the organizations. In this, version, the bipartite network will, therefore, contain human resources (instead of organizations) and patterns. More specifically, consider the case when multiple human resources in an organization are assuming similar work roles. Being participants in the same business process, human resources are interested in improving their personal competencies with respect to their performance about the process. The formulation elements for this case are:

- $\mathcal{A}_{hr}$ is the set of the process participants, the human resources manager (or any other manager that performs some kind of performance appraisal), and the process owner, in the sense that he/she provides the process performance metrics and evaluations.
- $\mathcal{O}_{hr}$ comprises a performance metric which is the target of improvement, the atomic behaviors that are routinely followed by the process participants during the process execution, and the motivation (including incentives) of each participant to improve her own personal performance.
- $\mathcal{S}_{hr}$ consists besides of the implicit elements (the labour, the knowledge, etc.), of an event log (a flat-file that registers the traces of the process execution) and of a set of *patterns*, i.e., atomic behaviors (e.g., extreme handover, intense collaboration) which the process participants demonstrate during the process execution.
- $\mathbb{A}_{hr}$ is a set of patterns that can be adopted in order to improve the performance of every individual participant. We should emphasize two important issues: *i*) we assume that the process innovation project consists of the convincing participants to adopt a subset of those patterns so that eventually the process execution is improved; *ii*) patterns are meant as the elements of the final solution as a reflection of the capabilities that are required to perform them.
- $\mathbb{V}_{hr}$ the evaluation dimensions include the potentials of improvement that each pattern brings, the feasibility of its realization in terms of the possession of the required personal capabilities, and the suitability of the pattern for the particular resource.
- Π_{hr} is the problem statement is similar to Π_{org} since we suggest again to be non-purposeful, i.e., to describe the patterns under the points of view established in $\mathbb{V}_{hr}$.

The template outcomes have the same format (yet not the same content) with the ones that we derived during the previous case (formulation at the level of organizations). More specifically, the degrees of the network will have the interpretation that is suggested by Table 2, and the 2×2 matrix will illustrate the atomic behaviors (e.g., extreme handover, intense collaboration) that are exhibited by the human resources (staff performing the business process) during the process execution, as Figure 3 demonstrates. By the same token, the top-left square (sporadic behaviors exhibited by diversified staff) identifies again the most interesting patterns (the atomic behaviors that we gauge as the ones carrying the greatest potential to improve the sophistication metrics).

Then, the *Operations Sophistication Index* will indicate how sophisticated are the atomic behaviors that every human resource (staff member) applies to perform the specific business process, and the *Pattern Sophistication Index*, which will indicate how sophisticated each pattern (atomic behavior) is within the context of the specific business process. The *opportunity value* and the *opportunity gain* are two metrics of particular interest for the human resources managers since they will point out what atomic behavior can be pursued by each human resource (identify the most proximate ones and reckon the pertinent benefits), an insight particularly relevant for training or change management projects.

