# LEVERAGING IN-MEMORY TECHNOLOGY TO IMPROVE THE ACCEPTANCE OF MSS – A MANAGERS' PERSPECTIVE

*Complete Research*

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## Abstract

*Management support systems (MSS) help managers to perform their jobs more efficiently. With in-memory technology, a new IT enabler promises to support managers by benefits ranging from reducing time for MSS data entry and analysis to completing even new topics of analysis. Hence, the present situation is favorable for an MSS redesign applying in-memory apps. Such apps are field-tested and ready-to-use, but from a business perspective they lack "impact." Based on findings from a literature review and results from a workshop with an expert focus group validated with one-on-one manager interviews, we propose four initial use situations in which in-memory apps contribute to greater MSS acceptance: (1) In-memory apps should accelerate the MSS response time for both check status and receive an alert. In doing so, they should focus on information from management accounting. (2) By delivering information more timely, in-memory apps should contribute to MSS standard reports and financial closing. (3) In-memory apps should accelerate MSS response time for both ad-hoc analysis and drill-down/drill-through analysis. (4) Leveraging in-memory apps, MSS ad-hoc analysis and drill down/drill-through analysis should become more flexible.*

*Keywords: Information Systems (IS) Analysis and Design, Human Factor in IS Design, New-Generation Managers, Business Intelligence (BI), Management Support Systems (MSS), Self-Service IS, In-Memory Technology*

# 1 Introduction

Due to the 2008/2009 economic crisis and the ongoing financial turbulences in Europe, companies operate in an increasingly *dynamic environment* (Sultan, 2012). As a consequence, managers have expanded their role in operations—parallel to their strategic leadership. At the same time, they have to make decisions faster than in the past (Power, 2011).

*Management support systems* (MSS) help managers to perform their jobs more efficiently by serving as their central, hands-on, day-to-day source of information (Clark et al., 2007). The present situation is favorable for an MSS redesign applying in-memory technology (Wust et al., 2011). Leveraging the declining cost of random access memory and the capabilities of multi-core central processing units, in-memory technology promises to contribute to new MSS design by reducing time for information system (IS) data entry and analysis (Plattner, 2009; Gartner, 2012). From a hardware perspective, in-memory technology makes data access faster by querying data to the processor from a RAM instead of physical disks (Read, 2013). From a software perspective, in-parallel computation running 64-bit technology improves the computation power per se and column-based data storage enables faster and even new topics of analysis by accessing fewer data points (Plattner and Zeier, 2011).

*In-memory apps* are small capsulated software programs applying in-memory technology. They are field-tested and ready-to-use (Plattner and Zeier, 2011), but from a business perspective they lack "impact." Furthermore in-memory apps are only covered by very few publications such as Schapranow et al. (2013), who consider them in a medical environment, or vom Brocke et al. (2014), who consider a salesman app. From our perspective, two shortcomings are of particular interest. Firstly, it is unclear how in-memory apps can contribute to *managers*' *new role in operations*. For example, they exhibit a growing preference for "drill-throughs" into downstream enterprise resource planning (ERP) systems (Uppatumwichian, 2013). Secondly, it is unclear how in-memory technology can accommodate managers' new willingness to undertake *MSS self service* (Acker et al., 2011).

The objective of this article is to develop a research model exposing initial use situations in which in-memory apps can contribute to greater MSS acceptance. We cover the perspectives of both "analyst"- and "consumer"-type managers (hereafter referred to as consumer and analyst managers, see in detail Sect. 3.3) and answer two research questions:

- What are new-generation managers' preferred day-to-day interactions with MSS and what is their perceived usefulness of doing so?
- In accommodating these preferences, what are most important MSS use situations in which in-memory apps can contribute to greater MSS acceptance?

Following the emerging tenets of design science research in IS (Hevner and Chatterjee, 2010), we motivate this article in terms of current gaps in MSS design that arose from practice and suggest in-memory apps to close the gaps. After revisiting the foundations of our research questions and based on findings from a literature review, we lay out our research model. We use results from a workshop with an expert focus group to generate our findings. One-on-one manager interviews enhance our findings and demonstrate utility of our model. The article concludes with a summary and avenues for future research.

# 2 Foundations

Managers and their IS have been a constant topic of interest to researchers over the last five decades (Ackoff, 1967; Mintzberg, 1972; Rockart and Treacy, 1989; Elam and Leidner, 1995; Wixom and Watson, 2010). Both the terms MSS (Clark et al., 2007) and decision support systems (DSS) (Arnott and Pervan, 2008) have been proposed as labels for IS intended to support managerial tasks. Since DSS evolved from a specific concept that originated as a complement to management information systems (MIS), and overlapped in the 1980s with executive information systems (Power, 2008), we refer to our object of study as *MSS* (Mayer, 2013b). This term covers MIS, DSS, Executive Information Systems, and—more recently—knowledge management systems and business intelligence (BI) for managers (Carlsson et al., 2009). Complementing stationary use, we define *mobile MSS* as IS offering services for managers as they move from place to place, especially outside their fixed workplace, where technology is accessible, but not necessarily embedded in the environment (Lyytinen and Yoo, 2002).

The higher managers are positioned in the organization, the more likely they have an extensive education and work experience that becomes a basis for a highly individual IS attitude (Volonino et al., 1995). Thus, it is especially important that they perceive IS design as attractive (Mayer et al., 2012a) and, consequently, a one-size-fits-all concept that designs IS for a "typical" manager is no longer appropriate (Marchand and Peppard, 2008). In contrast, MSS design that would meet individual IS use characteristics of all managers is untenable from an efficiency perspective. *IS design for use* provides a way to achieve such a balance by segmenting different classes of user-group preferences (Winter, 2011). Thus, we assign our research to such an MSS design for use leveraging in-memory technology. In doing so, *MSS use situations* generalize classes of "similar" user-group preferences (Winter, 2011). They result in requirements—prerequisites, conditions, or capabilities needed by managers using MSS to solve a problem or achieve an objective (IEEE, 1990).

