Which Business Information Do Decision-Makers Need at Work? — Towards a Classification Framework

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***Abstract*—Having the right information at hand is crucial for decision-makers. To support decision-makers with adequate IT systems, it is necessary to know which type of information decision-makers need at their workplace. Therefore, our research goal is providing a framework that structures the information needs for decision-makers in large organizations. In this paper, we conduct a structured literature review to find different classifications of information needs. We combine and integrate three well-known frameworks. Our resulting framework consisting of the dimensions scope, time-orientation, abstraction and presentation is evaluated in eleven interviews conducted with managers. This shows that the information categories found in literature can be mapped to the actual information need found in practice.**

***Index Terms*—Business Information, Management Information Systems, Information Need, Decision-Makers, Framework**

I. Information for Decision Makers

For decision-makers in large organizations, having the right business information is crucial [1]. On a day-to-day basis, decisions must be made both on strategic and operative levels in the organization. The concrete information, a decision-makers needs, may vary widely and depends on the decision-maker's positions and the industry of their company [2]. Therefore, it is obvious that a marketing manager in a retail company requires different information than a supply chain manager in automobile company. From the perspective of the Information Systems (IS) discipline, this information has to be provided in an adequately designed Management Information System (MIS). As such, the structure of the information required by decision makers is important to enable an effective design of IT artifacts.

Currently, both managers and software developers mostly focus on one industry. This leads to MIS which are closely targeted at a certain market, like MIS for the health sector [3], MIS for crisis management [4] or other specific purposes. MIS have been discussed intensively in academic literature in the 70s, where the term MIS first arose. Researchers have discussed the user of MIS [5], their attitude towards MIS [6] as well as the value of MIS perceived by the users [7]. Furthermore, architectures for MIS have been developed, providing the integration of different departments and roles in large organizations [8]. Although there is several research about the identification of information needs and the satisfaction of information needs e.g. [9], there is rather few research about the general structure of information that decision-makers need [10]. More recent publication tend to focus more on characteristics of the information quality [1], or on the decision task itself [11].

Therefore, we pose the research question *how can data in MIS be structured adequately, to reflect management-relevant information from different company-wide sources in a cross-industry scenario*. To answer this research question we structure our work into two research objectives. First, our goal is to identify categories of management-relevant information from a literature analysis and, second, our goal is to validate these categories in interviews lead in organizations across different industries. Consequently, we develop a framework to structure management-relevant information in a MIS. Such a framework can be used to structure information needs in the development process of an adequate MIS.

Our research method and literature analysis are presented in chapter 2, chapter 3 presents our findings and, therefore, contributes to our first research objective. In chapter 4, we present our empirical study with interviews we have conducted, which contributes to our second research objective. We discuss our work regarding future evaluation and application in chapter 5. Our paper concludes with chapter 6, where we summarize our findings and provide an outlook on future research.

II. Research Method

To gain insights about the different information needs, we conducted a structured literature review according to vom Brocke et al. [12] and Webster & Watson [13]. Following Cooper's taxonomy [14], our goal is the integration of different findings from the literature. Due to the high interdisciplinary of the field and the use of different terms in different disciplines like business administration, IS and psychology, we decided to do a representative review, instead of an exhaustive, which results in a broader overview. The literature search was conducted in September 2018 and included all indexed publications up until then. In total we found 131 paper. The

search terms were grouped trough continues iteration in four groups.

In our search query, we connected the different groups, so that our search query contains at least one search term from each group from the first two groups and at least one from the last two groups, e.g., (”Information demand” or ”Information need”) and (”Category” or ”Characteristic” or ”Classification”) and (”Decision support system” or ”Business intelligence” or ”Executive information system”). We used Scopus[1] and Google Scholar[2] and as our search engines. Initially, we also used Springer Link and ScienceDirect but due to similar results to Scopus we decided to focus on Scopus. Our search revealed a high number of papers from the health and medicine discipline, which focused on systems storing data of patients and surgeries. Since we consider such systems as operative data storage and not as MIS, we have excluded these papers from our search by excluding the “health” and “medicine”. Our search terms are depicted in Table I. Furthermore, we used forward and backward search to find additional papers.

