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RAPPORT

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Information and Communication
Technologies and Supply Chain in
Facilities Management in
Denmark

**Centre for Facilities Management - Realdania Research, DTU
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List of abbreviations

CAFM:	Computer Aided Facilities Management
CEO:	Corporate Executive Officer
EDI:	Electronic Data Interchange
ERP:	Enterprise Resource Planning
FM:	Facilities Management
ICT:	Information and Communication Technology
IOS:	Interorganizational Systems
IT:	Information Technology
MIS:	Management Information Systems
O&M:	Operation and Maintenance
SC:	Supply Chain
SCM:	Supply Chain Management

Abstract

This report presents the results of a study of factors impacting Information and Communication Technology (ICT) adoption in the supply chain of Facilities Management (FM) in Denmark.

The research questions addressed in this study are: What are the key factors that influence adoption and assimilation of ICT systems in the supply chain of FM? What are the main benefits gained from deploying ICT systems in FM supply chain?

This study is important because it investigates motivators, barriers and benefits of adopting ICT systems in the FM supply chain, which is new to the FM literature as well as the IT innovation adoption literature and supply chain management literature.

The report takes the starting point on the definitions of supply chain, supply chain management and FM to go deeper into a literature review of factors that can affect the adoption and assimilation of ICT in the supply chain. On the base of this literature review a semi-structured interview guide has been developed and 12 in depth interviews have been conducted with respondents from 12 different companies. Each interview lasted circa 1.5-2 hours and all interviews were fully transcribed. Data for the study were also gathered from archival sources as well as attendance to practitioner conferences and workshops on the topic of IT systems in FM. The participant lists of these seminars and conferences, the web site of the Danish network for FM as well as discussion with industry experts were used to find relevant companies and people to interview.

The results of the study show that there are a number of factors that influence adoption and assimilation of ICT in the supply chain of FM in Denmark. By following the literature, these factors have been grouped according to organizational, technology and external environmental factors. Some of the most important organizational factors are better FM management decisions, better long term and short term planning and forecasting of FM resources, better overview and control over the budget and the activities that need to be done as well as better service provided to the customers. Among the organizational barriers important ones are the difficulty of writing in the contract the process of how and when to get data from the FM service providers, and lack of resources to implement the systems and to make the necessary organizational changes in order for the system to get implemented. Among the external drivers there are improve and control relationships with FM service provider, opportunity to offer single point of contact also in complicated bundled services, government regulation, and critical mass of users. Among the external barriers there are lack of collaboration among software providers, clients and users in

order to develop and store all those info and disagreements between the service provider and the customer about the data that need to deliver. In any case supplier-customer interdependence was found as a key external factor. Among the technological factors important are increased control and systematization in data collection and service delivery, better decision regarding service provision and employees got more control of their daily work. Among the technological barriers there are the ICT systems are still not user friendly, different systems are not compatible, and lack of standard format and classification schemes for FM data input.

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1. Introduction

In the last decade or so companies have been forced to focus on their core competences due to trends such as globalization, increased efficiency, lower costs . To do so, organizations have outsourced many of the corporation's functions to external suppliers. The driver for **outsourcing** is, in fact, the ability to shift non-core services out of the organization, to allow the organization to better focus on their proprietary functions - those functions that give the organization the competitive advantage (Rogers, 2005). This is also true for non core-services such as Facilities Management (FM) (e.g. Rogers, 2005; Ventovuori, 2006).

In the first generation FM was considered as an overhead to the organization and was therefore something that had to be managed for minimum cost rather than optimum value. In the second generation, FM took a process perspective. That is FM promoted the process focus between the organization's individual businesses and the FM organization by making FM activities within the organization a continuous process (Amaratunga, 2001 in Pathirage et al., 2008, p. 8). In the third generation, FM becomes more concerned with resource management, concentrating on managing supply chain issues associated with the FM functions. Finally the fourth generation focuses on the alignment between organizational structure, work processes and the enabling physical environment arguing that the organization's strategic intent must clearly reflect the facilities dimensions in its strategic business plans. Accordingly Alexander (1996) identifies 3 levels for FM: the strategic, the operational and the tactical. In discussing FM in this report we do not take such strict distinction into consideration and mainly position the paper in the third generation of FM according to Pathirage et al. (2008). These are however just background concepts for investigating and understanding the factors impacting ICT systems adoption in the FM supply chain. Therefore it can be that some factors affecting ICT adoption and diffusion are more relevant at strategic level, others are more relevant at tactical and operational level, while some are important at all three levels.

As a result of **outsourcing**, organizations need to ensure they do not lose sight and control of the outsourced service provider, especially if the supplier becomes dependant on driving up volumes in order to remain profitable, to the detriment of quality and innovation (Rogers, 2005). Thus, lately, the role of supply chains and their management has increased importance (Christopher, 2000; Moberg et al., 2003). In addition, supply chains in every industry are moving toward integration as the demands on individual organizations have become too vast to allow them to continue operating in isolation (e.g. Rogers, 2005; Christopher, 2000; Skipper et al., 2008).

The advent of Web technologies and related supply chain management systems is also facilitating planning, collaboration and integration of supply chain partners (e.g. Johnson and Whang, 2002; Rudberg et al., 2002). However, the adoption, assimilation and diffusion of these Web and other IT systems to support the supply chain is often largely contingent upon the extent to which the system is assimilated internally and diffused among networks of business partners in a supply chain (Ranganathan et al., 2004). Previous literature on Interorganizational Systems (IOS) or Electronic Data Interchange (EDI) adoption have showed that such adoption process is not easy and there are a number of factors that influence it (Ranganathan et al., 2004).. In this study we focus on the factors that affect adoption and assimilation of ICT systems for FM supply chain and investigate the following research question: What are the key factors that influence adoption and assimilation of ICT systems in the supply chain of FM? What are the main benefits gained from deploying ICT systems in FM supply chain? This study is important because it investigates motivators and barriers to adopt ICT systems in the FM Supply Chain (SC), which is new to the FM literature as well as the IT innovation adoption literature and Supply Chain Management (SCM) literature. For example Moberg et al. (2003) find that inadequate information systems are one of the main barriers to effective supply chain relationships. The results of this study are expected to be of importance for researchers in the field of IT adoption and operations management, facilities managers and software industry alike.

The report is structured as follows. In this introduction, the background and the research questions have been introduced. In the second section we will provide a literature review of SC and SCM as well as position this paper within the facilities management literature. Then a short literature review of adoption and diffusion of ICT with special focus on IOS and web-based systems literature is given. In the third section the research method is described, while the following section presents the study's results. Finally the last section will discuss the results and give some concluding remarks and suggestions for further research.