# 3 Literature Review

## 3.1 Search strategy

Starting with a journal search (Vom Brocke et al., 2009), we focused on leading IS research outlets provided by the London School of Economics (Willcocks et al., 2008)[1] complemented with journals from HCI[2] (AIS 2013), computer science[3], system and software engineering[4]. We complemented our search with proceedings from ICIS, ECIS, and AMCIS. We used EBSCOHost, Science Direct, Google Scholar, and AIS Electronic Library to access the journals. Our Boolean search string combined real-time corporate management or in-memory technology with MSS (design). We then examined the titles and abstracts of promising publications and, in doing so, ended up with 18 hits in total—including only two high-ranked articles. Thus, we complemented our search with tier-2 IS journals[5] and proceedings[6], and readjusted MSS design with IS design in general. Table 1 lays out our final Boolean search

[1] This catalog incorporates not only mainstream IS journals, but also social studies. We chose the five top journals from each set, namely: MIS Quarterly, Information Systems Research, Information&Management, Journal of Management Information Systems, and Decision Support Systems, as well as European Journal of Information Systems, Information&Organization, Information Systems Journal, Journal of Organizational and End User Computing, and Journal of Information Technology.

[2] International Journal of Human-Computer Studies/Man-Machine Studies, Human-Computer Interaction, International Journal of Human-Computer Interaction, ACM Transactions on Human Computer-Interaction, and AIS Transactions on Human-Computer Interaction.

[3] ACM Transactions on Computer Systems, IEEE Transactions on Computers, Journal of Computer and System Sciences, and Journal of Information Technology.

[4] IEEE Transactions on Software Engineering, IEEE Data Engineering Bulletin, ACM Transactions on Systems Engineering and Methodologies, Journal of Systems and Software, IEEE Software, and Information and Software Technology.

[5] Business & Information Systems Engineering, Communications of the ACM, Lecture Notes in Business Information Processing, Lecture Notes in Computer Science, International Journal of Information Management, Distributed and Parallel Databases, Knowledge and Information Systems, Business Intelligence Journal, and Information Management&Computer Security.

[6] International Conference on Extending Database Technology, Nordic Conference on Human-Computer Interaction, SIGMOD Record, SIGMOD International Conference on Management Data, Multikonferenz Wirtschaftsinformatik, Conference on In-Memory Data Management, Workshop on Foundations of Databases, and Datenbank Spektrum.

string with its constituents of the three umbrella terms we used. After a final back and forward search, we found *93 articles* to be relevant (Figure 1).

<table>
<tr><td colspan="3"></td><th colspan="6">OR</th></tr>
<tr><td rowspan="3">AND</td><td rowspan="2">OR</td><td>Real-time management</td><td colspan="2">Decision support</td><td colspan="2">Management/ managers</td><td>User</td><td>Acceptance</td></tr>
<tr><td>In-memory technology</td><td colspan="2">Application/ app</td><td colspan="2">Data warehouse (DWH)</td><td colspan="2">Enterprise resource planning (ERP)</td></tr>
<tr><td colspan="2">IS design</td><td>Management support systems (MSS)</td><td>Management information systems (MIS)</td><td>Executive information systems (EIS)</td><td>Decision support systems (DSS)</td><td>Knowledge management systems (KMS)</td><td>Business intelligence (BI)</td></tr>
</table>

*Table 1. Boolean search string*

## 3.2 Literature systematization

Structuring the 93 publications classified as relevant in terms of (1) the elements of IS design theories they employ and the (2) research approach in IS they apply, Figure 1 exposes our results.

*(1)* Referring to Walls et al. (1992), *IS design theories* consist of three elements:

(a) Leveraging findings from HCI research (Zhang et al., 2002), our literature systemization is based on Mayer and Mohr (2011) and starts with a *user model*. An IS user-group analysis segments user groups and their characteristics that influence how managers use MSS (Mayer et al., 2012a). The effects of use occurring to managers while using IS complement our IS design for use proposal (Benbasat and Nault, 1990).

(b) We define *user requirements* as prerequisites, conditions, or capabilities needed by managers using IS (IEEE, 1990). They consist of functional and non-functional aspects (Sommerville (2010). The first address "what" in-memory apps are supposed to do or must do (purpose). The latter reflect "how well" it performs its function within its environment (Paech and Kerkow, 2004).

(c) Serving as predefined actions specifying how in-memory apps in MSS are brought to life, *design guidelines* go beyond mere requirements and contribute to theories specifying how IS should be designed based on kernel theories (Vaishnavi and Kuechler Jr, 2007; Hoogervorst, 2009). They contribute to both models and methods. Models outline concrete systems, specific in-memory features, or combinations of these (Gregor, 2006). Complementary, methods describe the process of building IS (March and Smith, 1995).

*(2)* The *research approaches in IS* influences the granularity of requirements and design principles from high-level findings such as "ensure reporting" to features such as "pricing simulations in sales."

(a) Publications with a *behavioral focus* explain phenomena from practice. They rely on observations and apply empirical methods (Urbach et al., 2009). We differentiate between experiments, findings from literature reviews, and surveys (Podsakoff et al., 2003; Webster and Watson, 2002). Case studies (to explore an as-is status in practice) are another way of data analysis to conduct behavioral research (Yin, 2009).

(b) *Design science research approaches* give recommendations for the conceptual design and implementation of in-memory apps for creating a better world (Walls et al., 1992). We divide these publications into single items and list approaches investigating specific aspects on the one hand and more general frameworks focusing on requirements with technology aspects or IS design guidelines on the other hand.

