Process Orientation of Information Logistics – An Empirical Analysis to Assess Benefits, Design Factors, and Realization Approaches

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Abstract

Process-oriented information logistics is proposed as a new paradigm aimed at supporting and improving the execution of an organization's operational processes by embedding analytic information and/or analysis capabilities into the context of process execution. The paper describes empirical research providing substantial evidence that organizations can realize benefits by adopting the concept. It furthermore provides insight into the dominant design factors and distinct realization approaches of process-oriented information logistics. This kind of information is particularly useful for the engineering of situational methods aimed at the implementation and advancement of the concept within real-world organizations.

1. Introduction

Providing the right persons with the right information at the right time has certainly become a major success factor for an organization in order to both attain and retain competitive advantage: "With the help of information system technology, a company can become competitive in all phases of its customer relationships" [26]. Information and communication technology aimed at supplying an organization's employees – at all levels, i.e. both operational and managerial – with relevant information in order to stay ahead of its competitors has undergone fundamental changes in recent years. The well-known term "business intelligence" (BI) was coined about a decade ago by analysts of a major information and technology research and advisory firm [2]. Ever since that moment, various players such as consultancies, software vendors, practitioners, and the scientific community have used the term rather vaguely to describe processes and systems dedicated to the systematic and purposeful analysis of an organization and its competitive environment.

In this paper, we will argue that traditional approaches to BI exhibit major shortcomings with respect to lacking integration of information on the one hand and business processes on the other hand [17]. We will outline and discuss a new paradigm that we will refer to as "process-orientation of information logistics". The term "information logistics" (IL) has previously been used by a small number of authors, in most cases apparently synonymous to the data warehousing concept and/or to BI applications [35, 40, 42]. In contrast to this understanding, a few authors have also used the term to refer to information systems dedicated to the field of logistics [32]. However, we will not assume the latter understanding but rather stick to the prevalent definition.

In the context of this paper, we therefore define "information logistics" as planning, execution, and control of information flows within or between organizations [41]. Note that we use the term "information" deliberately to distinguish IL from purely transactional data flows. Information is different from data in the sense that it represents a preprocessed, useable, interpretable form of data [1]. The fact that information has run through preprocessing, integration, aggregation, and quality assurance steps is oftentimes expressed by adding the prefix "analytic".

As it has been said before, a major shortcoming of traditional BI is its inherent data-centricity [13, 38]. The collection, transformation, and integration of data as well as information supply and analysis are commonly isolated from business process execution. The "informational world" and the "process world" are oftentimes not integrated at all, i.e. related activities occur concurrently and oftentimes without any interlinkage. As a consequence, if one regards an organization as a set of well-integrated processes [21], most of the information (not data!) that intrinsically exits within an organization remains either unused or is at most partially used but deprived of its interpretation context.

Furthermore, traditional BI is primarily aimed at supplying employees at the management level of an organization with relevant information in order to support tactical and strategic decision making. However, managerial tasks are less frequently organized by means of processes as this is the case for operational day-to-day tasks.

To overcome the aforementioned shortfalls of traditional BI approaches, concepts like operational BI [9, 33] and real-time BI [37] have been introduced. Although the focus is thereby shifted from the exclusive support of managerial tasks to that of both managerial and operational activities, most of these suggestions still fall short of taking the process perspective into account.

The essential shift towards the process orientation has been discussed intensively in the management literature in recent years. Traditionally, process orientation is aimed at replacing function-oriented separation of work by processes that span both functional and organizational boundaries. As early as in 1993, Hammer and Champy argued in their seminal work on business process reengineering in favor of empowering frontline workers by granting them more leeway for decision making [21] – an important side effect of process organization. In doing so, those in charge of process execution need a "tool" or a "technology", i.e. they need to be granted unrestricted access to all relevant information sources and corresponding analysis tools. A lot of authors from both the management science and the information management discipline have argued similarly [3, 12, 13, 17, 18, 23, 24, 25, 33, 38].

The intended goal of the embedding of analytic information and/or analysis capabilities into the context of operational processes, in this paper denoted as "process-oriented IL", is to support and improve process execution. We explicitly focus on non-automated operational processes, i.e. on business and support processes that require human interaction and decision making. In order to support process execution, it is necessary to harmonize the information supply with the processes' information requirements. Moreover, information must relate to the business objects that are handled by the processes. It must be provided at process runtime, be adequate for the target audience, and be easily accessible, understandable, and interpretable.

We have reviewed both scientific and practitioner-oriented publications in order to assess the state-of-the-art of process-oriented IL. Whilst there are numerous articles published by consultancies, research and advisory firms as well as software vendors, only little work can be attributed to the scientific community.