III. Structure of Decision-related information

The existing literature is more focused on the decision process and not specifically on information needs. Different models about the process of identifying information were, for instance, presented by Rockart [15]. However, the information needs of decision makers are fundamentally related to the corresponding decision [16]. The foundation of this connection was developed by Gorry and Scott-Morton [17] in their framework which is one of the most cited articles in IS literature [18]. Besides their famous Decision/Control grid, they also defined seven different information characteristics as an integral part of their MIS framework:

- Source: Largely internal – External
- Scope: Well defined, narrow – Very wide
- Level of Aggregation: Detailed – Aggregate
- Time Horizon: Historical – Future
- Currency: Highly current – Quite old
- Required Accuracy: High – Low
- Frequency of Use: Very frequent – Infrequent

Gorry and Scott-Morton claim that these information characteristics are dependent on the level of management which was defined by Anthony [19] earlier. This relationship was later empirically confirmed [18]. Although, it includes the well-known framework of Gorry and Scott-Morton, many studies used different forms of information classification. Most of the empirical literature focuses only on one characteristic of information. The most common form of classifying information is the subdivision in internal and external information [2], [16], [20]–[24] However, this subdivision is not well defined, so different authors count different information towards internal information, e.g. [25], did not include sales in internal information, while others include them [20].

[1]https://www.scopus.com/

[2]https://scholar.google.com/

Many papers only focus on specific industries or functions [26]–[28], like production or sales, and include therefore less abstract and more specific categories of information, e.g., material prices or inventory levels [29]. A few authors also use different categories, e.g., Marx et al. [22] identified four different scopes of information in the literature, which are financial vs non-financial data, internal data vs external data, task-related vs individual data and information clusters for “managing a company”. Especially the difference between financial and non-financial data can be found in different other publications, particular in accounting literature [28], [30] Other authors combined different aspects of the Garry-Scott-Morton-model, leading to the categories Scope, Timeliness, Aggregation, and Integration [21]. In that paper, the information characteristics are connected to the perceived usefulness of MISs.

Different approaches were made to include also the presentation or the medium in the information needs [16]. With technological progress and new mediums emerging, like web-based and mobile devices for instance, the medium and presentation become more important [31], [32]. Additionally, Big Data and specialized information systems enable future prediction at lower levels of management and even in operational systems [33]. However, the categories are still applicable and used in literature. Therefore, we propose a model that includes different information characteristics from the Garry-Scott-Morton framework but extend it by other characteristics we have found in the literature. We still included Anthony’s categories of managerial activity in our model as an own criterion of information.

To improve simplicity and understandably, we followed the approach of [21] and combined different types of categorization (see Table II). Our model adopts the first dimension of their model: *Scope*. This includes similarly categories about the location of information: internal vs. external, functional area, and the level of management and the type of data: financial vs. non-financial. The next dimension is the *time-orientation* of the data: ex-post vs. ex-ante, the currency and the frequency of use. The third dimension is the *level of abstraction*. This can be measured by the level of aggregation and the required accuracy. The fourth and last dimension is the *presentation* which embraces the medium (PDF-file, printed paper report, Excel-file, presentation, etc.) and the forms of visualization used (such as the use of highlighting and charts).

IV. Empirical Study - Interviews

Our information categories identified from literature (cf. Table II) has been evaluated in an empirical study, where we have lead interviews with managers from different organizations.

A. Interview Setting

We have interviewed eleven people in four different companies. To better understand the information needs and methods, we interviewed decision makers from the upper management as well as other participants in the decision making process. We focused our interview study on information needs and the

TABLE I
SEARCH TERMS

Information demand	Category	Manager	Decision support system
Information need	Characteristic	Executive	Business intelligence
	Classification		Executive information system

TABLE II
DIMENSIONS FOR STRUCTURING INFORMATION NEED.