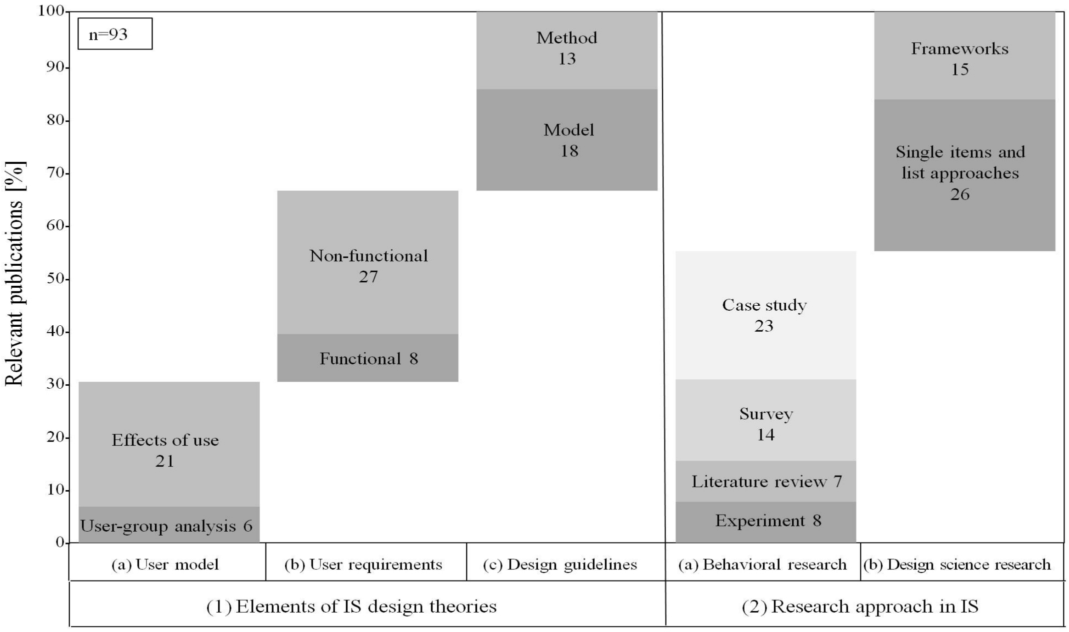


*Figure 1. Results of the literature review*

## 3.3 Gap Analysis

From the systematization of the literature we identified five gaps. *(1a) A user perspective on in-memory technology exposing different MSS use situations is missing:* With 27 publications researched (Figure 1, first column on the left), the state of the art of IS user models is comprehensive. However, only six publications provide methods to differentiate individual cognitive styles or cover techniques for user-group analysis (Mayer and Stock, 2011) whereas 21 publications cover effects of IS use (including MSS) on human beings. Within the first group, one of the most popular techniques is Huysmans (1970) distinction between the analytical and heuristic style of managers. The studies investigating the effects of IS use either apply the techniques employed in the above group to examine characteristics that have an impact on IS (Powell and Johnson, 1995) or they utilize an explorative procedure to identify manager user-group characteristics and their MSS usage (Walstrom and Wilson, 1997). In a current study of managers from companies listed in the FT “Europe 500” report (Mayer and Stock, 2011) two basic working styles among managers and their different MSS usage are identified: *Analyst managers* seek causal relationships, prefer quantitative data, and pay attention to details (Huysmans, 1970). They might use standard reporting as an MSS entry point, but want to be able to switch to an interactive, deep-dive mode rather than simply information presentation. *Consumer managers,* in turn, pay less attention to detail and rely often on content in a predefined order (Mayer et al., 2012b). We consider this approach as being appropriate for our research model as it offers an elementary distinction of different user types—a prerequisite to examine managers’ IS acceptance more in detail than the state of the art does.

With respect to in-memory technology, Carton et al. (2011) consider real-time corporate management to be one of the current issues for MSS design. However, in-memory databases in enterprises (Koleva, 2011) and dashboards for real-time BI (Steinkamp and Mühlbauer, 2013) lack a business perspective in content and handling especially when supporting analytical applications (Loos et al., 2011). We reflect these issues in our research model by considering self-service in-memory apps for managers from their business perspective. The examined publications most often follow the black-box model exposing IS layouts (Wu et al., 2011). Warmouth and Yen (1992) structure software components into information presentation, dialog control, and information analysis and collaboration functions, that managers can operate by themselves. However, the publications we have reviewed either provide just lists of software components without a rigorous basis (Papageorgiou and De Bruyn, 2010; Eckerson and Hammond, 2011) or only examine attributes of single software components. Currently, just two articles expose managers' different *MSS use situations* (Arnott and Pervan, 2008; Mayer et al., 2012a), all other publications researched stay on a generic level (Winter, 2011).

*(1b) User requirements lack a focus on corporate management:* 35 out of 93 publications deal with requirements for in-memory technology (Figure 1, second column on the left). 27 publications focus on non-functional requirements covering a range between easy-to-use computation "on the fly" (Plattner and Zeier, 2011) to short IS response times (Chaudhuri et al., 2011; Loos et al., 2012). In-memory technology also enables flexible and spontaneous analysis, which so far did not work on data warehouse (DWH) technology (Winter et al., 2011; Zeier et al., 2011).