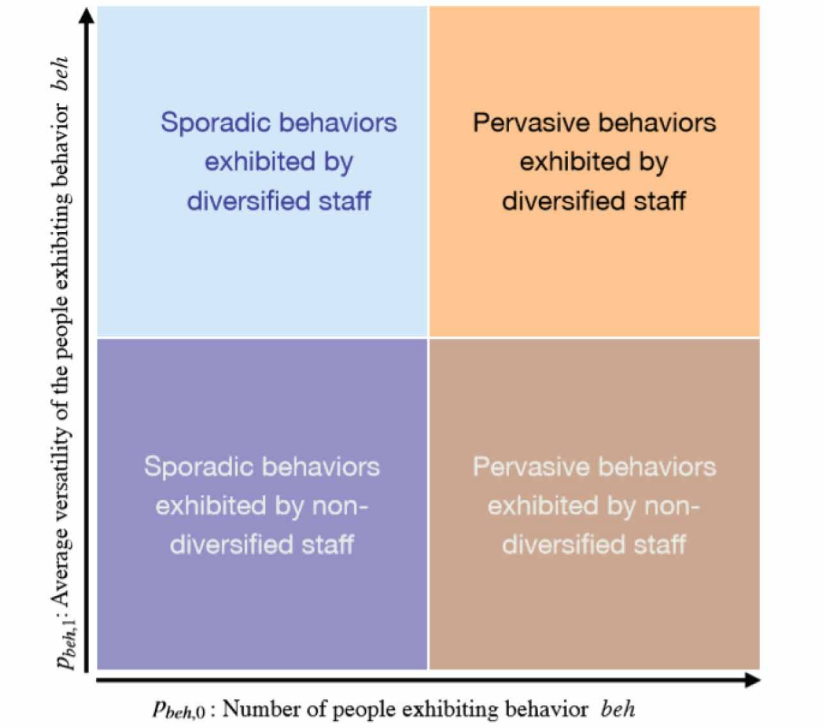
AN ILLUSTRATIVE EXAMPLE

To illustrate the practical potential of the problem formulation for process innovation, we present in this section a simplified, fictional example, which (without loss of generality) is based on a formulation at the level of resources. In particular, we assume an *issue-to-resolution* process, which takes place within the customer contact center of a firm, and which is triggered by a customer raising an issue (e.g., a complaint) and continues until the customer concedes that the issue is resolved. Multiple human resources are performing the role of the *Customer service representative*, with identical job descriptions. The corresponding formulation elements for this illustrative case are:

Table 2. Interpretation of the degrees of the bipartite network and of their subsequent refinements at the level of human resources

Outcome	Description
$v_{hr,0}$	Versatility. Number of behaviors exhibited by the staff member hr
$p_{beh,0}$	Pervasiveness. Number of people exhibiting behavior beh
$v_{hr,1}$	Average pervasiveness of the behaviors exhibited by the staff member hr
$p_{beh,1}$	Average versatility of the staff members exhibiting behavior beh
$v_{hr,2}$	Average versatility of the staff members with a behavior profile similar to the staff member hr
$p_{beh,2}$	Average pervasiveness of the behaviors exhibited by staff members that exhibit behavior beh

Figure 3. A visual aid by plotting the first two iterations of the pervasiveness of the behaviors



- $\mathcal{A}_{hr}$ is the set of the customer service representatives and the human resources manager which evaluates *customer satisfaction* for every instance of the process, as the single critical metric for this process.
- $\mathcal{O}_{hr}$ is an index of customer satisfaction (measured by a numerical 0-100 scale), and which is estimated through a questionnaire that is filled by customers themselves after the resolution of the issue, i.e., the end of the process. We assume that customers fill rationally that questionnaire. The customer satisfaction index is assigned to a process instance, and the performance of an employee is a weighted average of the satisfaction indices of the cases to which she/he has been involved (the weight reflects the percentage of involvement).
- $\mathcal{S}_{hr}$ consists of:
  - An event log that traces the process execution and which has the format of Table 3.
  - A set of capabilities pertinent to the execution of the process, which is latent, i.e., can be observed through a set of patterns (see the definition for $\mathbb{A}_{hr}$ below).
- $\mathbb{A}_{hr}$ is a set of patterns that are considered for their improvement potential to customer satisfaction. We recall that every pattern is evaluated for each employee. These patterns are:
  - Prioritization: How much FIFO holds for every employee.
  - Workload: The number of concurrent cases.
  - Rework: The average number of repeated activities in each case.
  - Handovers: How many times on average the employee is passing the case to a colleague.
  - Number of cases in each communication channel: A case is classified into the channel that was used for its first activity.
  - Number of activities: The average number of activities visible to the customer per case.
  - Duration: The weighted average of the duration of the cases where this particular employee was involved (weight reflect the percentage of involvement).
- $\mathbb{V}_{hr}$ the evaluation dimensions include the pattern sophistication index (the potentials of improvement that each pattern brings), the proximities' network (the feasibility of a pattern's realization in terms of the possession of the required personal capabilities), and the opportunity gain (the suitability of the pattern for the particular resource). Having the definitions for $\mathcal{A}_{hr}$, $\mathcal{O}_{hr}$, $\mathcal{S}_{hr}$, and $\mathbb{A}_{hr}$ and applying the algorithm of the Method of Reflections as it is described in (Delias et al., 2019), all the metrics of $\mathbb{V}_{hr}$ can be calculated. This step, however, is out of scope for this work and is not explained here.
- Π_{hr} is the problem statement, which as we previously described, it is considered as non-purposeful, i.e., to describe the patterns under the points of view established in $\mathbb{V}_{hr}$.