The first author of the report has been responsible for the research and is the main author. The second author has contributed with knowledge about FM research and practice, proposed companies to interview, informed about ICT systems in the FM supply chain, and commented and added to the report, including figure 2 and table 4.

2. Literature Review of Major Concepts

Three main streams of literature form the theoretical background of this study: the literature on SCM (e.g. Christopher, 2000; Moberg et al., 2003), the innovation diffusion literature and theory (e.g. Rogers, 1995), and the FM literature (e.g. Jensen, 2008; Alexander, 1996). The innovation diffusion theory (e.g. Rogers, 1995; Tornatzky and Fleischer, 1990) has been applied in several areas including IT adoption and diffusion and especially IOS or EDI adoption and diffusion.

2.1 Supply Chain Management (SCM)

There are many definitions of SC and SCM. SCM takes a systems view regarding all activities and functions that are needed to bring a product or service to market (Sanders, 2007). For example Cooper et al. (1997) define SCM as

“The integration of business processes from end users through original suppliers that provides products, services and information that adds value for customers”.

Christopher (2005) defines SCM as

“The management of upstream and downstream relationships with supplier and customers to deliver superior customer value at less cost to the supply chain as a whole (p. 5)”.

In addition Christopher (2005) defines the SC as

“a network of connected and interdependent organizations mutually and cooperatively working together to control, manage and improve the flow of materials and information from suppliers to end users (p.6)”.

According to Akkermans et al. (1999) it is possible to detect some common characteristics in the various SCM definitions:

- *“involves multiple echelons, processes and functions like, for example, suppliers, purchasing, manufacturing, distribution, marketing, sales, and customers;*
- *Clear focus on the coordination and/or integration*
- *Main aim is to achieve a simultaneous increase in customer service and profitability (p. 567)”.*

The SCM concept has traditionally centered on the manufacturing industries and according to Vandaele and Gemmel (2006) only a few studies have investigated SCM in the service industries (e.g. Ellram et al., 2004; Mabert and Venkataraman, 1998). However in services, SCM is becoming more and more important due to trends such as outsourcing (Li et al, 2006). In addition SCM in services deals rather with customer-supplier dyadic relationships than with the unidirectional movement of physical goods ([Fitzsimmons and Fitzsimmons, 2006](#); [Sampson, 2000](#)). Finally few studies have investigated SCM in the facilities business (e.g. Vandaele and Gemmel, 2007, Nelson, 2004, and Jensen, 2007) and none have focused on the factors affecting ICT adoption in the FM SC.

2.2 Facilities Management (FM)

There are many definitions of FM (e.g. Then, 1999; Nutt, 2000). According to Jensen (2008) the European Standard FM definition is the most widely adopted in Europe. This definition is:

“Facilities Management is the integration of processes in an organization to maintain and develop the agreed services, which support and improve the effectiveness of the primary processes (Jensen, 2008, p. 10)

According to Pathirage et al. (2008), another definition frequently used describes FM as:

“... An integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organization in order to create an environment that strongly supports the primary objectives of that organization (Pathirage et al., 2008, p. 5)”

This definition implies that the processes or the activities of an organization are divided into primary and support activities (e.g. Porter, 1980). In this study by applying the above definition of SC (Christopher, 2005) to the specific field of FM, we can define the facilities management supply chain as *a network of connected and interdependent organizations mutually and cooperatively*

working together to control manage and improve the flow of facilities services and information from suppliers to end users.

FM is then a support activity supplying facility services to support the demand of the primary activities in an organization (Jensen, 2008). Since the origins of the concept of FM it has been increasingly recognized that FM can contribute to the success of an organization and provide a competitive advantage (Alexander, 1996; Puddy et al., 2001; Jensen, 2008). Initially FM was managed as an isolated activity and considered as an overhead like any other cost in the budgeting process. Nowadays FM is managed as an integrated activity, integrated with the commercial, manufacturing and marketing function of the enterprise (Alexander, 1996; Puddy et al., 2001; Jensen, 2008). Pathirage et al. (2008) argue that the FM literature (e.g. Amaratunga, 2001) identifies four generations of FM that focus on the changes to the management of facilities over the last few decades as mentioned in the introduction.

2.3. ICT Adoption and Diffusion in Supply Chains (CS)

The innovation diffusion theory (e.g. Rogers, 1995) has been extensively used in studying technology adoption and implementation as well as in the identification of the factors that facilitate or inhibit technology adoption and implementation (e.g. Grover and Goslar, 1993; Ranganathan et al., 2004). Several researchers have identified the factors or group of factors that affect IT adoption and diffusion in an organization (e.g. Jeyaraj et al., 2006) and more recently and to a lesser extent in a SC context. Ranganathan et al. (2004) by conducting an extensive review of the literature on IT, IOS, EDI adoption and diffusion and SCM identified 2 main groups of factors that affect IT adoption and diffusion in the SC: the external environment of the firm and the internal organizational environment. Within these two groups they identified six factors that are important in web-based systems adoption and diffusion in the SC of the extended enterprise: supplier interdependence, competitive intensity, IT activity intensity, managerial IT knowledge, centralization, formalization of IT unit structure.

Ranganathan et al. (2004) expect that the three factors from the organizational environment (managerial IT knowledge, centralization, and formalization) are associated with internal assimilation of Web technologies and systems, while the three factors pertaining to the external environment (supplier interdependence, competitive intensity, and IT activity intensity) are

associated with the external diffusion of Web technologies and systems in the SC management. The importance of factors belonging to the organizational environment as well as to the external environment has been showed in a number of studies (e.g. Fichman, 2000; Jeyaraj et al., 2006). Many studies have also found that the characteristics of the technology itself might be important in the adoption and diffusion process both at organizational (e.g. Rogers, 1995; Tornatzky and Fleischer, 1990) and SC level. For example in a study of adoption of mobile technology in the SC, Doolin and Ali (2008) found that three key attributes of the technology have an impact on mobile technology adoption in the SC: relative advantage, compatibility and complexity (See Table 1).