Scope	*Time-Orientation*	*Abstraction*	*Presentation*
Internal vs. external	Ex-post vs. ex-ante	Aggregation	Medium
Functional area	Currency	Required accuracy	Visualization
Level of management	Frequency of use		
Financial vs. non-financial			

gathering of information. Depending on the company, different positions are responsible for the collection and preparation of the information. Usually, it is a strategic accountant, an IT employee or a similar position [34]. These people are well suited for an interview because they work everyday with new information needs provided by the management and individual decision maker. We only focused on large enterprises with over 1000 employees with a more sophisticated reporting structure. We interviewed eleven different people in four companies in Germany. The municipal utility and the wholesale company were private companies and only operating in Germany. In contrast, the retail group and the automotive companies were publicly-listed international companies. The companies belong to different industries, ranging from mixed conglomerates to automotive companies and retail groups. The interviewees, their positions and departments, as well as the sector of the organization, are depicted in Table III.

The used reporting systems and Business Intelligence (BI) software used in the different organizations were not homogeneous. All interviewed companies used multiple systems for their reporting, depending on the information needs. One company used only self-developed software for their core business systems. The other three companies used mainly customized commercial of-the-shelf software, complemented with special niche market software tailored to the specific industry.

Three interviews were conducted in a joint setting, i.e., two people were interviewed together. This was the case, where the actual decision maker (upper management) had an assistant who was concerned with data collection and preparation. Eight interviews were conducted in the respective company's office in a face to face setting. Three were conducted via telephone. The language of all interviews was German and we translated all relevant quotes for this paper to English. The length of the interviews varied from 25 to 52 minutes.

We used a semi-structured interview to gain a broader understanding while still getting comparable interviews. In context of information systems, this technique is often used in requirement analysis and similar fields [35]. This was necessary because the different backgrounds of the interviewed people required different wording and explanations. Additionally, this open approach provided a more open platform and allowed us to adapt to the different "language" used in the different areas. To still ensure comparability, we used a guideline to structure our interviews.

B. Analyzing the Interviews

For analyzing the interviews, we have first transcribed all interviews. Based on these transcriptions, we have evaluated the interviews regarding two aspects.

For the first research objective, we have already developed a model for the structure of decision-related information (see chapter III), which we are now comparing to the information categories found in practice. Therefore, we used a selective approach and started with the existing model which we extracted from the literature. To prevent biased answers, we did not ask the interviewees directly for the information need categories they used. Instead, we asked about the different processes for fulfilling the information needs. We considered a differentiation as found when one of the following two conditions were fulfilled:

- The interviewee explicitly talks about different categories of needs, or different categories of decision.
- The interviewee mentions that the company uses a different process or different systems for the fulfillment of a information need.

Additionally, we were looking for information challenged and common practices among our interviewees. For the challenges, we used a bottom-up approach based on the grounded theory [36]. After we found the individual challenges, we started to paraphrased the sections and abstracted from the individual companies and cases.

C. Information Categories in Practice

The differences from the interviews could be mapped to our model from the literature. Although, we found an additional

TABLE III
OVERVIEW INTERVIEWS

Int. No.	*Position*	*Department*	*Sector*
1	Strategic Accountant	Accounting	Retail Group
2	Project Member	IT - Business Warehouse	Retail Group
3	Project Lead	IT - Database Development	Retail Group
4	COO/CTO	Management	Municipal Utility
5	Leading Strategic Accountant	Strategic Accountant	Municipal Utility
6	HR - Lead	Human Resources	Municipal Utility
7	Assistant HR	Human Resources	Municipal Utility
8	CEO	Management	Wholesale
9	Leading Strategic Accountant	Accounting	Wholesale
10	CRM Manager	Marketing	Automotive
11	Development Engineer	Development	Automotive

category: *push vs. pull*. We were also able to identify five different general challenges faced by decision makers.