This paper aims at contributing to the scientific discussion of process orientation of IL by addressing and answering the following research questions:

1. From an organization's point of view, does it make sense to embark on the concept of process-oriented IL? If so, what are the beneficial effects that can be realized by relying on the concept?

2. From a constructivist point of view, what are the dominant design factors of process-oriented IL? Based on these factors, which distinct approaches to process-oriented IL are pursued by real-world organizations?

The remainder of the paper at hand is structured as follows: Section 2 provides an extensive overview of the research design and procedure. Since established knowledge on process-oriented IL is scarce, we have chosen to conduct an empirical analysis. Section 3 is dedicated to the discussion of the first research question. We will explain beneficial effects of process-oriented IL by means of structural equation modeling – a confirmatory analysis technique. The second research question is addressed in Section 4 by means of an exploratory study. Knowledge of design factors and realization approaches of process-oriented IL is particularly useful for the engineering of situational methods [5] aimed supporting the implementation and advancement of the concept within real-world organizations. The results of the factor analysis and subsequent cluster analysis described in Section 4 are discussed and interpreted in the subsequent Section 5. Finally, Section 6 concludes and provides an outlook on further research.

2. Design of empirical analysis

2.1. Data collection and selection

Data for the empirical analysis was collected by means of a written survey that was conducted at a practitioner conference on data warehousing and business intelligence held in Switzerland in late 2006. The conference was attended by some 110 specialists and executive staff who are working primarily in their organization's IT departments or in various operating departments that are closely associated with IT functions.

The questionnaire used for the survey was designed to assess design factors and benefits of process-oriented IL. The respondents were asked to indicate their agreement with several statements on a five-tiered Likert scale in respect of the organization for which they are working. Before being used for collecting empirical data, the questionnaire was revised by experts from both the scientific community and the entrepreneurial world in terms of completeness and comprehensibility. Furthermore, a pretest was carried out and some items were reformulated based on the respondents' feedback. The questionnaire and the projected course of analysis were briefly explained to the conference participants during the event.

52 questionnaires were completed and returned. After consolidating multiple questionnaires submitted by different employees of one and the same organization and after eliminating questionnaires with missing values, 43 valid observations remained that were included in the analysis. These numbers take account of seven questionnaires that were returned only after the conference day. Correspondingly, the overall return rate is about 39 percent.

The interviewed organizations are primarily medium-sized and large companies (some 79% have more than

1’000 employees) from the German-speaking countries. The sectors mainly represented were banking and insurance, software and IT, telecommunication, commerce, and manufacturing (cf. Table 1). Industries represented within the sample by three or less organizations were grouped into a residual category.

The conference participants had adequate knowledge in the fields of business intelligence, data warehousing, and business process management in order to answer the questionnaire. Out of those observations that were included into the analysis, some 80% reported to have advanced or expert knowledge in business process management. The corresponding figures for business intelligence and data warehousing expertise are even higher (both 93%). It seems reasonable to assume that one can arrive at substantial insight into the state of the art of process-oriented IL based on this empirical basis even though the sample size is rather small.

Table 1. Interviewed organizations

Industry sector	Less than 1’000 employees	1’000 to 5’000 employees	More than 5’000 employees	Total
Banking	1 (2.3%)	8 (18.6%)	2 (4.7%)	11 (25.6%)
Insurance	0 (0.0%)	4 (9.3%)	1 (2.3%)	5 (11.6%)
Software and IT	1 (2.3%)	3 (7.0%)	4 (9.3%)	8 (18.6%)
Telecommunication	0 (0.0%)	0 (0.0%)	4 (9.3%)	4 (9.3%)
Commerce	2 (4.7%)	1 (2.3%)	1 (2.3%)	4 (9.3%)
Manufacturing	1 (2.3%)	0 (0.0%)	3 (7.0%)	4 (9.3%)
Others	4 (9.3%)	2 (4.7%)	1 (2.3%)	7 (16.3%)
Total	9 (20.9%)	18 (41.9%)	16 (37.2%)	43 (100.0%)

2.2. Characterization of the data set

In addition to information about demographic characteristics of the respondents themselves as well as of the organizations for which they are working, the data set comprises questions describing the implementation level of IL and process management as well as the implementation level and design of process-oriented IL. These variables can be grouped into four categories:

1. Reliability of supply with analytic information: Analytic information must be provided with high reliability in order to support operational decision making effectively. The data set comprehends items describing whether the reliability of supply with analytic information is comparable to the reliability of operational systems or not. In case those two reliability indicators are unequally distributed, the data set comprehends items indicating the degree to which delays occur during data integration, data analysis, and/or decision making [19] with regard to the supply of analytic information.