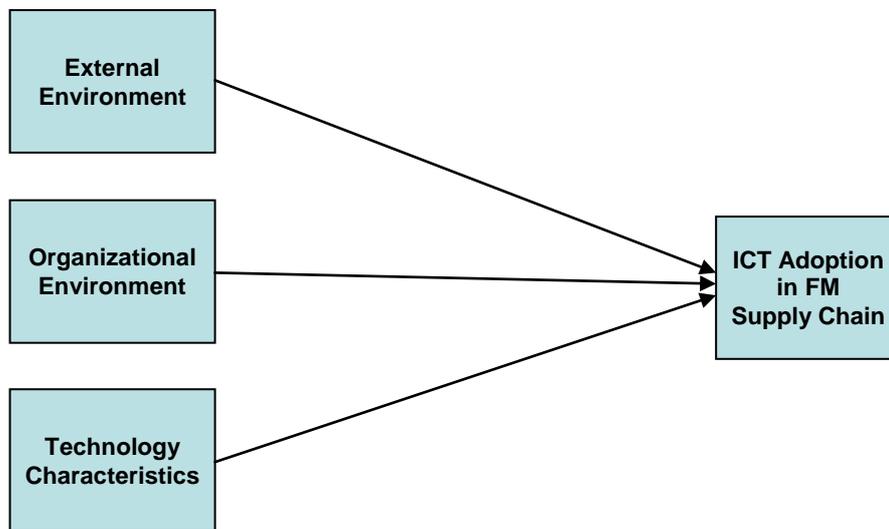
Key drivers	External Environment	Organizational Drivers	Technology Characteristics
	Customer/Supplier interdependence	Managerial IT knowledge	Relative advantage
	Competitive intensity	Centralization	Compatibility
	IT activity intensity	Formalization of IT unit structure	Complexity

Table 1: Synthesis of key drivers impacting IT adoption in the supply chain

By drawing on the study by Ranganathan et al. (2004) and Doolin and Ali (2008), it is proposed in this paper that the external environment, the organizational characteristics (drivers and barriers) as well as the technology characteristics all influence adoption of ICT systems in the SC of FM, therefore the following model (Fig. 1) is proposed.

For many decades, intermediaries within a SC have used EDI and other types of information technology to send data electronically between different firms. This service was costly, and traditional EDI was cost-prohibitive for small and medium sized firms (Lancaster et al., 2006). Today the public internet and web based applications are making exchange of information within the SC much easier and cheaper (Wang and Zhang, 2005), and consequently many more firms, including small and medium size, are adopting ICT systems in their SCM activities. Nevertheless, the adoption and use of IT and especially web-based technology in the SC of FM has not been investigated earlier. Therefore the importance of this study.

Figure 1: A Model of Key Factors influencing ICT Adoption in FM Supply Chain



3. Research Method

A critical issue in answering the research question was whether to use a quantitative research method such as a survey or a qualitative research method such as interviews. Here the choice to use a qualitative research method has been made. This is because it is considered important, in first place, to qualitatively understand the factors that might be peculiar to the FM industry. In fact, even though studies have investigated ICT adoption in the SC in general (e.g. Ranganathan et al., 2004; Johnson and Whang, 2002), this is the first study (to the best knowledge of the author) that particularly focuses on the FM industry. This methodology in the investigation of adoption and diffusion related research questions is further justified by Rogers (1995, p. 390) who states: “data about the innovation process are obtained by synthesizing the recallable perceptions of key actors in the innovation process, written records of the organization adopting, and other data sources”.

The research has been designed by first conducting a thorough literature review of studies investigating IT adoption in the SC as well as IOS and EDI adoption factors. With this background in mind, a number of qualitative interviews have been conducted with facilities managers involved with ICT in FM SC, CEOs in companies developing software systems for FM

SC and managers in facilities service provider companies. Here a selection of companies that are already adopters of ICT systems in the supply chain has been made in order to understand the reasons leading to adoption as well as adoption benefits. Understanding these factors should help other companies and researchers to make a decision. In a second phase of the research, the author intends to use these results to conduct a comprehensive survey of factors affecting IT adoption in the FM SC in Denmark to further test these qualitative results. This research design has been successfully employed in other studies (Chong and Bauer, 2000).

3.1 Data Collection

Data for the study were gathered from archival sources, interviews with companies as well as attendance to practitioner conferences and workshops on the topic of IT systems in FM. The participant lists of these seminars and conferences, the web site of the Danish Facilities Management network (www.dfm-net.dk) as well as discussion with industry experts were used to find relevant companies and people to interview. In all, representatives from twelve organizations were interviewed. Only two of the companies contacted were unwilling to release an interview due to company policy.

A mix of facilities service providers, FM customers and FM ICT system providers and consultants was chosen to help reveal differing factors affecting the adoption and implementation of ICT systems in FM. In facilities service providers and FM customers, the respondents were high level managers responsible for FM IT systems investment, application development and usage. In software companies providing and selling IT systems solution for FM SCM, high level managers and directors were interviewed. Software vendors and providers have been selected as it is believed that they have a good insight about the factors that influence IT adoption both in the service provider and the customer.

All interviews were conducted in the period December 2008-March 2009, and each lasted circa 1.5-2 hours. Interview questions were semi structured (Yin, 2003) attempting to elicit the variety of factors that affect adoption of SCM IT systems in both FM providers and customers. All interviews were tape-recorded and transcribed. Notes were also taken during the interviews. To increase reliability an interview protocol was used and a database was developed (Yin, 2003).

This protocol was slightly adjusted depending on the type of company interviewed: facilities service providers, FM customers or IT system providers. The protocol questions were organized into two parts. The first captured company background information such as type of business, years in business, FM activities and use of IT in FM. This information were supplemented by information provided on the companies' web site, annual reports, sales brochures and other material provided by the companies or collected in the practitioner workshop and conferences where the author participated.

The second part specifically aimed at collecting information about the significant factors affecting adoption of IT systems for the FM SC. These questions were very broad, giving the possibility to account for as many factors as possible, even though based on the literature review. In addition they were semi-structured and open ended in order to collect as much information as possible about the factors that affect IT adoption in FM SC. In addition, each interview ended by inviting the respondent to add anything else that could have affected FM IT systems adoption in his/her company. This research design is based on Miles and Huberman (1994, p. 58) suggestion to create a provisional "start list" of codes prior to the field work to guide the analysis. The coding was manual. As already said, this "start list" was based on the literature review and the research question. However, new codes emerged progressively during the data collection, often uncovering new factors related to IT adoption for FM supply chain. Finally, sometimes the respondents mentioned factors belonging to a context in a question related to another context or talked freely, therefore in the analysis there was a necessity to go back and forth in the transcriptions in order to place the factors under the right category as suggested by the theoretical framework.

Table 2 provides a summary of the characteristics of the companies interviewed.