All companies differentiate between several information needs. We mapped their described differentiation with our categories found in the literature (see Table II). Often different processes or software are used to fulfill the different information needs. The information needs highly affects the choice and usage of the MIS [1].

Every company distinguished between different information needs. Often, different processes were used to fulfill the information needs. In four cases, even different systems were used. Additionally, every company customized its reports for different groups of users. In some cases, different user groups required completely different processes. Some decision makers preferred to get the information and reports at specific intervals, other preferred to only get information if some major changes occur. Other decision-makers facilitated their skills to explore the new information by them self or ask others for specific information (see below).

Level of Management. This category was found in every company. However in two companies it was only distinguished between two different levels: strategic and operational, instead of the three levels proposed by Anthony [19]. The CEO of the wholesale company only differentiated between operational and strategic decisions: ”There are two types of decision situations: the standard reporting, where you look in a report and get some information [...] and if a have a concrete decision which is bigger, [for example] where you have to build a new warehouse” (Int. No. 8).

The COO/CTO of the municipal utility company had a similar differentiation. In a strategic decision, the company used a completely different process: ”Strategic decisions, for example: the start into new business areas? So, there we don’t use standard reports, because there we only try to model the current business [... for strategic decisions,] we use more like a project form” (Int. No. 4). A similar distinction was done in the retail group. In this case, the whole department was only responsible for decisions and information needs on a operational level (”The focus is more on operational questions”, Int. No. 2).

Frequency of Use. We also observe that the people, who prepare the data, handle information needs different if they are requested more often. Some information are only needed for a specific one-time decision. Whereas, other information are needed daily. However, this difference is not fixed and can change over time. The one-time request can convert to periodically reporting (“if there is a repeated need, we’ll try to analyze these things and include them into our standard reports.”, Int. No. 2)

Functional Area. Even for the same decision task, different information needs exist. We observed that employees working in different departments have completely different needs, although the decision task is similar (“somebody controlling in the accounting has a completely different view”, Int. No. 2)

Medium. In all interview company multiple mediums were used. Whereas, the previous categories mostly depend on the position and department, this category is highly individual. Even for the same question in the same department, different mediums were used: “It is really individual, some people like that but I’m somebody who is really paper orientated” (Int. No. 1). Some interviewees preferred interactive reports, other wanted emails or paper reports. However, it was not solely a individual decision, as it depended on many different factors. The interviewed HR department of the utility company only decided to only present their data in a face-to-face meeting. They hold a presentation, tailored to specific department, once or twice a year. Their presentations are . They prefer this medium for the following reasons:

- To compare the numbers and benchmark them in the company and to competitors
- To give an overview over different action
- To prevent that the information are not considered.

The work-load of managers was mentioned as a reason for choosing a certain medium: ”You have to imagine the view of

a manager. They have a lot topics to work on every day [...] We have the experience that, in doubt, if lucky, that they only check it once and then file it" (Int. No. 6). Similarly, timing issues were mentioned as a reason to choose a certain medium (e.g., printed paper): "You can go directly in a dialog if the traffic lights switch to yellow. For example: the absenteeism rise - you can then immediately start an exchange, about past experience, what you learned, and what actions you can do" (Int. No. 6).

Internal vs. External. This category was less important for the interviewed managers, because the most important data was internal. Only the the CRM manager in the automotive company and interviewees in the municipal company used information from external sources (about competitors, markets) in a larger extent.

Financial vs. Non-financial. Financial data has specific attributes which differentiated them fundamentally to other types of information. If it is used for an external purposes, it has to follow specific accounting standards (IFRS, US-GAAP, etc). Therefore this data is legally required to be exact. We observed that this leads to better data quality for financial data compared to non-financial data: "I trust the financial data. We often have more implausible data in the area of operating figures for example volume" (Int. No. 2). The differences can also be found in the organisational structure. In many of the companies, the financial accounting was a separate entity. However, the data was shared between the different entities.