2. Design of the embedding of analytic information into process execution: The embedding of analytic information and/or analysis capabilities into the context of process execution can be dealt with in a variety of ways, e.g. synchronously vs. asynchronously with process runtime, via the user interface of a workflow management system vs. via a self-contained user interface, in the form of predefined reports vs. by use of instruments of ad hoc reporting [24], by information being pushed into the process vs. by information being pulled by those responsible for process execution, by exercising information democracy [2] vs. by granting information access rights in a more restrictive way, etc. The items within this category represent the main component of the data set.

3. Approach to process management: Having adopted a mature approach to process management is a necessary prerequisite for the embedding of analytic information and/or analysis capabilities into the context of process execution. In our previous work on the classification of approaches to process management [6] we have identified a list of variables that can be used to determine the maturity of process management (e.g. priority given to process orientation, communication of initiatives pertaining to process management, and role of process managers). Those items are covered in the data set at hand. Furthermore, it comprehends information on the level of attention that the interviewed organizations pay to process orientation of IL

4. Benefits of process-oriented IL: The process orientation of IL involves multiple benefits that take effect both on the inside and outside of the organization. Benefits internal to the organization include acceleration of process execution, improvement of process performance, gain of efficiency, and increase in employee satisfaction with the processes. Benefits external to the organization take account of increases in customer satisfaction, loyalty, and profitability as well as of improvement of services to external stakeholders. The data set comprises information on the level of attainment of these benefits within the interviewed organizations.

Furthermore, the data set comprehends information on the addressees of processes that are supported by embedded analytics as well as on the types of information that are typically made available in support of process execution. These items were not used in the context of the empirical analysis at hand.

2.3. Course of analysis

The goals of the empirical analysis described in this paper are twofold. On the one hand, the potential to realize benefits based on process orientation of IL should be assessed (cf. research question 1). On the other hand, design factors and resulting realization approaches of process-oriented IL were to be identified (cf. research question 2).

A hypothesis-testing analysis (cf. subsequent Section 3) was conducted in order to address the first research question. The hypotheses forming the basis of the causal analysis are the following:

Hypothesis H1: "The level of adoption of process-oriented IL within an organization positively influences the achievement of benefits internal to the organization."

These internal effects of process-oriented IL have been discussed by numerous authors of both scientific and practitioner-oriented articles relating to the embedding of analytic information into processes [11, 18, 25].

Hypothesis H2: "The level of adoption of process-oriented IL within an organization positively influences the achievement of benefits external to the organization."

Similarly to the derivation of the aforementioned hypothesis H1, this relationship has likewise been observed and described in various articles [11, 25, 33]. Furthermore, we have analyzed a total of ten use cases of process-oriented IL by means of case study research and found significant evidence for the emergence of beneficial effects among the customers of those organizations that have adopted a process-oriented approach to IL [4].

Hypothesis H3: "The achievement of benefits internal to an organization is positively associated with the achievement of benefits external to the organization."

This dependency between different kinds of benefits (internal vs. external, direct vs. indirect) is hypothesized and/or explained similarly by various authors and in various contexts [7, 14, 16, 36].

Furthermore, an exploratory analysis (cf. Section 4) was conducted in order to attain scientific knowledge regarding the second research question regarding design factors and realization approaches of process-oriented IL. Unlike hypothesis-testing analyses, the hypothesis-generating research approach is applied when results from antecedent research are scarce and/or when established theory pertaining to the research area in question does not exist. This is the case for design factors and realization approaches of process-oriented IL. Within the scope of the exploratory research, a factor analysis was conducted in order to gain insight into the design factors of process-oriented IL. Building upon the calculated factor values, organizations were classified by means of a cluster analysis algorithm for the purpose of identifying distinct approaches to process-oriented IL.

3. Benefits of process-oriented IL

Benefits that can potentially be realized by means of process-oriented IL were assessed by means of structural equation modeling (SEM). SEM is a particular approach to multivariate data analysis allowing for the formulation, calculation, and testing of causal effects between variables that are incapable of direct observation and measurement [34]. In order to reproduce these so-called latent variables (LVs), measurement models are used that relate each LV with one or more quantifiable indicator variable(s). By means of SEM, the entire structural model consisting of both LVs and indicator variables is tested.

The aforementioned hypotheses H1 through H3 were operationalized and transferred into a structural model (cf. Figure 1). The directed paths that connect the variables of the structural model represent causal relationships.

There are three LVs in our model: the level of adoption of process-oriented IL (POIL), benefits internal to the organization (BINT), and benefits external to the organization (BEXT). Each of these LVs is operationalized by three or four indicator variables using reflective measurement model constructs. The indicator variables and their assignment to LVs are explained in Table 2. Furthermore, the table shows selected descriptive statistics (arithmetic mean and standard deviation (SD)).