In turn, just 8 out of 93 publications cover functional requirements for in-memory technology. They focus on multiple optimizations for procurement in IS (Schütte, 2011), analytics for supply-chain management (Sahay and Ranjan, 2008), volume and price simulations for sales representatives (Wust et al., 2011) or customer relationship management in telecommunication companies (Acker et al., 2011). Zeier et al. (2011) promise that in the future separate IS for simulations can be reintegrated in the ERP landscape to reduce complexity. Piller and Hagedorn (2011) argue to apply in-memory apps for faster (financial) consolidation runs and analyses. So far, there is no comprehensive classification of functional areas for manager apps and there is no publication about the use of in-memory apps within the corporate management domain. Especially new functional types of analysis for (real-time) corporate management are missing (Koleva, 2011). Thus, we expose *managers' day-to-day interactions with MSS* in our research model and, following Mayer (2013a), we distinguish *five information clusters* contributing to corporate management: Financial accounting, management accounting, cash flow & liquidity management, compliance management, and program management.

*(1c) Design guidelines for in-memory apps lack impact for practice:* We examined 18 publications about IS models outlining guidelines for in-memory technology in general and for in-memory apps in detail (Figure 1, third column on the left). However, these references focus on technical details such as cloud computing (Demirkan and Delen, 2013) or dashboard implementation (Pankaj et al., 2006). They are complemented by a description of an IT-vendor platform (Färber et al., 2012) and a prototype for an available-to-promise application (Müller et al., 2011). Design guidelines on how to develop and customize in-memory apps in practice are missing. Distinguishing between the data volume and the need for integration of in-memory technology, Winter et al. (2011) provide a matrix of four use cases for operational analytics and the BI/DWH environment. Piller and Hagedorn (2011) lay out six patterns of in-memory technology: operational reporting, exploratory analysis of mass data, complex analysis, fast consolidation, adaptive planning, and analysis of consumer data. However, both publications stay generic with design guidelines for ready-to-work IS with in-memory technology.

Focusing on methods for IS design, we researched 13 publications. They cover the influence of in-memory technology on data warehouses (Knabke and Olbrich, 2011) and on the implementation of real-time dashboards (Nichols et al., 2009; Pappas and Whitman, 2011). Another three articles, such as (Eckerson, 2010), address in-memory technology and mobile platforms in general and we found two articles about in-memory and mobile analytics (Wust et al., 2011; Chen et al., 2012). Yuan et al. (2010) examine the fit between mobile work and IS along mobility, location dependency, and time criticality. Gebauer et al. (2010) classify mobile use contexts in terms of the level of distraction, connection quality, and mobility statuses for these situations. However, there is no publication about managers' mobile information access, especially on manager apps. Hence, we specify our research topic towards *in-memory apps for managers*—supporting them even when they are mobile.

*(2a, 2b) Concrete interaction with practice when designing MSS is missing:* With 52 publications our literature review reveals a slight preference for behavioral approaches in in-memory-technology research (Figure 1, fourth column on the left). Focusing on case studies (23 references) research justifies

the general adoption of in-memory technology. Only one case study instantiated real-time dashboards in practice (Nichols et al., 2009). The 41 publications adhering to design science research in IS apply (application) frameworks (15) and single item/list approaches (26, Figure 1, fifth column on the left). Frameworks are offered for BI and analytics (Chen et al., 2012), online analytical and transactional processing (OLAP and OLTP, Seibold et al., 2013) and BI for small and medium enterprises (Grabova et al., 2010). List approaches expose in-memory capabilities (Piller and Hagedorn, 2011) and consider data for analytics (Read, 2013). However, an interaction with practice is missing. Thus, we propose a *manager (expert) focus group* to improve the transfer of technological progress into practice.

To conclude, our gap analysis reveals a model exposing use situations in which in-memory apps can contribute to greater MSS acceptance. We apply our findings from the literature review in a 2+1 research model differentiating managers' MSS preferences by their day-to-day interactions with IS (1) and their perceived IS usefulness (2, Sect. 4.1). We expose the selection of information clusters (+1, Sect. 4.2) as a mechanism to specify in-memory apps for MSS to the demonstrated use situations.

# 4 Research Model

## 4.1 MSS Use Factors

*(1) Managers' Day-to-Day Interactions with MSS:* Based on the references from the user model (Figure 1, column 1a), we identified eight day-to-day activities how managers interact with MSS. Following Warmouth and Yen (1992), Table 2 illustrates our findings structured according to information presentation, IS dialog control, and information analysis and collaboration. Using this basic structure we further researched interactions that can be subsumed under these three umbrella terms. In order to maintain a concise structure we only selected distinct interactions that could be affected by in-memory apps. Starting with *information presentation*, managers need to enter the MSS at a clear starting point especially when they check status (Interaction 1) and receive an alert (I3) (Mayer, 2013b). For standard reports (I2), Giner et al. (2009) expose the quality of information presentation on the "first screens" as important for managers' perceived IS usefulness.

Managers should then be able to navigate within the IS by an intuitive *IS dialog control*. Additionally, the usage is strongly affected by the way information and analyses are presented (Salimun et al., 2010). In this respect, dashboards (I4) are a form of visualization providing a condensed overview but also flexible access to detailed information (Eckerson and Hammond, 2011). IS dialog control should provide filters, drill-downs and sorting (Walstrom and Wilson, 1997) and MSS should provide *information analysis and collaboration* handled by managers themselves (Young and Watson, 1995). This should cover both ad-hoc (I6) and drill-down/drill-through (I7) analysis (Papageorgiou and De Bruyn, 2010). Especially, collaboration tools (I8) complement their use by getting feedback.

*(2) Perceived Usefulness:* Referencing to the technology acceptance model (Davis, 1989), we differentiate between four main determinants of perceived usefulness applying in-memory technology (Houdeshel and Watson, 1987): *Faster response times* in terms of information delivery allowing to react instantaneously (Piller and Hagedorn, 2011), *more timely information delivery* without the need of extensive batch runs (Oxford, 2011), *more flexible information analysis* even on mobile devices (Acker 2011), and *more consistent data storage* (Chaudhuri et al., 2011).