Ex-post vs. Ex-ante. We could confirm this category in three interviews. Future ex-ante (foretasted or target) values have complex properties. Historic values are known and in theory no uncertainty exists. Future values, on the other hand, are not known yet and it is not clear, to which degree these values will meet the future reality. There is also a small difference between target values and forecasted values. Two companies used a complete different systems for the planning and forecasting values with its own database and different reporting capabilities, even though both are fully integrated: "It's about providing planning support. So the planning-system is fed with actual data from SAP, so that those who need to plan have them to, so we can plan accordingly" (Int. No. 4). This municipal utility company has an own team only for planning and forecasting purposes.

Aggregation. For many decisions the right level of aggregation is important. Usually, single transactions are not interesting for decision makers. Instead they are interested in getting an overview and seeing the whole picture. Therefore aggregated data is needed. We observed many different forms of aggregation. It depends mostly on the decision, how the data is aggregated. Even for the same decision different aggregations could be useful. Aggregation on a higher level is easier to get. However, a finer structure could provide additional useful information: "In the past, we had a more refined structure, where we planned down to individual fares. That was a much larger number and the planning granularity was much larger [...] it's nice when you can analyze it more precisely in the plan/actual comparison on a much smaller level, but it is an incredible amount of work" (Int. No. 4).

Required accuracy. Data validity and data quality was discussed in every company. Although, we observed that not always the highest accuracy is necessary. Instead a "sufficient" accuracy is needed: "I'm not a bookkeeper who is trying to find the last cent. I only look if I would have made a different decision if the data was different. So, we don't search for the last hundred Euro" (Int. No. 9).

In one interview it was claimed that in bigger companies reporting is seen as high priority although it does not generate any business value: "Reporting is not an end in itself, so that one says: The bigger a company is, the more it is understood as an end in itself" (Int. No. 9). However, low accuracy is often a problem as well. In fact, only in three interviews unnecessary high data quality was mentioned. In contrast five interviews mentioned problems with insufficient data quality, for example: "As a result it has to be stated that better data quality increased cost and leads to a conflict of goals between the high data quality and low costs" (Int. No. 9) and "Data validity costs money. The more exact data you want, the more you have to impose obligations onto people in the operational business: to ensure that are cleanly handled. [...] The last number after the comma don't have to be true one hundred percent" (Int. No. 8).

Visualization. Graphical representation was an important topic in our interviews. Often the information need required data to be in specific graphical representation because a quick overview is very important ("It was really colorful and you could see everything quickly", Int. No. 5).

Raw data alone is less useful for the interviewed decision makers, because it takes more time to draw conclusion from it. Because managers do not have a much time, gaining a quick overview is crucial. It allows that decision can be made faster and without additional support ("We also had graphics which can be used to solve problems individually", Int. No. 5).

Push vs. pull. Besides the information categories identified in the literature, we also found a new category in our interviews. For some manager it is necessary to push new information because they simply do not know that there is new information that require their attention. They have access to so much data that important information can get lost, for example: "The decision makers have so much to do that they don't have the hours to click through the reports. They need a medium or impulse: 'Man, I need to think about this'" (Int. No. 8).

The push category can be described as an information need which exists, but where the affected person is not aware of. Consequently, we extend our model to five categories to include this newly found category. The resulting framework is depicted in Table IV.

D. Information Challenges and Common Practises

We grouped the different individual challenges into five different generalized categories:

- Technical skills required
- Low data quality

TABLE IV
FRAMEWORK FOR CLASSIFICATION OF INFORMATION NEEDS.

Scope	*Time-Orientation*	*Abstraction*	*Presentation*
Intern vs. extern	Ex-post vs. ex-ante	Aggregation	Medium
Functional area	Currency	Required accuracy	Visualization
Level of management	Frequency of use		Push vs. Pull
Financial vs. non-financial			

- Missing overview over reports
- Slow software
- Large amount of manual work

Technical Skills. Often special technical skills are required. In particular, when ad-hoc queries in the data warehouse are necessary ("you need some SQL skills", Int. No. 9). These skills could also be learned in the company. In two companies, the accountants learned these skills through workshops provided by the company.