So-called goodness-of-fit indicators (e.g. GFI, NFI, CFI, RMSEA) help to assess whether the hypothesized model fits the empirical data or not, i.e. whether the research model should be accepted or rejected [27, 30]. Although the GFI (0.877) and the NFI (0.867) indicate merely marginal fit for our model, the CFI (0.999) and the RMSEA (0.001) are well within the recommended range of acceptability, pointing towards an adequate model fit.

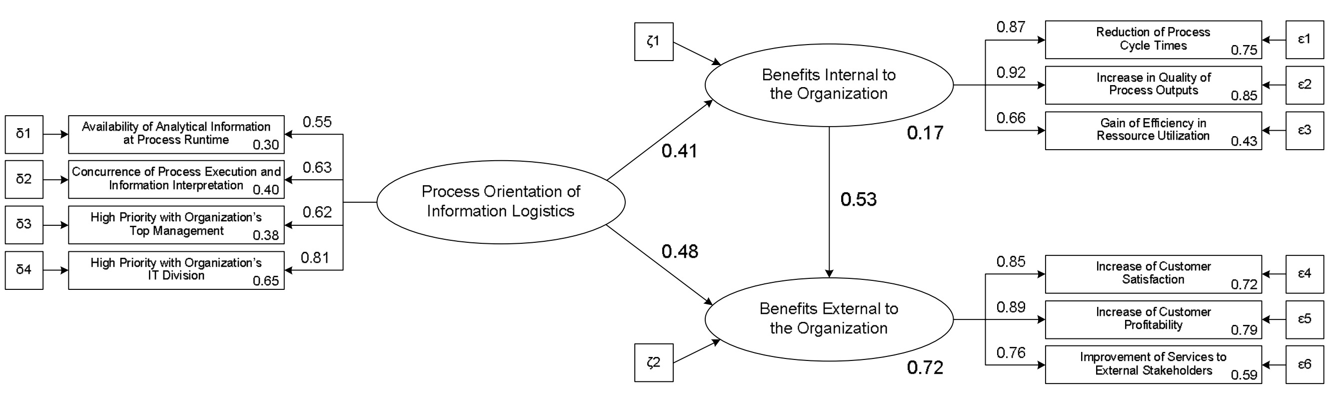

Figure 1. Standardized research model results

The explanatory power of the structural model can be evaluated by looking at the squared multiple correlations of the dependent LVs (i.e. of BINT and BEXT). An exceptionally high proportion of 71.9% of the variation in benefits external to the organization is explained jointly by the level of adoption of process-oriented IL (POIL) and the realization of benefits internal to the organization (BINT). By contrast, the squared multiple correlation of the BINT LV merely amounts to a value of 0.169 which can be interpreted as rather low or at most moderate explanatory power [10]. Only 16.9% of the variation in benefits internal to the organization (BINT) is explained by the level of adoption of process-oriented IL (POIL).

The predictive power of the model is assessed by examining the standardized regression weights between the variables. All path coefficients exhibit positive values (indicating a positive causal effect) and are highly significant (at the 0.05 level for the two effects of POIL on BINT and BEXT, respectively, and at the 0.001 level for all other relationships). Thus, all hypotheses H1 through H3 are proven to hold as expected.

Table 2: Indicator variables

Indicator variable	LV	Mean	SD	References
Analytic information is made available to the employees in charge of process execution at process runtime and is embedded into the context of process execution.	POIL	2.42	1.139	[3, 12, 15, 17, 18, 24, 25]
Data analysis, interpretation of analytic information, and taking relevant action are within responsibility of those employees that are in charge of process execution.	POIL	2.93	0.936	[3, 17]
The embedding of analytic information into the context of process execution has high priority with the organization's top management.	POIL	3.26	1.049	[12, 39]
The embedding of analytic information into the context of process execution has high priority with the organization's IT department.	POIL	3.09	1.019	[12, 18, 39]
By embedding analytic information into process execution, process cycle times are reduced.	BINT	3.19	1.029	[11, 18, 25]
By embedding analytic information into process execution, the quality of process outputs is increased.	BINT	3.33	0.993	[11, 18, 25]
By embedding analytic information into process execution, resources are used more efficiently.	BINT	3.00	0.951	[18, 25]
By embedding analytic information into process execution, stakeholders that are external to the organization can be provided with superior services.	BEXT	2.95	1.214	[25, 33]
By embedding analytic information into process execution, customer satisfaction is increased.	BEXT	2.81	1.029	[4, 11, 25]
By embedding analytic information into process execution, customer profitability is increased.	BEXT	2.86	1.104	[4, 11, 25, 33]