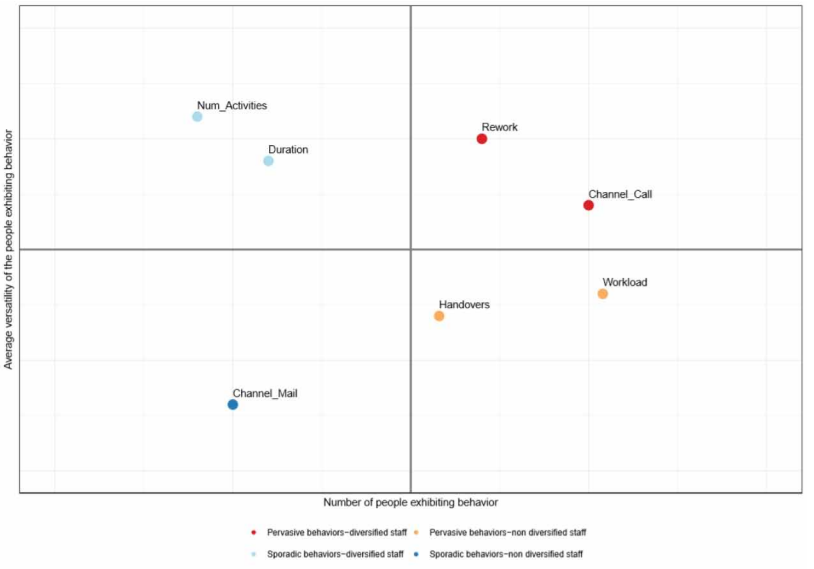
As mentioned earlier *Operations Sophistication* reflects the knowledge and capabilities that an employee possesses and the availability of the required skills to exploit them. We strongly suggest as a preparatory control for every process innovation project, to test the Operations Sophistication relation to the performance metric that we have defined with $\mathcal{O}_{hr}$. This can be tested through a regression between the sophistication index and the performance metric. There are two main reasons for this recommendation: The first is to check the internal and the construct validity of the formulation. If a regression line cannot be fitted, this is an indication that the set of examined patterns is not adequate. The second reason is to help the analyst anticipate the size of the unexplained variation, hence establishing a more relevant point of view for the later interpretations.

Then, exploiting the visual guide that is suggested by Figure 3, we obtain Figure 4, which can already highlight the most interesting patterns (the atomic behaviors that we gauge as the ones carrying the greatest potential to improve the customer satisfaction). These are the ones located in the top-left

Table 3. Fragment of the Event Log. All the available columns are presented.

Issue ID	Activity	Start Timestamp	Complete Timestamp	Employee ID	Customer ID	Communication Channel	Satisfaction Index
0102	Issue registered	Jul 23 2019, 10.11.56	Jul 23 2019, 10.15.14	A34	09856411	Call	83
0102	Check Customer History	Jul 23 2019, 10.15.45	Jul 23 2019, 10.21.11	A34	09856411	CRMsoft	83
0103	*Issue registered*	Jul 23 2019, 10.17.23	Jul 23 2019, 10.19.03	C2	00874499	E-mail	91
0102	Check product guarantee	Jul 23 2019, 11.32.56	Jul 23 2019, 11.33.34	C12	09856411	CRMsoft	83
0102	Contact vendor	Jul 23 2019, 11.41.56	Jul 23 2019, 11.49.45	A17	09856411	B2Bsoft	83

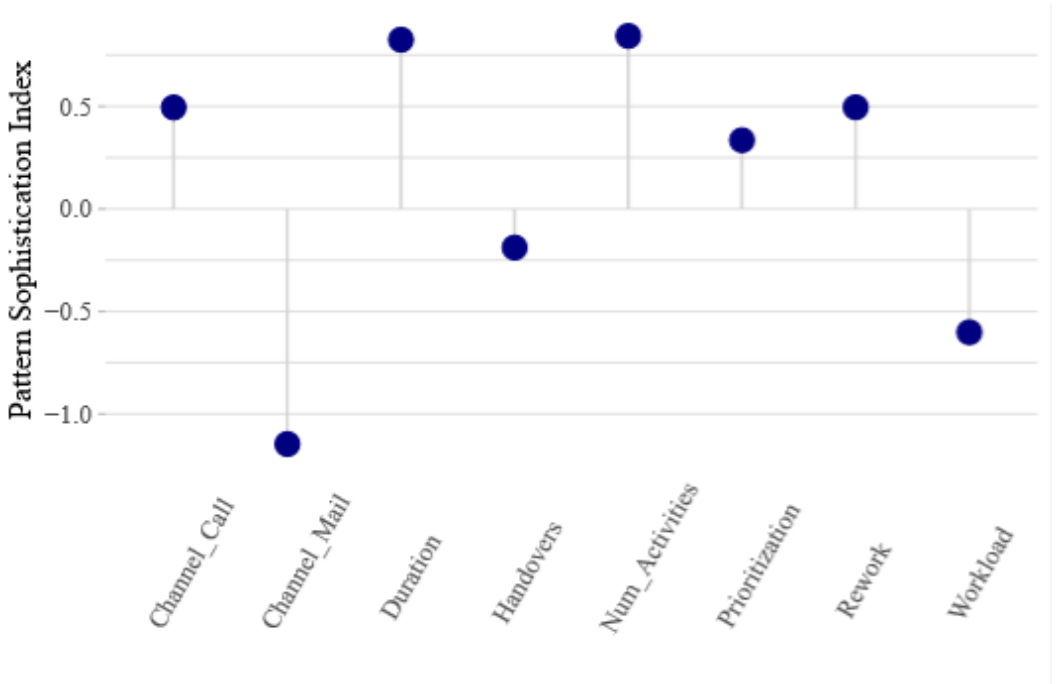
Figure 4. The first two iterations of the pervasiveness of the behaviors demonstrate sporadic and pervasive behaviors