## 4.2 Selection of Information Cluster to Specify In-Memory Apps for MSS

In order to identify relevant information clusters for corporate management, we follow Mayer (2013a), who conducted two consecutive surveys with 59 and 42 managers of companies listed in the Financial Times "Europe 500" report, and differentiate as follows: *Financial accounting* covers standardized financial information for internal and external stakeholders whereas *management accounting* concentrates on internal requirements exposing even qualitative information (Kaplan, 1984). *Cash flow and liquidity management* offers direct insight into key financial data for the cash flow statement and liquidity status (Campello et al., 2011). *Compliance management* assures the conformity of business activities with legal requirements (Abdullah et al., 2009), especially risk management, and *program management* deals with key performance indicators such as statuses, responsibilities and schedules of most important projects. Under these considerations, MSS use situations—defined as classes of “similar” user-group preferences (Sect. 2)—can now be specified for our research as a threefold combination of manager day-to-day interactions with MSS, specific information clusters for their corporate management, and attributes of their perceived usefulness in using MSS.

| | | | |
|---|---|---|---|
| **A. Information presentation** | | | |
| | I1 | Check **status** (e.g., notify important information delivery) | Young and Watson (1995): status access to information; Gebauer and Shaw (2004): request, approve, and receive as procurement functions |
| | I2 | Receive **standard reports** (office documents) | Carroll and Gillen (1987): reading and reviewing reports, letters, etc. |
| | I3 | Receive an **alert** (exception reporting) | Warmouth and Yen (1992): advanced internal control; Gebauer and Shaw (2004): mobile technologies in business environments |
| **B. IS dialog control** | | | |
| | I4 | Use **dashboard design** (comprehensive overview as a starting point) | Eckerson (2010): monitor, analyze, manage; Eckerson and Hammond (2011): visual reporting with tiles, graph types, and sliders |
| | I5 | Use **predefined navigation** (deep-dives or additional information access) | Salimun et al. (2010): breadcrumbs, blend out/gray out, avoiding overlapping windows, tabs instead of pull-downs, etc.; Plattner and Zeier (2011): simplify daily business by automatic query composition |
| **C. Information analysis and collaboration** | | | |
| | I6 | Conduct **ad-hoc analyses** | Walstrom and Wilson (1997): interactive navigation with filters, drills, sorting, etc.; Papageorgiou and De Bruyn (2010): ad-hoc facilities and drill downs as major capabilities of MSS |
| | I7 | Conduct **drill-down/drill-through analyses** | |
| | I8 | Use a **collaboration tool** (emailing, share an opinion or decisions) | Vodanovich et al. (2010): increasing use of rapid and agile collaboration and information sharing; Mayer et al. (2013): communication and cooperation “on the fly” |

*Table 2. Managers’ day-to-day interactions with MSS*

# 5 Demonstrate

## 5.1 Workshop with Expert Focus Group

According to Mingers and Brocklesby (1997) and Tashakkori and Teddlie (2003) mixed methods combine exploratory and confirmatory research and allow a better adaptation to the real world. To validate our findings we organized a workshop with an *expert focus group*. This research format provides direct suggestions and feedback between researchers and practice in a personal atmosphere and, thus, supports in particular a design-oriented IS research (Österle and Otto, 2010). Expert focus groups have the advantage that participants show particular interest in the topic and are well informed in comparison to answering questionnaires. Our focus group consisted of *25 participants*—either executives (L1) or managers (L2) from 12 different companies. Meeting three times a year since 2006 they discuss developments in corporate management and IS research. Table 3 summarizes the characteristics of the expert focus group. Regarding managers’ working style, the group consisted of fourteen analyst and eleven consumer managers (third column of Table 3). The workshop was hosted by the competence center “Corporate Management Systems” at University of St.Gallen (http://uss.iwi.unisg.ch).

A pre-test of the questionnaire was performed with three persons to ensure the relevance, completeness, and distinctiveness of the questions as well as an “appropriate” duration of about two hours bearing in mind that managers have “typically” less time than knowledge workers (or believe they do). Data was then obtained in a *two-hour survey at the end of a two-day moderated workshop* in June 2013. The workshop started with an introduction by two moderators followed by two case examples. The first one was an app about material planning allowing to manage out-of-stock situations more effectively  and the second covered a planning in a band width of worst, most probable, and best case with different material prices.

| **Position** | No. | % | **Frequency of MSS use** | | | **Market capitalization** | | |
|---|---|---|---|---|---|---|---|---|
| Executive (L1) | 5 | 20 | Permanent | 3 | 12 | <30 | 13 | 52 |
| Business department manager (L2) | 13 | 52 | Multiple times a day | 7 | 28 | 30-89 | 9 | 36 |
| IT/BI department manager (L2) | 7 | 28 | Once every day | 6 | 24 | 90-120 | 2 | 8 |
| | | | 2-3 times a week | 6 | 24 | >120 | 1 | 4 |
| | | | Once a week | 3 | 12 | [bn USD] | | |
| Total | 25 | 100 | Total | 25 | 100 | Total | 25 | 100 |
| **Gender** | No. | % | **Sector** | | | **Working style** | | |
| Male | 22 | 88 | Industrial | 12 | 48 | Analyst | 14 | 56 |
| Female | 3 | 12 | Financial services | 5 | 20 | Consumer | 11 | 44 |
| | | | Other | 8 | 32 | | | |
| Total | 25 | 100 | Total | 25 | 100 | Total | 25 | 100 |

*Table 3. Sample characteristics*

The facilitators then followed-up with the questionnaire asking the participants to assess their perceived IS usefulness for their day-to-day MSS interactions by the following attributes: faster response time, more timely information delivery, more flexible information analysis, and more consistent data storage (first section). The second section covered managers’ most important information clusters when accessing MSS: financial accounting, management accounting, cash flow & liquidity management, compliance management, and program management. The participants then evaluated their perceived usefulness and the information clusters, on a Likert scale: [1] not important, [2] less important, [3] undecided, [4] important, [5] very important.