It therefore seems reasonable to conclude that process orientation of IL can help an organization to realize major benefits that take effect both at the inside and the outside of the organization. Furthermore, benefits that are realized within the organization facilitate the realization of external benefits. A recapitulatory answer to the first research question might therefore be that, according to our findings, it does indeed make sense for an organization to embark on the concept of process-oriented IL. A multiplicity of beneficial effects can be realized in this way, and especially external stakeholders can be provided with superior services, resulting in increases in customer satisfaction and customer profitability. These external benefits are both direct effects of the embedding of analytic information into the context of process execution itself as well as indirect effects that are due to internal benefits such as reduction of process cycle times, increase in quality of process outputs, and efficiency gains in resource utilization.

However, it should be noted that the small sample size (n = 43) constitutes a serious limitation of the present analysis. Since the quality of estimates is influenced by the number of model parameters in comparison to the number of observations, we have chosen to keep the number of hypotheses that are to be tested (and thus the size of the structural model) to a minimum. Accordingly, there exist at least two important chances for improving the present analysis: First, our findings should be tested against a much broader empirical basis. Second, the simple research model could be extended, e.g. by trying to explain the current adoption level of process-oriented IL by means of driving factors such as the significance of process orientation and of data warehousing or business intelligence initiatives in the organization, thereby making POIL a dependent LV itself.

4. Design factors and realization approaches

4.1. Principal component analysis

Design factors of process-oriented IL were identified by means of principal component analysis (PCA). PCA is a special technique for extracting a small number of mutually independent factors from a multiplicity of variables. It aims at answering the question of how to summarize all variables that load on a particular factor by the use of a collective term [22].

A factor analysis was performed on a reduced data set covering 14 items. The measure of sampling adequacy (MSA, "Kaiser-Meyer-Olkin criterion") for this reduced data set is about 0.710. MSA represents an indicator for the extent to which the input variables belong together and therefore provides information on whether a factor analysis can reasonably be performed or not. Kaiser and Rice appraise a value of 0.7 or more as "middling", i.e.

the data set is considered to be appropriate for applying factor analysis techniques [29].

Four factors that jointly explain about 64% of the total variance were extracted by means of PCA. Both the Kaiser criterion and the scree plot point to this solution. The resulting component matrix was rotated using the Varimax method with Kaiser normalization in order to improve the interpretability of the items' assignment to factors. The rotated component matrix is depicted in Table 3.

Table 3. Results of factor analysis

Item description	F1	F2	F3	F4
Analytic information is made available in the context of process execution with high reliability.	**0.708**	0.036	0.048	0.003
Analytic information is made available in the context of process execution without data latency or analysis latency. However, decision latency does exist.	**0.438**	0.302	0.364	0.342
Analytic information that is made available in the context of process execution exhibits a level of granularity that is adequate for decision support.	**0.698**	0.101	0.178	0.249
All employees in charge of process execution are granted unrestricted, equitable access to relevant analytic information.	**0.749**	0.072	-0.132	0.288
Employees in charge of process execution are granted access to all analytic information that is relevant for process execution and decision support.	**0.727**	0.430	-0.021	-0.195
User interfaces for accessing analytic information in the context of process execution have user-friendly design and can be operated easily.	**0.507**	0.290	0.388	0.285
Raw data is consolidated for analysis and reporting purposes based on a harmonized enterprise data model.	**0.467**	-0.105	0.614	-0.302
Analytic information is made available to the employees in charge of process execution at process runtime and is embedded into the context of process execution.	0.183	**0.652**	-0.088	0.451
The sequence of activities of a process can be/are adapted as a result of particular analytic information on a single case basis.	0.122	**0.781**	0.317	-0.048
Analytic information is produced and preprocessed by dedicated analysts. Solely information treated in such a way is embedded into the processes.	0.136	**0.647**	-0.090	0.093
Analytic information is embedded into the context of process execution primarily by means of ad hoc queries or instruments of ad hoc reporting.	-0.112	0.154	**0.748**	0.215
Employees in charge of process execution can make simulations, impact analyses, and sensitivity analyses based on the analytic information that is embedded into the context of process execution.	0.015	0.698	**0.537**	0.102
Analytic information is provided at process runtime but is not completely embedded into the context of process execution. Instead, it must be accessed via dedicated user interfaces or reporting applications.	0.070	0.221	0.034	**0.778**
Analytic information is embedded into the context of process execution primarily by means of pre-defined reports.	0.312	-0.165	0.442	**0.645**