Company Type	No.	Person Interviewed	Number of employees	IT FM System
Big FM provider	A1	Department Senior Manager	250 in Denmark 4000 In Scandinavia	A system to handle reports on the tasks accomplished at the customer site, as well as a database. It is also used for forecasting. It is web based and the managers at the customer's site can log in and input and look at the data. Maximo
IT System provider	A2	Department Manager	25	Web-based system to handle the maintenance, space management and operations of buildings
Big Consulting company in the building and FM market	A3	Head of the FM department	45 in the FM Department	Have developed their own IT system, but also use FM systems developed by other companies. It depends on the customer needs and wishes.
Big FM provider	A4	Development Director	(company prefer to keep size undisclosed)	Have developed their own complex system. They are heavily relying on this system for their existence. Partially based on ERP systems.
Big Pharma Company	A5	FM Department Director	90 people in the FM Department (company prefer to keep size undisclosed)	Earlier had a pure FM system (FM anywhere, web based). Nowadays they have developed a module for FM within the ERP system called EAM, which is not web based; use a lot of e-mails and telephones
Consulting Institution	A6	Construction Consultant	Ca. 850	Have been involved in consulting services involving the use of ICT systems in FM
Big Public FM Organizations	A7	FM Manager	170	Are in the process of developing and implementing a web based system to coordinate FM tasks with external suppliers and consultants; ICT systems include Navision Stat, Byggeweb
Big Public Organizations	A8	FM Manager	45.000 employees in total. 15 in the FM department, FM dept. only takes care of building and basic installations maintenance and new construction	Web portal for e-procurement (but uses mostly e-mail) Excel for FM Planning Caretaker for FM data collection (used only internally, not in communication with suppliers) Byggeweb (not very used)
Big State /private Organization delivering experience services	A9	FM Manager	Ca. 1100	They have just installed a web-based FM system for supply chain management and are in the process of uploading older data and teaching their suppliers about how to use it.
IT System provider for FM	A10	Director of the Danish Subsidiary	6 in Denmark, Circa 12 in the Main office located abroad	DriftChefen
Big Financial Service Firm	A11	FM Manager	FM is organized as an intern function with 160 employees	DriftChefen
SME providing FM Service to mostly big corporations	A12	Manager also in charge IT	Ca. 145 managers Ca. 430 FM workers	They use different systems. Sometimes they suggest the customers to start adopting a system, most of the times it is the customer imposing them the use of a specific system in order to conduct business with them.

Table 2. Characteristics of the companies interviewed

Table 3 provides a quick overview of the number of companies interviewed in each category (Facilities service provider, FM customer, ICT supplier/consultants) and figure 2 shows how these organizations are placed in relation to each other in the FM SC. Both ICT suppliers and consultants can be providers to both facilities service providers, internal FM functions (FM customers) and the core business organization (client).

Sector	Facilities Service Provider	FM Customer	ICT Supplier/ Consultant
Number of Companies in Each Sectors	3	5	4
Number of Companies in Each Subsector		2 FM service customer with own FM department 3 mainly outsourcing FM service to external providers	2 ICT suppliers 2 consultants

Table 3: Summary of Companies by Sector

Figure 2. The companies in the FM supply chain

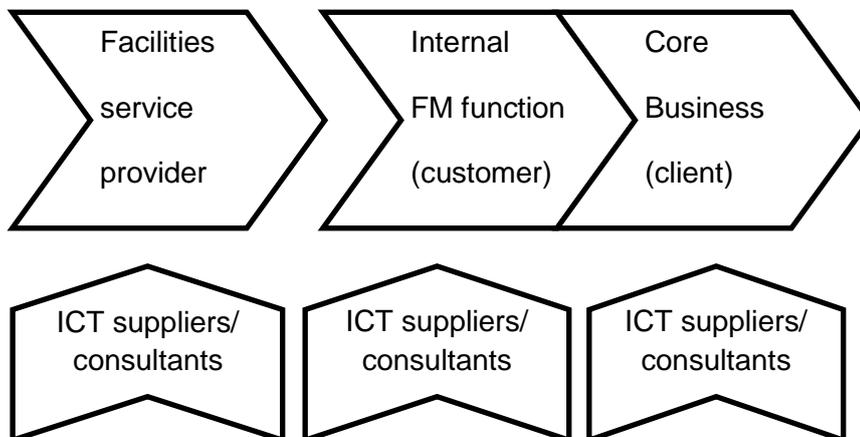


Table 4 provides a list with description of the IT FM systems mentioned in the interviews.

Name of IT FM system	Description
Byggeweb	Danish web-based project-web system for storing and exchange of documentation about building projects and existing buildings. Developed and introduced in 1997 by the company Byggeweb A/S, who also has developed CoreFM.
Caretaker	Danish FM systems with main focus on O&M. Developed and introduced in 1994 by the consulting company COWI. Caretaker is used by many Danish municipalities.
CoreFM	Danish CAFM system with main focus on space management. Developed and introduced in 2004 by Byggeweb A/S.
DriftsChefen	Icelandic FM systems with main focus on O&M. Developed and introduced in 1995 by the consulting company ICEconsult.
EAM	International asset management system with main focus on maintenance. EAM is marketed internationally by the IT company Infor.
FM Anywhere	Danish FM systems with main focus on O&M. Developed and introduced in 2004 by the consulting KeyCon.
Maximo	International maintenance system from 1984 marketed by IBM
Navision	International ERP system marketed by Microsoft. A version called Navision Stat is targeted towards state institutions
SAP	International ERP system developed and marketed by the German company SAP AG
Vista FM	International FM system also called TAC FM with main focus on O&M. Developed in 1991 by the Finnish consulting Granlund and marketed internationally by the building automation company T.A.C. – part of Schneider Electric

Table 4. IT FM systems in the interview survey

4. Analysis and Results

4.1 ICT use

The results show a complex and fragmented picture of uses of information and communication technologies in FM SC. Some companies are using only one ICT system; others are using several systems that not are necessarily communicating with each other. Still other companies have acquired and installed different systems, but they are still using the most well known systems such

as Excel for decision making. Even though this study acknowledges the limitation that not all the ICT systems used in the companies interviewed are systems that truly interconnect the SC in an automatized way, they are still taken into account and reported in this study as we assume that the systems interconnecting the different actors of the SC are the ones that are used in practice.

Therefore when the respondents perceive that an ICT system supports SC related decision making, then we take that system into account in this study. In addition some companies use only one system for decision making, independently of the decision making level (operational, tactical and strategic), others use different systems for different levels of decision making.