In other interviews (Int. No. 6,7), the department solved this problem by creating a new position in their department. So the decision makers inside this department do not have to touch any systems. Instead, they formulate a request and handle this request to the person in charge. One company outsourced the development for a BI Software (a scorecard analyzer). However, after a few month in use the system was abolished because of the high number of recurring changes and the resulting low flexibility. "We had a [SAP] BW application, web-based. It looked good but had the disadvantage that we always had to talk to the company, and they changed the report. It took some time and was not good. [...] We must report quickly and flexible" (Int. No. 5). An other executive describe a similar situation: "Previously we outsourced the know-how to a contractor, our IT supplier. But currently you can feel the backwards roll and now there is an internal department for that which only does this" (Int. No. 6).

The technical skills are highly dependent on the used system and the executive. Some are less dependent on the information system. Overall, we observed a trend towards self-services BI and systems that requires less technical skills. use. However, for special ad hoc queries, SQL and similar knowledge is still necessary.

Data Quality. In three interviews issues with the data quality were mentioned as a huge problem. In two of them, even the same words were used ("a big topic is the data quality", Int. No. 6; "Data quality is a big topic here", Int. No. 10). However, getting good data can be hard. In other interviews the data quality was described as sufficient for the decision (see section about required accuracy).

Missing Overview over the Reports. When the reporting is growing, we observed that it becomes harder for the decision makers to keep an overview over the different reports. Especially, when different departments or individuals uses the same names for different KPIs. Another problem is that KPIs are regulary calculated but not used: "We have a lot of KPIs which were defined but they are not used anymore and they are not part of any report" (Int. No. 3).

The CEO of the wholesale company described that it often happens that he asked for a specific report without knowing that the report already exist. "The complexity, it's hard to keep an overview" (Int. No. 8).

Slow Software. In the interviews, eight interviewees complained about slow systems. However, the duration mentioned for slow request, were totally different. Some stated that any not immediate reaction and waiting times of a few seconds are too slow. In another interview, the system was considered as slow, because it took longer than 2 minutes. However, in two interviews the slow software was only mentioned as a problem when we specifically asked about potential improvements: "Fast is always good, I would wish it was" explained the HR-Lead (Int. No. 6).

Large Amount of Manual Work. Some interviews also mentioned that they have to work on every report and they have to check for the data quality and that there is not a good interaction: "It's not really interactive, like: you can enter something and than you get individual results" (Int. No. 6).

In all of the interviewed companies, it is planned to introduce more interactive reporting. These reports should enable managers to quickly navigate trough the data and get the data their want without asking for new reports. This concepts is known and marketed as self-service BI.

V. DISCUSSION

The resulting framework includes many of the information categories found in literature and can be seen as an expansion and integration of the previous models of Gorry & Scott-Morton [17], Chenhall & Morris [21], and Chen et al. [31]. Following our research goal of structuring information needs to support the design of IT artifacts, we do not include classifications of information needs which are specific for a single industry type or functional area.

We can confirm our model from the literature and, probably even more important, we were able to show that many companies have similar categories for their information needs. Although the companies were in different industries and used completely different systems, the observed categories and challenges were similar. This indicates, that the categories and many challenges and problems are general and not industry or IT-specific. Nevertheless, for some problems to be solved, domain specific knowledge might still be required. However, we observed some solutions are applicable for other companies

in different sectors. For example, the current trend towards self-service BI can solve the problem of manual work and lack of technical skills. Our model is a framework for general information needs and can be used as a guideline for domain-specific models. It can also be combined with existing information need models from specific domains e.g. in logistics [37]

In our empirical study, we have identified a new category of information needs: push vs. pull. This category has originally not been included in our model we created in section III. Although, there is a lot of literature about pushing and pulling of information, this principle is not included in many existing models. Push information are often seen as distinct from information needs because they are more related to the decision process itself [38], [39]. Other propose a distinction between objective and subjective information need. However, over the last years, technology has drastically evolved. With more devices being online and connected at any time, the push principle is nowadays much easier to implement than it was 20 years ago [40]. Therefore, we argue that his principle has probably not been included in earlier models, simply because it was not relevant at that time.