## 5.2 Results

Table 4 shows the arithmetic means for consumer and analyst managers’ perceived usefulness for each MSS interaction (I1-I8, $\mu_A$ and $\mu_c$). Relevant results are highlighted with green boxes according to three criteria. The highest values are colored (1) if they are above 4.00 and (2) if there is an information cluster above 4.00 for this interaction. Additionally, (3) combinations are highlighted that are significantly ($p<0.1$) higher than 3.00 (undecided). This case applies, e.g., for analyst managers’ I6 faster response time. Regarding the significance of our results, we added indicators for the significance of the best-rated result against the other possible attributes[7]: one star “p<0.1 (10%),” two stars “p<0.05 (5%),” or three stars “p<0.01 (1%)”. For example, taking “I1, check status,” faster response time is the best-rated perceived MSS usefulness for both analyst and consumer managers ($\mu_A$=4.71 and $\mu_c$=4.18).

[7] P-values were calculated with both Student’s t-test and the Mann-Whitney-U test. There were only a few marginal deviations, e.g. “I1, check status” for consumer managers: management accounting was significant against financial accounting with p<0.05 using the U-test whereas it was only significant to p<0.1 with Student’s t-test. Conversely, for analyst managers: management accounting was no longer significant to p<0.1 against cash flow and liquidity management with the U-test.

| # | MSS interaction | Attributes of perceived IS usefulness / Working style | Analyst manager: faster response time (I) | Analyst manager: more timely information delivery (II) | Analyst manager: more flexible information analysis (III) | Analyst manager: more consistent data storage (IV) | Consumer manager: faster response time (V) | Consumer manager: more timely information delivery (VI) | Consumer manager: more flexible information analysis (VII) | Consumer manager: more consistent data storage (VIII) |
|---|---|---|---|---|---|---|---|---|---|---|
| **A. Information presentation** | | | | | | | | | | |
| I1 | **Check status** (e.g., notify important information delivery) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | **4.71** | 3.62 *** | 3.67 ** | 3.92 ** | **4.18** | 3.64 | 2.82 ** | 3.09 ** |
| | | Information cluster: Financial accounting | 3.29 ** | | | | 3.45 ** | | | |
| | | **Management accounting** | **4.07** | | | | **4.27** | | | |
| | | Cash flow & liquidity management | 3.29 | | | | 3.18 ** | | | |
| | | Compliance management | 2.86 *** | | | | 2.64 *** | | | |
| | | Program management | 3.21 ** | | | | 2.73 *** | | | |
| I2 | **Receive standard report** (e.g., monthly report, net sales deviation end of the week) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | 3.08 *** | **4.31** | 3.18 ** | 3.93 | 3.40 | 3.82 | 3.36 | 3.80 |
| | | Information cluster: **Financial accounting** | | **4.50** | | | | 4.27 | | |
| | | Management accounting | | 4.29 | | | | 3.73 | | |
| | | Cash flow & liquidity management | | 3.50 ** | | | | 3.27 * | | |
| | | Compliance management | | 3.08 *** | | | | 3.09 ** | | |
| | | Program management | | 3.43 *** | | | | 3.36 * | | |
| I3 | **Receive an alert** (push function for exception report) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | **4.00** | 4.00 | 2.83 ** | 3.00 * | **4.00** | 3.82 | 3.00 ** | 3.55 |
| | | Information cluster: Financial accounting | 3.62 | | | | 3.90 | | | |
| | | **Management accounting** | **4.00** | | | | **4.20** | | | |
| | | Cash flow & liquidity management | 3.31 | | | | 3.70 | | | |
| | | Compliance management | 2.92 * | | | | 3.80 | | | |
| | | Program management | 2.85 ** | | | | 3.60 | | | |
| **B. IS dialog control** | | | | | | | | | | |
| I4 | **Start navigation by dashboard design** (take a comprehensive overview as the starting point of navigation) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | 3.83 | 3.55 | 3.62 | 2.55 ** | 4.30 | 3.80 | 3.40 * | 3.10 ** |
| | | Information cluster: Financial accounting | 3.71 | | | | 3.45 | | | |
| | | Management accounting | 4.21 | | | | 3.82 | | | |
| | | Cash flow & liquidity management | 3.62 | | | | 3.09 | | | |
| | | Compliance management | 2.86 *** | | | | 3.27 | | | |
| | | Program management | 3.43 * | | | | 3.64 | | | |
| I5 | **Use predefined navigation** (e.g., deep-dives or additional information access) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | 3.58 | 3.42 | 3.64 | 3.67 | 3.60 | 3.40 | 3.60 | 3.30 |
| | | Information cluster: Financial accounting | | | | 4.07 | | | 3.73 | |
| | | Management accounting | | | | 3.79 | | | 3.55 | |
| | | Cash flow & liquidity management | | | | 3.77 | | | 3.30 | |
| | | Compliance management | | | | 2.50 *** | | | 2.91 | |
| | | Program management | | | | 3.07 ** | | | 3.45 | |
| **C. Information analysis and collaboration** | | | | | | | | | | |
| I6 | **Conduct ad-hoc analysis** (e.g., net sales by customer, country, or product, details of important projects) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | **4.31** | 3.83 ** | **4.54** | 3.67 * | **4.36** | 4.00 | **4.45** | 4.00 |
| | | Information cluster: Financial accounting | 3.86 | | 3.86 | | 3.45 | | 3.45 | |
| | | **Management accounting** | **4.21** | | **4.21** | | **4.00** | | **4.00** | |
| | | Cash flow & liquidity management | 3.21 ** | | 3.21 ** | | 3.27 | | 3.27 | |
| | | Compliance management | 2.50 *** | | 2.50 *** | | 2.18 *** | | 2.18 *** | |
| | | Program management | 3.21 ** | | 3.21 ** | | 2.91 * | | 2.91 * | |
| I7 | **Conduct drill-down/through analysis** (e.g., switch from an data aggregate to individual lines of data) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | **4.62** | 4.17 | **4.42** | 4.15 | **4.70** | 3.30 *** | **4.82** | 4.36 |
| | | Information cluster: Financial accounting | 4.07 | | 4.07 | | 3.55 | | 3.55 | |
| | | **Management accounting** | **4.36** | | **4.36** | | **4.00** | | **4.00** | |
| | | Cash flow & liquidity management | 3.54 * | | 3.54 * | | 3.00 | | 3.00 | |
| | | Compliance management | 2.86 *** | | 2.86 *** | | 2.73 * | | 2.73 * | |
| | | Program management | 3.50 ** | | 3.50 ** | | 3.09 | | 3.09 | |
| I8 | **Use a collaboration tool** for information communication (e.g., share an opinion) | **Perceived usefulness** ($\mu_A$ and $\mu_C$) | 3.31 | 3.25 | 3.25 | 3.31 | 3.36 | 3.09 | 3.09 | 3.00 |
| | | Information cluster: Financial accounting | 3.14 * | | | | 3.27 | | | |
| | | Management accounting | 3.79 | | | | 3.45 | | | |
| | | Cash flow & liquidity management | 3.00 ** | | | | 3.00 | | | |
| | | Compliance management | 3.29 | | | | 2.82 | | | |
| | | Program management | 3.86 | | | | 3.00 | | | |