The companies interviewed have adopted different kind of ICT systems in the SC. Most companies are using, have used or are familiar with web-based systems. However a few still prefer using Excel or other spread sheets. Companies use a variety of ICT systems and they say that often it is not easy to choose the right ICT system for the FM SCM. CoreFM, SAP, Maximo, Driftchefen, FM Anywhere and Caretaker are some of the systems used. ERP systems such as SAP are also used, but they include customized modules for FM such as Asset Management Systems. In the public sector it is used Navision System, Vista FM. Sometimes the IT system is managed by the adopter company whether this company is an facilities service provider or FM customer; sometimes it is outsourced to third party IT providers. When using web-based systems, the companies have a customized portal for each client/customer. This portal allows each company to get into the share of the database and ICT system that concerns them.

It looks like there is no specific system really prevailing on the market, even though a couple of them were mentioned by a few companies to start being more common. According to a system provider of web-based FM solutions for FM SC, circa 20% of the Danish companies that could be potential adopter of an ICT system have already adopted one.

ICT systems in support of FM SC are seen first of all as a recording and data collection systems that need to be used on a daily basis at operational level if they have to add value to the company's operations and decision making in general. On the other hand such systems may reveal to be very valuable in operation planning and control as the following statement shows:

Interviewer (I): When solved (the FM related problem) who registers (in the ICT system) that it is fixed?

Respondent (R): The one who logged on and who informed of the error. It is a reporting and data catch system. If an installation (FM related) breaks down again with the same type of errors

repeatedly, a replacement of the installation should be considered rather than a repair. Part of our key performance indicator is based on the fact that there have been a certain number of errors for various reasons. (A1)

These systems have also provided the basis for improved management decision making regarding FM provision to customers and have contributed to make work practices more systematic and stringent, thus making it easier to “manage”. They are also used by middle and upper management to make decisions regarding the service level, budget, future FM investments, etc as the following statement shows:

I: What did you have before (this ICT system)?

R: We had paper.

I: Has anything been changed since in the way you handle things?

R: Yes

I: In what way?

R: The system is now more systematic and standardized with less individuality – standardized and systematic. (A1)

ICT FM systems are also used for e-procurement and for communication with the users of the buildings as the following statement shows:

R: There is information on leases so the tenants can see the size of the lease, the rent and in the future we will also inform about the maintenance plan – it is information from us to the users and the tenants. When inviting for tenders, we do this on the portal, so it is on the internet we have just launched our own portal. (A8)

We can conclude that ICT FM systems can be of great value to a corporation if used appropriately and can support not only one specific FM level (operational, tactical and strategic) but all of them in different phases of service provision/consumption and with different purposes.

4.2 FM and Supply Chain

The study results show that FM is increasingly seen as a support activity to the core activities of the organization rather than a cost center as already pointed out in the literature review (e.g. Amaratunga, 2001 in Pathirage et al., 2008, p. 8). Companies acknowledge more and more the value of their building assets, working space and anything related to FM. In addition FM activities are more and more outsourced to external service providers. Often this is a good thing for the FM department employees as the following citation states:

R: We are happy to take over their employees, which they like because we are specialists in this field. Earlier they were used to being on their own and being a cost center, and now they are more active with us. (A1)

The study also shows that companies use different business models in managing their facilities and their outsourcing operations. The ones we encountered are:

1. FM is completely outsourced to external service providers. This includes also the bidding process for FM services etc. In this case usually there is someone in the client organization responsible for the FM budget and the quality delivered by the service provider. The customer organization might even have a small department depending on how big the company is.
2. FM is conducted by an FM department internal to the organization, who serves all the organizational units and buildings.
3. The parent company establish a subsidiary company in charge of all FM tasks in the organization.
4. FM is partially conducted in house and partially outsourced.

4.3 Organizational Context Factors

The study reveals that there are a number of organizational drivers and inhibitors that influence ICT systems adoption and assimilation in FM SCM, summarized in Table 5.

Organizational Drivers and Barriers	Organizational Drivers	Organizational Barriers
	<p>Improved control over the data that are being handed to the service providers in the outsourcing situation (A2) and data gotten from the service provider (A7)</p> <p>Better FM management decisions (A1)</p> <p>Better long and short term planning and forecasting of FM resources (A7)</p> <p>Better overview and control over the budget and the activities to be done (A3, A6, A5, A8)</p> <p>Better servicing of customers (A1)</p> <p>Top management support through organizational policy (A8)</p> <p>Return on investment and improved efficiency (A4);</p> <p>Being closer to the clients and the users of services through direct communication (A4)</p> <p>Get around gate keepers (A4);</p> <p>Source of innovation (A4);</p> <p>Overview of the portfolio by making it (e.g. 3D) (A6, A8)</p> <p>The right information to give to the service provider or internal FM people (A6)</p> <p>Better working conditions by having all the info in one place (A6; A7)</p> <p>Political Decision due to state requirements (A7, A8)</p> <p>Need to keep FM knowledge in house when the FM task is outsourced (A7)</p> <p>Need to keep all the FM and buildings info in one place in periods of growth or buildings extensions (A7)</p> <p>Improved quality assurance of the service delivered (A7)</p> <p>Cost Transparency (A5) and capability to link costs to each activity (A5)</p>	<p>Employees resistance to change at the operational level Lack of FM education (A1, A2, A6, A7, A9, A10)</p> <p>Lack of training and resources to learn the new system (A2, A6, A9, A10)</p> <p>Lack of IT competence (A1, A2, A6, A7, A8, A9, A10)</p> <p>Fear of flying (A1, A8)</p> <p>Building owner do not know what to ask from FM in the construction phase (A6, A7)</p> <p>Lack of knowledge at the client about how to incorporate FM in the building phase and how to use IT for it. (A6, A7, A8)</p> <p>Difficulty to incorporate in the contract the process of how to get data from the service providers (A7)</p> <p>Lack of language skills (e.g. English) (A5, A9)</p> <p>Lack of resources to implement the ICT system and to make the necessary organizational changes in order for the system to get implemented (A10)</p>

Table 5: Organizational Drivers and Inhibitors

The study shows that the key organizational factors that initiated ICT adoption in FM SC are top management leadership and vision, the decision to outsource FM operation to an external service provider, return on investment, the company's growth and expansion that made necessary the need to have an overview on the buildings and related FM expenditures (therefore company size).