square (sporadic behaviors exhibited by diversified staff), namely the number of activities and the duration of cases. In this illustration, we observe that among resources that utilize a large palette of behaviors, the most top-left ones, are the rarest, thus the ones that could hint best practices. However, to be able to respond to the research questions that we described in the introduction, we have to be able to make the manager aware for the process behaviors that contribute to better performance, so our decision support will advise the manager to be more vigilant on patterns with a higher PSI. Figure 5 illustrates the PSI for every pattern we considered in our example, and in that respect, it recommends that patterns "Number of Activities" and "Duration" have the greatest potential and pattern "Communication Channel: E-mail" has the smallest potential for better performance.

An additional decision support capacity comes from highlighting the most feasible innovation paths, namely the highlighting of the patterns that are more reachable. The relevant premise is that patterns that are more proximate to each other, indicate changes easier to be adopted. More specifically, assuming an employee is already adopting a specific pattern, we could expedite the adoption of

Figure 5. Patterns Sophistication Index for the set of considered patterns



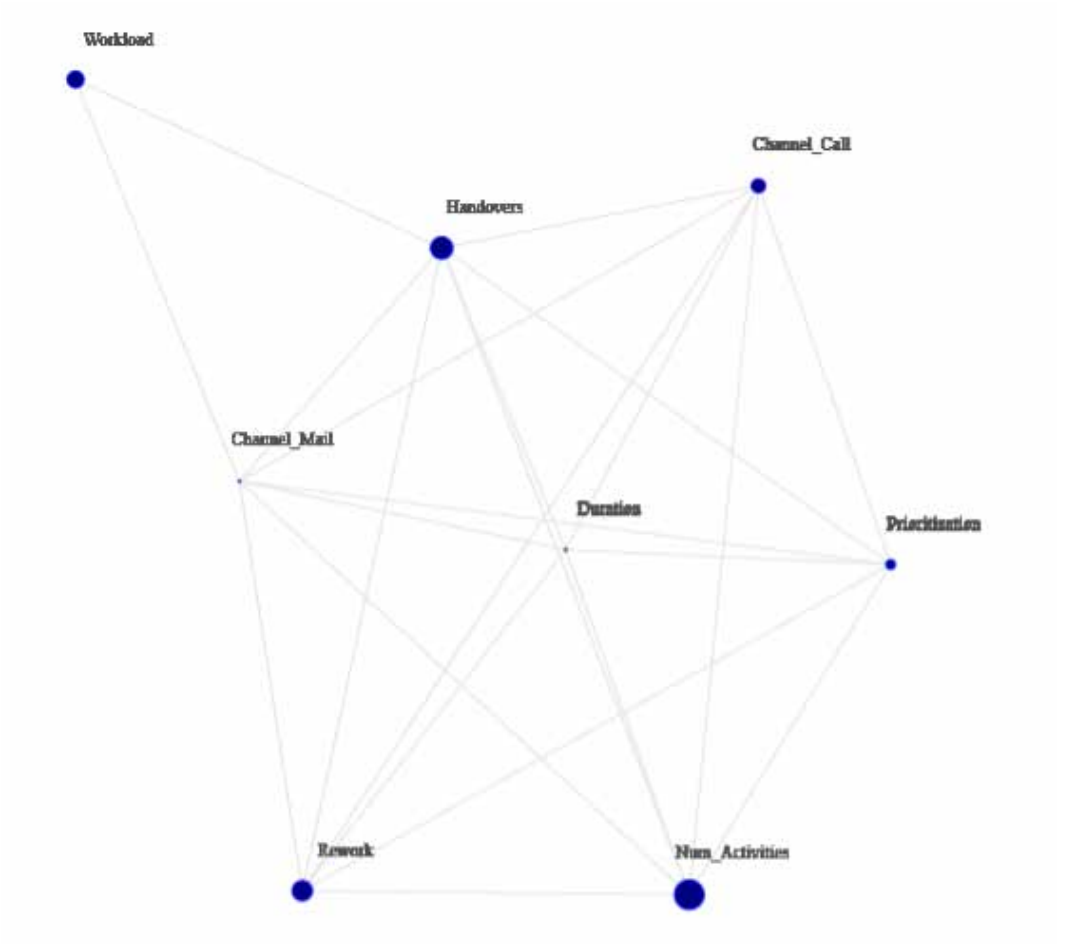
proximate patterns. To this end, we plot in Figure 6 a network of the considered patterns, which illustrates these (more feasible) paths. In that network, the size of a node is proportional to its PSI (i.e., employees would benefit more if they move towards large nodes). For instance, if an employee is adhering to the pattern of "Prioritization", i.e., she/he hold the FIFO principle when performing the process, then it would be more difficult to start pursuing the pattern of "Workload" (i.e., to reduce the number of concurrent cases she/he handles) because there is no direct connection between those two in the network. It has first to develop the capabilities to apply the "Handovers" pattern, and then it will be more feasible to pursue the "Workload" pattern.