In general, an item is assigned to a factor if its factor loading amounts to a value of at least 0.5 [31]. If this threshold value was not met, the item was assigned to the factor on which it loads highest. Contrary to this rule, two items were assigned to another factor (with similarly high factor loadings) due to logical reasons. The mapping of items to factors can be learned from the factor loadings printed in bold face in Table 3. The four design factors of process-oriented IL can be interpreted as follows:

Factor 1: "Excellence in information supply". Seven items were found to have significant impact on the first factor. Their common denominators are quality and/or maturity aspects of information supply. According to our analysis, an organization achieves excellence in information supply in the context of process execution if analytic information is made available with high reliability and without undesirable time lags due to data integration and/or data analysis, if it exhibits an adequate level of granularity, if information access is unrestricted, equitable, and all-embracing, if the user interface design is user-friendly, and if raw data is consolidated for analysis and reporting purposes based on a harmonized enterprise data model, thereby cutting down on the complexity of data transformation and data integration processes and thus reducing the likelihood of nonconformance and errors.

Factor 2: "Integration of analytic information into process execution". The second factor is made up by three items that essentially account for the integration of information supply and process execution. Our findings suggest that the level of integration depends on the simultaneousness of information supply and process execution, on the way the information is embedded into the context of process execution, and on the way information is produced and preprocessed before being made available to those in charge of process execution. Furthermore, the level of integration rises if workflows can be and/or actually are adjusted due to particular analytics on a single case basis. In our opinion, this is a key characteristic of process-oriented IL.

Factor 3: "Utilization of advanced instruments for information access and analysis". Two items exhibit high loadings on the third factor. Both items describe viable ways that organizations can adopt for accessing and presenting analytic information: ad hoc queries and sophisticated analysis applications that allow users to make simulations, impact analyses, sensitivity/what-if analyses, and the like. Those two groups of instruments for information access and analysis are considered to be advanced tools [8, 28]. Therefore, the third factor describes a particular approach to information access and analysis. The higher this factor value, the higher is the utilization of advanced instruments for information access and analysis within a particular organization.

Factor 4: "Utilization of basic instruments for information access and analysis". Similarly, two items covering more basic instruments for information access and analysis were found to have substantial impact on the fourth factor, describing the utilization of standard reporting tools. Standard reports can either be accessed via a self-contained reporting application or be embedded into the user interface of the workflow management system. Standard reports, ad hoc queries, and advanced applications are considered to constitute a continuum of sophistication in information access and analysis [28]. It therefore appears reasonable that the use of basic and advanced instruments was split into two independent factors. Organizations can adopt any one or even both of these two ways of information access and analysis.

4.2. Hierarchical cluster analysis

In order to identify distinct realization approaches of the process-oriented IL paradigm, cluster analysis was applied on the data set, using the calculated factor values of the four previously identified factors as input data. The Ward algorithm and the squared Euclidean distance have been used as fusion algorithm and distance measure, respectively. The Ward algorithm is a very popular hierarchical fusion algorithm that is widely accepted and has been used extensively in various disciplines. In contrast to the so-called linkage approaches that assign observations to clusters while minimizing inter-cluster distance measures, the Ward algorithm builds categories by minimizing the clusters' variances [20]. The so-called dendrogram provides a graphical representation of a hierarchical clustering process. It supports the determination of the number of clusters that should be built for a particular clustering problem. In the context of the present analysis, this heuristic suggests that the construction of five clusters (representing five distinct realization approaches of process-oriented IL) is the most reasonable solution.

Table 4 exhibits the standardized arithmetic means of the four calculated factor values for each of the five clusters. Based on this information, the clusters can be characterized as follows:

Cluster 1: Those 14 organizations that were grouped into the first cluster are characterized by high levels of excellence in information supply but low levels of integration of information supply and process execution. Both basic and advanced instruments for information access and analysis are used. We refer to organizations having adopted this realization approach as "information experts".

Cluster 2: The second cluster is made up of solely two organizations that exhibit high levels of both excellence in information supply and integration. They are furthermore characterized by exclusive usage of basic instruments for information access and analysis. Because of the small number of organizations that have been grouped into this cluster, we interpret these to be "outliers". It seems very unlikely that organizations having adopted a rather mature approach to process-oriented IL would otherwise rely solely on basic instruments for information access and analysis.

Cluster 3: A total of 13 organizations were combined in the third cluster. These organizations exhibit high levels of integration of analytic information and process execution but low levels of excellence in information supply. Both basic and advanced instruments for information access and analysis are applied. Organizations having adopted this realization approach are referred to as "integration experts".