Adoption Drivers

The decision to outsource FM activities to external service providers has created new challenges regarding the company's FM knowledge, especially since the FM external service providers could potentially change periodically due to the limited time procurement contracts. Therefore the need to keep such FM knowledge in-house. The decision to adopt the FM ICT-system therefore is seen as a way to centralize the FM knowledge in a place where it can be accessed both by the service provider and the service customer as the following statement shows:

R: I think that one of the most important factors isit is a decision that has been made that we must outsource ... not only we outsource, we have to tender in four year contracts, and this made by outsourcing, first we moved all knowledge of our buildings outside our organization and then by doing in four year contracts we assured that any knowledge that our external had about our buildings disappears every four years. So it's been a very vital factor that we need to take all of the information and bring it home again into a system. (A7)

Top management also has an important role in the adoption decision as pointed out by A8. In addition company size and company growth also influence the adoption decision. This is because as the company grows there is the need to centralize the FM information in one place to make it easier for employees to access FM related information in order to make the right decisions. As the company grows it might in fact be impossible to rely on the single employee for FM information. ICT systems help keeping record of all the information relative to FM, therefore making it possible to provide better FM services. Establishing a FM help desk is seen as a good solution to immediate FM service response, but it can only be justified by the size of the company as the following statements show:

R: I think one of the factors is that we've... experienced this, a rather large growth and suddenly you know when we had 35 buildings we had every one that has to do with the buildings knew exactly what was going on, but now we have people who have the responsibility of maintenance for 50 estates and they just don't have that level of detail so ..We have to put it into the system and also sometimes suddenly you have to work on your colleagues' 50 buildings and you know it's just.. There's absolutely no way you can avoid putting this data together. (A7)

R: Size is an important factor to have a help desk.. . We have been into this solution for the property management to have one call center and one email box ... but we are not large enough ... for two reasons. There are not calls enough and jobs enough to have a person there to take care of it... and the other thing is that many of these calls have to be done right a way so it is not beneficial... so even if we are a big company ... we are not big enough. We have been thinking to join our IT site help desk to use their help desk ... but we have not gone further with that. (A5)

Some actors of the FM SC such as FM consulting companies might decide to adopt ICT FM system because they see them as a market opportunity or just because they are forced to adopt that system if they want to conduct business with a certain company as the two following citations clearly show:

I: What has made you going for example for(ICT) system?

R: Because we see it as a market opportunity..we are not able only to take care of the program we made ourselves ...and we are able to work with them because we know when we meet a client we have to accept what he has as IT program and we have done work with that other place before and so it must be ..we find that very often when clients want to have such program it is hard job to build it up and to put all the info in so that you can work with it, next thing it is to learn the people to work with it in a day time, if you should not work with that program in maybe 3 years then the info inside will be outdated. (Manager, A3)

Return on investment and efficiency are key factors influencing the adoption decision as a big service provider states:

I: How about the internal factors, personal or reasons that influence this system adoption.

R: Return on investment and efficiency, that is the only reason that we can find out to invest in. (A4)

Assimilation Drivers

However there are a number of organizational factors that influence the assimilation of ICT in FM SC, including better overview of the activities and the budget, better decision making, better

communication with customers, more systematic ways of recording and analysing data. For example a manager of an facilities service provider mentions how ICT FM systems have helped them to be more systematic in conducting their work and how it can help them to manage, improve efficiency and make better service development decisions, thus in general providing a competitive advantage and added value to the company:

R:We would like to be more ahead of things, be with the clients who have entrusted us in this field. We would like to manage, develop and make things more efficient, so some of these management information systems (MIS) are mainly a question of management. (A1)

A7 points out how they wish to have a better overview of the FM budget and FM activities as well as the drive to make better FM management decisions have been also important drivers to assimilate the FM ICT systems in their company:

R: But also there have been a number of demands for a better overview and better data to make management level decisions because as soon as we have centralized all these costs we have so much better possibilities extracting data and you know data mining and making management level decisions and that's also are rather large wish. (A7)

In addition ICT systems make it easier and faster to get the information needed to make FM management decisions as showed by the following statement:

R: This would often be something that would take days, sometimes weeks of manual work to put together the data to make a ...and now we have...a much shorter answering time. That means management ...feels able to know, to ask more intelligent questions and I think this gives management the feeling of more freedom to be able to maybe ask more often and get more data to make the right decisions. Because earlier they had too, maybe sometimes think, which question is the most important because if I ask it will take them five days to give me an answer. (A7)

Another major organizational driver in assimilation is better communication between the supplier and the customer, making service providers and service customers feel closer to each other as well as making it easier to get around gatekeepers and communicate directly with the relevant people:

R: Of course we are much closer to the clients and the users of our services and we can communicate directly with them. It has helped us get around gate keepers, if the person sitting here responding is acting like a gate keeper they would not allow to talk with their employees, then now they cannot control information and communication. (A4)

A big importance for proper ICT assimilation is also the organizational policy and ICT system implementation strategy used by the company. If the adoption and assimilation decision is made centrally and enforced throughout the company by top management the assimilation might be more satisfying than situations where the assimilation decision is left to each employee of the company as the following shows:

We see that where they make a central decision ... now the people, the project are not the problem they have decided to go for this and that is ok, we experience many places that one individual is dealing with this part and he does it this way , and another does it that way, very isolated so it is just as much the organization how they organize. (A3)

Adoption and Assimilation Barriers

There are also a number of barriers that slow down adoption and especially implementation of FM ICT systems. Important ones include lack of resources to learn how to use the system, lack of knowledge from the client about what they would like regarding FM in the future of the building, lack of competences.

An important organizational barrier to ICT FM systems adoption is that usually at the point of construction, the client does not know what he/she would like from from FM afterwards. Therefore they underestimate FM and the data collection process related to it. This is already important to take place at the stage of planning and construction of a building as the following citation shows:

R: As a building client you must also consider what you want finally as a client, what do we need, and therefore there is a great need for this identification: What do we need afterwards? Actually, nobody knows. Many research projects are looking for barriers, but it is a very practical problem. (A6).

An important organizational barrier is also the lack of resources to dedicate to learn how to use a new system as often pointed out in the literature and by the following citation:

R: This is to a great extent related to the resources you have internally. You are busily engaged in many activities, and resources are required to familiarize yourself with the new tools that are often not optimal user friendly... the software companies know how to take advantage of this putting new versions on the market every year requiring you to attend courses... It is also a question of freeing the required resources, so you can work with the new system now. (A6)

The ICT systems offer many advantages and opportunities to be accurate and stringent with the FM data. On the other hand accuracy and standardization can also be a barrier to assimilation as showed below:

R: I see one of the downside is that you have to adjust for stronger demands for accuracy and standardization and a certain systematic way of doing everything. There is less freedom for doing things your own way for some of our architects and for some of our own people this has been a sort of a stone in the road which they have to overcome and I know this is very much at the operative level (A7).