The network illustration provides recommendations about the more reachable innovation paths, however, these are not personalized for employees. Such personalized recommendations can be delivered by examining the *opportunity gain* of every pattern for every employee. This kind of information is illustrated in Figure 7. In that chart, every row is dedicated to an employee. Columns represent patterns, and the circles in the cells stand for the opportunity gain values. There is a colored spectrum (blue for large positive values, red for large negative ones) that guides our recommendations for the improvement potentials for each employee (the size of the circle is an additional visual aid). Ultimately, by looking at such a chart, we are able to recommend to each employee what patterns have a greater capacity in improving her/his operations sophistication index, and hence, how the process innovation projects should be directed by the manager.

CONCLUSION

Process Innovation projects are assumed as mainly creative challenges, however, in this work, we challenged the idea that there can be artifacts derived from rational practices that are capable to provide insightful recommendations. By focusing on the *Business Understanding* phase of the relevant

Figure 6. Network of patterns based on their proximities to assess the feasibility of change. Edges with weight less than 0.5 were removed to unclutter the illustration.

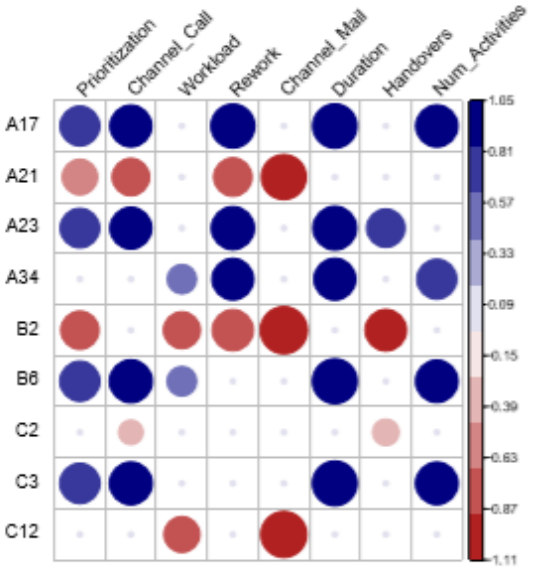


projects, we tried to present an approach to support an organization's decision on what elements of a business process should gain emphasis and priority during a process change project.

We described how a decision model can be formulated for two different situations. In both cases, the triggering object is an event log which registers the execution of a business process, and the expected outcomes have the shape of recommendations for pertinent improvements. In one case, the situation is centered at the level of organizations that perform the same process and strive for a growth upbeat, and in the second case, the situation is centered at the level of human resources that strive for amelioration and self-development.

By defining (distinctly for each case) the set of actors that will get affected by the consequences of the decision, as well as the actors that are influencing the decision; the problems, the interests, and the opportunities introduced by each actor; the resources committed by each actor to each object of her concern; the set of potential actions that the process owners may undertake; the set of points of view from which the potential actions are observed, analyzed, evaluated, compared, we were able to suggest a set of template outcomes that eventually respond to the research questions of promoting and prioritizing process change solutions.

Figure 7. Opportunity gain for resources and patterns. The scale is illustrated by the side color-bar.



The *problem formulation* challenge is a principally conceptual activity within the *business understanding* phase, and as such, any validation arguments can only be defended within the scope of entire projects (i.e., projects that go beyond the business understanding phase). However, we tend to consider that on the one hand, proceeding to projects' completion requires clear problem situations and problem formulations definitions, and on the other hand, this kind of formulations can benefit from the *operations sophistication* manifestation that we advocated in this work, thereupon, the capacity of our approach becomes advantageous and promising.

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