Cluster 4: The fourth cluster merges ten organizations that are characterized by high levels of integration and low levels of excellence in information supply – just as those that make up the third cluster. By contrast, the organizations that were grouped into the fourth cluster majoritarianly apply advanced instruments for information access and analysis. Organizations that have been assigned to this realization approach are designated as "advanced integration experts".

Cluster 5: Four organizations were grouped into the fifth cluster. They are characterized by high levels of excellence in information supply and equally high levels of integration of information supply and process execution. Furthermore, they mainly make use of advanced instruments for information access and analysis. These organizations seem to have adopted the most mature approach to process-oriented IL. We therefore denote organizations assigned to this realization approach as "process-oriented IL experts".

Table 4. Results of cluster analysis

Cluster description	F1	F2	F3	F4
Cluster 1 ("information experts")	1.118	-1.311	0.022	0.171
Cluster 2 ("outliers")	0.622	0.422	-1.494	0.451
Cluster 3 ("integration experts")	-1.420	0.238	0.255	0.928
Cluster 4 ("adv. integration experts")	-1.262	1.129	0.316	-0.182
Cluster 5 ("process-oriented IL experts")	0.653	0.507	0.327	-1.487

The five realization approaches to process-oriented IL can be arranged in a two-dimensional matrix with "excellence in information supply" (factor 1) being depicted on the vertical axis and "integration of analytic information into process execution" (factor 2) being displayed on the horizontal axis. For both dimensions, high and low parameter values (i.e. high and low levels of implementation) are distinguished. Thus, the classification scheme resembles a 2x2 matrix. Within each of the four segments, we furthermore differentiate between the utilization of advanced (factor 3) and/or basic (factor 4) instruments for information access and analysis. If the organizations that were grouped into one cluster solely rely on advanced instruments, the cluster is depicted at the upper left side of the respective matrix segment. On the contrary, if a realization approach is characterized by exclusive utilization of basic instruments, the cluster is depicted at the lower right side of the respective matrix segment. Clusters shown in the middle of a segment represent realization approaches that use both advanced and basic instruments for information access and analysis. Figure 2 exhibits this classification matrix.

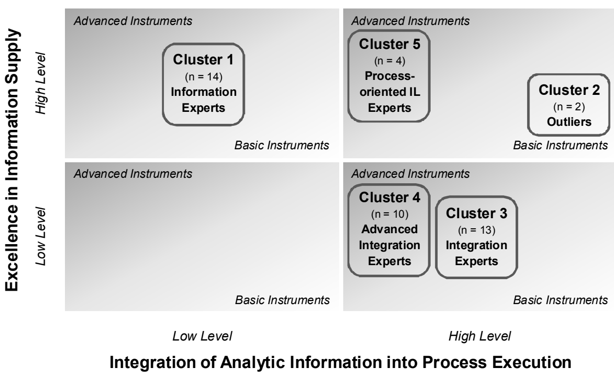

Figure 2. Realization approaches of process-oriented information logistics

5. Discussion and interpretation

We have identified four relevant realization approaches of processes-oriented IL in Section 4. For the reasons given above we will not consider the outlier cluster in the following discussion any more. The cluster analysis indicates that all organizations that have participated in the survey (except for the outliers) have already realized high levels of factor 3 ("utilization of advanced instruments for information access and analysis"). Therefore, factor 3 does not represent an adequate criterion to differentiate organizations regarding their maturity of process oriented IL. Furthermore, factor 3 can be interpreted as a more mature approach when compared to factor 4 ("utilization of basic instruments for information access and analysis") (cf. Section 4.1). Despite this coherence, both factors can be considered as independent design factors due to their possible coexistence - which is indeed often realized. We will therefore argue that the occurrence of different levels of factors 3 and 4 has no impact on the maturity of process-oriented IL. Consequently, neither factor 3 nor factor 4 is regarded as a distinguishing criterion in the subsequent discussion.

However, factors 1 and 2 are the dominant criteria to determine the maturity of process-oriented IL. Moreover, both factors represent distinct directions of development of process-oriented IL. As shown in Figure 3, low values of both factor 1 ("excellence in information supply") and factor 2 ("integration of analytic information into process execution") result in low maturity of process-oriented IL. Medium maturity is reached if any one of the two factors shows high parameter values. Finally, high parameter values (i.e. realization degrees) in both factors are equivalent to high maturity of process-oriented IL.