Another major factor slowing down assimilation is also employees' competences that can be either ICT use related or English language related, especially for employees using the system at operational level as the following shows:

R: ...In the daily operation we have 2 people who are our super-users in the EAM system within FM here ... but as all our communication is in English when you come to the system then it is actually a problem... it is language skills... the main problem today. .Yes, that is part of (the company).. That they have to be able to communicate in English. And many of the employees are educated as electrician, carpenters or plumbers and they have not been travelling, they have not learned English (A5).

*R: ..There are certain competency barriers, not everybody are equally trained in using ICT systems.
(A8)*

4.4 Technology Related Factors

The study shows that there is a number of technology related characteristics that influence both adoption and assimilation of FM ICT systems in the supply chain as showed in Table 6.

Technology	Benefits	Barriers
	Give quick overview of the situation at the customer site and be able to serve the customer better (A1) The customer get a better overview of the service providers' service quality (A9, A10) Increased control and systematization in data collection and service delivery (A1, A7, A8, A10) Faster service delivery and response to help situations (A1, A9) Better control of the tasks accomplished by the service provider (A9, A10) Better specification and measurement of the desired services (A10) Employees got more control of their daily work (A10)	The ICT systems are too complex to use (A2, A6, A5, A8, A9, A10) Continuous updating and inserting the information in the system (A3, A8) Data validity (A8) Lack of standard format and classification schemes for FM data (A6, A7, A8, A9, A10) The easiness of use is not good enough (A6, A5) Incompatibility of different systems, implying a lot of re-keying if it is necessary to change the system (A5, A8) Nye software versions making it more complicated to learn how to use the system (A6)

Table 6: Technological Drivers and Inhibitors

Drivers

For example one of the assimilation drivers is that FM service providers can get a better and quicker overview of the situation at the customer site and be able to provide a better service as the following citations show:

R: When with the clients it is important quickly to assess their business and to serve the clients better. (A1)

...

I: What about efficiency?

R: They get it quicker and can take the correct action so they quickly can use the system and be told what to do to read to key performance indicators from the system.

For instance in the case of a cooling system, I definitely think you will be with the client quicker (A1)

Another important technology driver is a better overview over the activities that need to be done as well as budget, resource management and better data integration. Another important factor is making it easier to control that the planned activities really get implemented and therefore employees' control:

R: The main benefit is that we can link our asset....directly into our finance system and then we can keep track of all costs on both sides... the investment and the daily.... capacity costs ... the daily operations costs ... yes...and we can track that, because each ventilation and cooling machine or what ever has one unique number where all costs can be added to, and that part has being established in this period... so suddenly we are able to see the costs for one machinery from birth to death... we are able to track that in the future, and that is the major benefit. (A5)

....

R: It is a planning system and it is a control system...The advantages .. are that we fix our schedules for our maintenance jobs...meaning that I am sure that the employees in my organization are doing what they have to do ...I am getting a report each month....so it is very easy to control our maintenance has been done...(A5)

....

R: Normally you have double or triple accounting..here you get a much better overview over the budget and the activities you need to have done. (A3)

....

R: Overview – you have to be systematic.... Data integration, you have all data only at one place. (A8)

In addition the possibility to visualize the data as well as have intelligent buildings could be an important potential driver in the future:

R: In FM it is all clear ... you have for example. an overview of your portfolio with many m2 to manage, that is important. For renovation and maintenance you have exactly the information needed by the consultant. That is a very important parameter, e.g. for cleaning staff to know what to be done and cleaned, it is all about making data accessible, and that we have an overview by visualizing them, thus we can make quicker and better calculations and resource management. We can prioritize our efforts and initiatives, e.g. roof repair work is more important than interior painting. In the long term we can incorporate tags in the buildings. I could think of a model with intelligent tags indicating humidity damages so we can prioritize our efforts. (A6)

Barriers

A major technology related barrier is found in the daily use of the system and in the updating of the data in the system. In fact if this is not done in a very systematic and stringent way, then the data might not be valid and the decisions might be taken on a wrong basis. So, if a company decides to adopt such an ICT system it is important to keep the data up to date, otherwise they cannot be used for decision making, as the following citation shows:

R: The problem is not in the installation of the system, it is in the use of the system and as a matter of fact looks like a complicated task every time updating what has been done and what has not been done E.g. in a building how many people would you need there..dealing with this system. (A3)

R: It requires discipline to use the systems. Data entering must be stringent. If data in the system are incorrect and not updated, you do not rely on the data you draw from the system. High data validity is of great importance – this is a barrier when using the systems. (A8)

Other major barriers are the lack of classification schemes and standard formats to represent the data to be inserted into the FM ICT system, the lack of communication and compatibility standards between the different ICT systems as well as the lack of knowledge from the client about what they want with FM as the following citations shows:

R: I think that one of the barriers is that to use the system you need classification systems ...you need systems that describe hierarchies of building components, you need classifications of... all

your maintenance activities you ...Need a lot of classification and a lot of standardization and all this classification and standardization is new to everyone including the system developers and some of it has not been done yet and you know the new classification system. (A7)

I: You think that today we do not have a format where the different systems can communicate?

R: Even when the systems communicate, there are problems with correct data entry.

The building owners are often not completely precise about which maintenance data they are interested in ...and there are very few standards... they are also having trouble making correct decisions about just exactly what is the right data to put in. (A7)

I: You use different systems, ..., do you experience communication problems among the different systems?

R: Yes, but on a minor scale. (A8)

4.5 External Environmental Factors

The study found that one main external factor that influence ICT adoption in the FM SC is suppliers' or customers' suggestions, requirements or pressures as it is known from the literature on IOS adoption. Often customers request suppliers to adopt their own ICT systems in order to be able to conduct business together or vice versa. Sometimes the adoption is a prerequisite for conducting business together and therefore mandatory, sometimes it is a suggestion that might lead or not to the adoption of that system. This depends on the FM activity that has to be done, the specific contract the customer and the supplier engage in and, especially, the power relationship between the 2 companies engaging in a SC relationship. In any case this condition shows that definitely there is supplier interdependence among the companies as the following citation by a consulting company providing also FM services shows:

R: It is not always the clients that are aware of the IT systems..mostly that is us convincing the clients saying you are much better with an IT system, it does not have to be our system but any system because of course we can do maintenance of an organization building , but for us it is also much easier when we have an overview in the database. (A3)

An overview of the external drivers and inhibitors are given in table 7.