Table 4. Managers and their perceived usefulness for situated MSS design

Up to a level of $p<1\%$ it is more important for analyst managers than more timely information delivery ($\mu_A$=3.62) or more flexible information analysis ($\mu_A$=3.67). Looking at the highlighted boxes, Table 4 outlines the most relevant information clusters for manager MSS interactions. Clusters that are significantly less important than the best-rated one are marked accordingly. Following Likert values ≥ 4 in Table 4, we propose four initial MSS use situations to which in-memory apps can contribute to raise the perceived usefulness of managers' self-service MSS design.

*(1)* A first MSS use situation aims at *faster response times*. Having a couple of minutes waiting for example for a train and "checking status" (I1, Table 4), both analyst and consumer managers expect a faster response time from in-memory technology for their MSS ($\mu_A$=4.71 as the second highest arithmetic mean of the workshop; $\mu_c$=4.18). This result is highly significant in comparison to more timely information delivery and more flexible information analysis (***). A faster response time is also important for "receive an alert" (I3, $\mu_A$ and $\mu_c$=4.00). In doing so, managers reveal information from management accounting as the most desired (analyst managers, 4.07 and 4.00; consumer managers, 4.27 and 4.20). Thus, apps accessing information from management accounting are relevant for both analyst and consumer managers.

*(2)* Standard reports such as monthly reports or deviation reports require aggregated data. Analyst managers have a significant preference for standard reports being *more timely* (I2: $\mu_A$=4.31***) and expect information from financial accounting ($\mu_A$=4.50). Thus, a second MSS initial use situation to which in-memory technology adds value is more timely financial information for standard reports.

*(3)* Both manager types indicate that faster response times are relevant for ad-hoc analyses (I6, $\mu_A$=4.31; $\mu_C$=4.36) and they want drill-down/drill-through analysis to become faster (I7, $\mu_A$=4.62; $\mu_C$=4.70). With respect to functional areas, managers mention information delivery from management ($\mu_A$=4.21; $\mu_C$=4.00) and financial accounting ($\mu_A$=3.86; $\mu_C$=3.45). A third initial use situation should focus on a faster response time for *accounting information* using in-memory apps.

*(4)* Ad-hoc analysis as well as drill down/drill-through analysis have to become more flexible so that important KPIs such as net sales can be analyzed by product, customer, or country (I6 and I7, $\mu_A$=4.54 and 4.42; $\mu_C$=4.45, 4.82, highest arithmetic mean of the workshop). For such analyses, data from management accounting are perceived as most important (Table 4, I6 and I7). Managers also wish to apply various filters to subsets of data. More consistent data storage should be a side effect of in-memory technology for MSS ($\mu_A$=4.15; $\mu_C$=4.36).

# 6 Evaluate

Based on Peffers et al. (2007) design science research methodology in IS, in this evaluation section we observe and measure how well our research model fits to the exposed problem (Sect. 1). This can be achieved by a variety of activities such as a direct comparison of the result with its requirements, a simulation, or client feedback. We focus on the latter and use qualitative data from *one-on-one manager interviews* to complement our results from the expert focus group.

We chose a sample size of *eight managers*, as there were signs of saturation (Guest et al., 2006) and the aim was a more detailed insight—in contrast to a broader selection in the previous section. The interviewed managers belong to companies of the competence center "Corporate Management Systems (Sect. 5)," but were *not* part of the expert focus group to avoid a circular argumentation.

At first, a ten-minute introduction was given to the topic and the in-memory technology features of interest. For the following 20 minutes the semi-structured interview format was chosen to receive detailed evaluations on the four results without restricting it to a simple agree-disagree rating. One-on-one interviews increase the eagerness of interviewees to disclose even detailed and more confidential information and provide a rich understanding of their individual perspective on IS, including reasoning processes (Nadkarni and Shenoy, 2004). The first company was an automotive supplier (2012 sales:

32.8 bn. EUR, employees: 169,000) that has recently implemented a more flexible MSS solution called “FIRE” (financial reporting, Mayer and Winter, 2013). The second one was a large telecommunications company (2012 sales: 58.2 bn. EUR, employees: 232,000) currently harmonizing their financial reporting. These two companies were chosen because their management should be able to give sound feedback on the basis of the recent changes in their IT infrastructure. Their in-depth insights into specific MSS use situations enhance our initial MSS use situations with experience from practice.