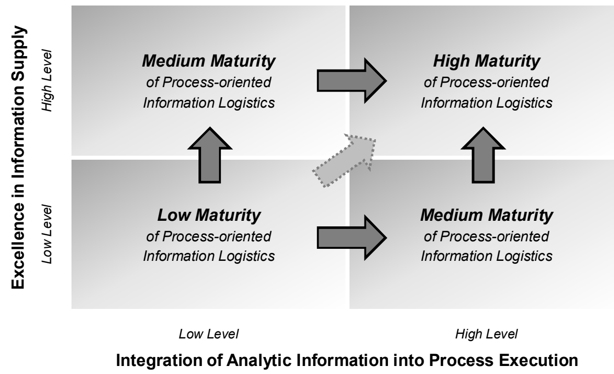

Figure 3. Maturity levels of process-oriented information logistics

According to the classification resulting from our cluster analysis, most organizations are currently at a stage of medium maturity – either by realizing excellent information logistics (cluster 1 in Figure 2) or by a comprehensive integration of analytic information into processes (cluster 3 and 4). No organization remains at the stage of low maturity. On the other hand, only a few organizations (cluster 5) have addressed both aspects of process-oriented IL so far. We will discuss the relevant clusters in detail in the following.

Cluster 1 is characterized by excellent information logistics, i.e. up to date, relevant, reliable, consolidated information is provided in right-time and in a user-friendly way. The information can be accessed and analyzed via different instruments, i.e. either by use of advanced or basic techniques. Information logistics is regarded as a key success factor in those organizations. It can be assumed that such an excellence and engagement is mainly pushed by organizational units responsible for data warehousing and/or business intelligence which are in many organizations part of the IT department. However, the excellent information supply is still focused on traditional use context (data-centric BI, cf. [13]) and is so far not or barely used in processes. It can be assumed that the organization's IT has not been able yet (or is not interested in) pointing out the benefits and potentials of expanding the use of analytic information in processes to the end users (i.e. to the business). Surveys like [17, 18, 24, 25] confirm our findings that many organizations still rely on data-centric BI and disregard the potentials of process-oriented IL.

On the other hand, there are a number of organizations that already integrate analytic information into processes (cluster 3 and 4). Apart from the comprehensive use of different analyzing instruments (advanced and/or basic, focusing on the former ones) an appropriate infrastructure of information logistics which satisfies the requirements of excellent information supply (cf. above) is still missing. Process management and execution mainly reside within responsibility of an organization's business units. It is therefore reasonable to assume that the business units have already identified the need for and the potentials of integrating analytic information into the processes. They might somehow have implemented solutions to get the information they need – however, an appropriate and comprehensive information supply provided by the IT department has not yet been realized.

As of today, at least a few organizations have realized process-oriented IL that can be regarded as mature (cluster 5). By the way, these companies mainly use advanced instruments for information access and analysis.

The results of the cluster analysis confirm the assumption that there is not only one single approach to the implementation process-oriented IL. According to the dominant design factors "excellence in information supply" and "integration of analytic information into process execution" the maturity of process-oriented IL can be increased either by improving information supply or by integrating analytic information into the context of process execution. In order to reach high maturity, both issues have to be addressed (in parallel or in succession). It also means that either information logistics or process management can be used as the starting point for process-oriented IL initiatives. Accordingly, process-oriented IL should and must be pushed by both IT and business units – as both are primarily responsible for IL and process management, respectively. Consequently, successful and comprehensive process-oriented IL needs involvement and commitment from various stakeholders within an organization.

The indicators which have significant impact on the design factors (cf. Table 3) also help to identify the issues that should be considered when addressing the corresponding design factor. For example if an organization in cluster 3 or 4 (high level of integration of analytic information and process execution but low maturity with respect to excellence in information supply) seeks for excellent process-oriented IL, it has to make sure that analytic information is provided with a level of granularity that is adequate for decision support (cf. Table 3).

These examples demonstrate how the results of the principal component analysis (Section 4.1) and cluster analysis (Section 4.2) can be used to formulate generic strategies for achieving mature process orientation of IL.

6. Summary and outlook on future work

In the context of the paper at hand, we have proposed process-oriented IL as a new paradigm aimed at supporting and improving the execution of an organization's operational processes by embedding analytic information and/or analysis capabilities into the context of process execution.

Our exploratory analysis and the subsequent discussion have shown that "excellence in information supply" and "integration of analytic information and process execution" are the primary design factors and drivers of process-oriented IL. Taking the two secondary design factors "utilization of advanced instruments for information access and analysis" as well as "utilization of basic instruments for information access and analysis" into account as well, four distinct realization approaches (and one outlier cluster) of process-oriented IL were identified.

As a result of the findings presented in this paper, two broad research opportunities exist: First, the maturity levels and hypothesized adoption trajectories of process-oriented IL could be validated by broadening the empirical basis of the exploratory analysis. Secondly, situational methods that account for the different realization approaches that have been identified in our paper could be engineered and evaluated. With the help of those situational methods, the implementation and advancement of the concept could be supported in an efficient and effective way.

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