Currently, our work still has some limitations. We have chosen to do not ask directly for the categories from our framework to not bias our result. Therefore, our results are less biased but fuzzier because our questions do not include any specific categories. Due to the chosen open interview style, the observed categories are not claimed to be exhaustive. In fact, it is likely that an interviewee does not mention a used category because we did not explicitly ask for this information. It is also possible that the companies used multiple differentiation for one category. For example, depending on the question, the same interviewee might distinguish between two levels on one management for a given question. For another question the interviewee might differentiate between three levels.

Our eleven interviews were only conducted in four different industries in Germany. Different industries or countries might have different needs. More studies are needed to confirm this framework in more companies and industries and outside of Germany. The challenges we described in section III are only based on our interviews. Further research is necessary to conduct similar studies or compare these challenges to existing literature.

There is a high interdependence between the categories. For example, the required accuracy is lower with some types of visualizations. In a graphical diagram very small deviations are not visible. A similar connection applies for connection between frequency of use and functional area. Some areas, especially the accountants requires data more often than other departments (power user, Int. No. 8). Additionally, the required accuracy and the aggregation have a strong relationship. One company actually changed their aggregation to a higher level for an analysis because that required a lower accuracy. There is also a strong interdependence between the categories and the challenges. The issue of data quality is almost one-to-one assignable to the category required accuracy. Often the information needs are not clear beforehand. We observed many changing needs because the initial need was unfulfilled.

VI. Conclusion and Outlook

In this paper, we have combined a literature analysis with an empirical study. Based on our literature analysis, we have identified four different dimensions of information needs, namely scope, time-orientation, abstraction and presentation, which altogether contain eleven different categories of information needs. Next, we have conducted eleven interviews at four different organizations. These organizations are active in different industries and use different software for reporting and BI. Within these interviews, we were able to identify the dimensions of our information need framework from literature. An additional category, namely pull vs. push information was identified in the interviews, for which we have extended our framework to include this category as well (cf. Table IV).

Our work contributes to the development of adequate MIS. Based on our information need categories, software developers can develop data models that are suitable for storing all type of relevant data as well as create interfaces, where managers can retrieve relevant information in a self-service BI style. In future work, we plan to further look at the development of such systems and implement an actual prototype.

We have also looked at challenges and best practices among our interview partners. Although there are many differences in the companies, the interviewees' positions and the global challenges the different industries are currently facing, there are still some challenges that appear among all organizations across different industries. The main challenges we identified are the technical skills required for BI reports, which currently some employees not yet have. Therefore, additional training for employees might be suitable. Next, we have seen that the data quality is quite low in many organizations, which mostly comes from the usage of many different IT systems. Using many different applications makes the IT landscape very complex and requires many complex synchronization processes, which have to be set up manually. During this, many errors can happen, which lead to outdated, inconsistent or simply wrong data. For the future, both researchers and practitioners should focus on developing integrated IS architectures. In an ideal world, a single MIS would store all relevant data as a primary source, so that synchronization and integration of different application would not be required anymore.

Moreover, managers currently seem to have no overview of the amount of reports that are available to them and reports that are available, are sometimes to complex. Given the common problem of software being considered to slow by their users, managers may not receive updates in time, simply because managers or their assistants are not aware of new data or do not request recent data from their system. We therefore argue that MIS need to focus more on the user and the application scenarios required. That is, system developers need to implement flexible systems, where managers can do ad-hoc request against the production system, to generate reports in real-time.

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