*(1) In-memory apps should accelerate the MSS response time for both check status and receive an alert. In doing so, they should focus on information from management accounting.* The CFO of the automotive supplier (analyst manager) agreed with our first finding from the expert focus group that in-memory apps have to improve the response time of MSS for both check status and receive an alert. To respond faster to customer requests, internal issues, information from procurement, production, sales, or competitors the need of speed answering provision is more important than a deep-dive advanced analysis. For example, he exposes that a daily net sales statement “on the fly” pushed on his smart device when he is on the road, is more relevant than an entire screen-scraped financial report. Consumer managers more often chose a quick phone call instead of a display notification. Although they all possess tablets, consumer managers tend to prefer paper-based and personal communication even more. Still, both analyst and consumer managers agreed that status checks and alerts need to be transmitted faster than their current MSS can do.

*(2) By delivering information more timely, in-memory apps should contribute to MSS standard reports and financial closing.* The head of “group accounting” of the telecommunications company focused on our second result and confirmed that time-consuming batch runs is the main bottleneck in reporting performance in practice. He explained that financial closing with a segmented group structure requires the precise adherence to deadlines at every hierarchical level and leaves no room for errors. A reconsolidation as the result of an error in a subsidiary jeopardizes the timeliness of superordinate departments. Based on the aspired—but not practicable—fast close with reports handed out at the beginning of the new month, management in some cases receives reports that cover one week of the previous month plus three weeks of the actual month, instead of four weeks of the actual month. This shift obviously does not solve the problem but only fakes a fast close. Thus, a reduction in batch cycle times for more timely information delivery in financial accounting by in-memory apps would not only speed up the process, but also reduce the gravity of minor errors.

*(3) In-memory apps should accelerate MSS response time for both ad-hoc analysis and drill-down/ drill-through analysis.* In our next manager interviews, the COO outlined that he does not like IS very much. In his words, operational tasks most often require one-on-ones directly in the production line. However, when reporting the results in a board meeting, he requests easy-to-use real-time analyses. He reveals that in-memory apps can contribute to decision making in board meetings when fast analysis and what-if simulation are needed. Furthermore, he can investigate more scenarios in the same span of time. With a faster response time of MSS enabled by in-memory apps it is possible to perform such analysis during the meeting, instead of postponing the issue to the next meeting. Complementing this result, group management accounting from the telecommunications company sees considerable potential in fast ad-hoc analyses for their monthly meetings, which are still based on printed reports. If, in previous meetings, important data was missing, for the next meeting, this data could be provided right from the start. However, this has led to constantly increasing stacks of paper impeding the efficiency of meetings whenever an issue has to be discussed in detail.

*(4) Leveraging in-memory apps, MSS ad-hoc analysis and drill-down/drill-through analysis should become more flexible.* The CFO of the automotive supplier supports our fourth workshop result by giving two other initial MSS use situations for in-memory apps. First, they should allow managers to directly access the ERP systems and thus provide a wider data base for analysis. For example, his distribution manager should be able to drill down on a single-order basis and react to material shortages

by rearranging other orders. Secondly, in-memory apps should enable a more situational analysis, so that managers can refine their analysis from any point of self-service analyses.

An accounting manager of the surveyed telecommunications company was concerned that self-service analyses are not always constructive. Although up to L2 management (e.g., corporate management accounting), many managers have access rights to ERP systems, however, these rights are rarely used. Knowledge of the different data models is necessary to acquire the desired information from different systems and thus, the person in charge is contacted directly, so as to avoid mistakes. Nevertheless, he assumes that, for less complex companies, this increase in flexibility could be a very helpful addition.

# 7 Outlook and Avenues for Future Research

The objective of this article was to develop a model exposing initial use situations in which in-memory apps contribute to greater MSS acceptance. Based on the findings from a literature review and results from a workshop with an expert focus group we applied a new research model to propose four MSS use situations.

For *practice*, the research model on hand provides recommendations from a manager perspective for both a checklist to improve existing MSS incorporating in-memory-technology and for the future design of such MSS. For *research purposes*, the proposed model provides a rigorous starting point for future investigations on in-memory apps for managers. Furthermore, we examined different determinants for an in-memory app design, such as MSS use situation and information clusters that influence the perceived usefulness of managers' day-to-day interactions with MSS. However, our findings are limited by the workshop results and the managers interviewed. Especially the small number of 25 participants of the workshop may lead to biased results. A survey with more managers even from smaller companies should provide a more solid basis. More in general, companies are just beginning to recognize and implement in-memory technology. Thus, another avenue of future research is to build a *prototype* to drive managers' awareness from database improvements to new topics of analyses. Especially mobile solutions powered by in-memory apps are only on the agenda of very tech-savvy managers.

Mobile devices are used mostly for information presentation and only little analysis is performed on tablets or other smart devices. This MSS use situation should be further investigated in future research as electronic reports replace more and more paper-based ones. If such a migration takes place, new-generation managers may have additional requirements and our results on hand should be adjusted accordingly.

From a technology perspective, there are two issues that should be considered in future research. On the one hand, in-memory technology is related to *big data,* which is another new IT-enabler. Smart metering, sensor networks and social media data may increase data volumes and in-memory technology can deliver new types of analyses on these new data. On the other hand, *cloud computing* plays a more and more important role. By providing users with the capability of storing their data on a cloud platform that may support in-memory analytics, smaller companies may benefit selectively without paying license costs for an own IT infrastructure within the company.

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