External Drivers/ Barriers	External Drivers	External Barriers
	Supplier Interdependence-FM provider or customer (in an outsourcing situation) are forced to accept the partners' system (A7, A4, , A3, A12.) Improve and control relationships with FM Service Provider (A2, A12); Market opportunity (A3) Clients ask for single point of contact (A4) Political decision (from the ministry) to outsource (A7) Knowledge acquired in different networks (A7) Forecasting that requirement on "Den digital FM system" could come within 1-2 years (A9) Job market flexibility (A7)	Lack of collaboration among software providers, building customer and users in developing ICT systems (A6) Government Regulation (validation)(A5) Sub-suppliers not knowing Danish if they are Germans or Polish (A9) Disagreement between the service provider and the customer about the data needed to be delivered (A8) Critical mass of users (A8)

Table 7: External Drivers and Inhibitors

Politicians, policy makers, regulation also have an important role especially in public organizations such as A8 and A7. In other cases, more complicated, the customer may require a single point of contact with the service provider and if the services provided are many or complicated, this task is impossible to be handled by only one person, so the single point of contact becomes the ICT FM system. In this case the ICT system might vital for the existence of the service provider, as the following citation shows:

R: Major reason is that the clients ask for single point of contact and you cannot have a single point of contact through one person; that is not possible. If you look at the client, here you have A4, you can put a manager here and there a manager, but they have a huge organization, so if everything should go through these people they would melt down, that is not possible.. You need to create a bypass so that the request from the client organization can go through those who have to deliver; it does not go through a manager, that is why we do not make a set up without putting in a help desk. Some of our clients have hundreds of meeting facilities to take care of, so it is impossible to do that without IT; that is impossible. It can't be done without IT - yes it can, but requires a lot a lot of people that nobody could afford it. (A4)

.....

I: Were your clients ready for this?

R: They did not know it was possible and we still meet clients for which it is a big surprise that they can get everything in one package and sometimes they are very reluctant, if they have made an investment, to through that investment in the water and invest in something new, even though there will be a lot of value, but no, we spent a million on this and now you want...let' us continue 2-3 yrs. until it is paid for.

R: It is included in our base price, they cannot negotiate, and without that we are not able to make things work. It is how simple it is. (A4).

On the other hand the type of industry the company is in might influence the type of ICT system to use in the company. For example a company had a web-based system that was not validated by some industry organizations and therefore they had to switch to an ERP system which was not web-based, implying that a lot of data have to be typed in manually into the system on a daily base:

R: ... And the EAM is part of our ERP system.... so before that we had a web based systemBut the problem with that system was not the functionality ... the problem was that they could not ... validate the system ...The web-based systems are easier to use. (A5)

Also job market flexibility, especially in periods of high economic growth, implying high turnover of employees and therefore the need to keep the information and knowledge that employees have in a central place might have an impact on the adoption of FM ICT systems:

R: ...Our employees disappear as well, so the flexibility of the whole setup and also of the job market has been a big factor in the decision in putting our information into an IT system. (A7)

Supplier Interdependence

As discussed in the literature review, the concept of supplier interdependence has resulted as a very important factor influencing ICT adoption in the SC. This is very understandable as in the SC what the service provider does influences the customer and vice-versa due to the definition of supply

chain. In our study we found that this factor is indeed important also in FM SC as the following citations show:

R: Especially if you have instructed your service partner in using the same system, for warning and correction purposes.

I: Does this often happen?

R: No, because we are good at preventive maintenance. (Manager, A1)

....

R: So you see the internal and external factors very much depend on each other, it is market opportunities, it is customer wishes and sometimes your own inputs to the customer (A3)

The study also shows that in understanding SCM issues it is important to take into perspective different actors from the SC. For example in order to have FM ICT systems that are easy to use and meet the FM clients or providers needs, it is important that software providers, client and users collaborate in order to specify what the characteristics of such a system should include as the following quote shows:

R: ..But for the incorporation of the information I think the relation between the user, the software dealer and the client's demands is very important. If we can all agree on this, we have come a long way. I think we are at the point of a paradigm shift working in reality with many of these elements The important thing is how to get all the information incorporated, also in operation, digitally, notes, and files. How do you include all this information in an intelligent way. (A6)

In the supplier interdependence a major issue is coordinating and formally righting in the contracts between supplier and customer when and in which format the data need to be delivered:

R: The simple thing of making sure ...that we have described also in our contracts the correct processes so we get data when we need to work with them that so that's a rather large piece of work which we're still working on. (A7)

5. Conclusions

This report has presented the preliminary results of a study of factors impacting ICT adoption in the SC of FM in Denmark. The study has showed that ICT systems for SC in FM are starting being adopted and used by companies, but still to a limited extent. In fact according to a key person interviewed circa 20% of the potential adopters companies are effectively using an ICT system in their FM SC in Denmark. So there is a huge potential out there.

The study shows that this is the case mainly due to the characteristics of the ICT systems, that are not that user friendly and often incompatible with each other, the lack of standards and classification schemes for imputing the data into the system as well as the lack of knowledge and awareness of the building clients about what data they want concerning FM.

The study shows that there are a number of important external drivers of ICT systems adoption among which the outsourcing trend and relative need to keep at least some of the data in house, the market flexibility, government regulation, and factors that go under the name of customer-supplier interdependence such as improved customer relationships.

The study found a number of organizational and technological drivers and barriers of ICT adoption. Among the drivers there are better FM management decisions, better long term and short term planning and forecasting of FM resources, better overview and control over the budget, as well as increased systematization in data collection and service delivery. Key barriers include instead the difficulty of writing in the contract the process of how and when to get data from the FM service providers, lack of resources to implement the systems and to make the necessary organizational changes in order for the system to get implemented.

6. Limitations

The study is not free of limitations. For example it is difficult to generalize from this data set, and it could be beneficial to conduct a survey to test whether the factors found in this study apply to the rest of the population of ICT adopters in Denmark. Alternatively an in-depth case study could also be conducted to go in depth in one company with the analysis of drivers, barriers and benefits of ICT adoption in FM SC. These alternatives are taken into consideration in further research.

Nevertheless I believe that this study is important because it gives an idea of the motivators, barriers and benefits of adopting ICT systems in the FM SC, which can be of interest to practitioners, especially managers involved in FM, and researchers alike.

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