Impact of emerging technologies on Facility Services

- A mixed-methodic approach on Smart Building Technologies

Alexander Redlein and Lisa Grasl
Vienna University of Technology
IFM – Real Estate and Facility Management
1040 Vienna, Austria

***Abstract* —The Facility Service (FS) industry is the third largest sector in the EU. In Europe, as well as in the US, around 10% of all employees work in this sector. Macro economic studies estimate that in general 47% of all jobs will be automated due to digitalization. FS will be highly affected by the megatrend digitalization as numerous routine tasks are performed in this sector. However, current studies only provide a macroeconomic view on the changes. Therefore, this paper aims to answer the following research questions: Which smart building technologies are relevant for FS? Which are already in use and which services will be affected?**

The basis for the current research was a qualitative pre-study. Fifty German speaking Facility Managers were asked about the technical and economic feasibility of smart building technologies in the FS sector. Based on the smart building technologies identified as relevant, the authors carried out a quantitative literature review. This analysis did not only include publications about the usage of smart building technologies in the FS industry, but also considered use cases on the technologies identified by the pre-study in other industries. In total, more than 350 cases were analyzed. Based on that literature review, a research database was set up to explore the relevant technologies and the affected services in detail. The next research step was to compare the results of scientific publication with those of commercial studies and the results of the pre-study.

Thus, this paper outlines the relevant technologies and FS. It further presents the detailed results of the validation process.

Keywords — evaluation of smart building technologies, internet of things, artificial intelligence, data mining and machine learning, augmented and virtual reality in buildings.

INTRODUCTION AND RESEARCH QUESTIONS

Facility Management (FM) is a key function in managing the demand and fulfillment of services and infrastructure necessary for the core business. Facility Management influences the ability to act proactively and meet all requirements of the core business. On the other side, it is dedicated to optimize the costs and performance of assets and services [1]. Digitalization affects Facility Management in two main areas:

1) Due to developments in the core business (new ways of working) the demand for changes in infrastructure and services is given.

2) Digitalization also has a huge impact on the Facility Service (FS) provision The application of emerging technologies within the area of building automation, such as, the Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML) allows control over the complexity of FM processes and services in a more effective way.

This paper will focus on the second topic, the use of smart building technologies within building automation to optimize FS provision.

The outsourced FS industry is the third-biggest industry regarding employment in the EU [2]. In Europe and in the US, around 10% of all employees work in this sector (as shown in Table I.). FM-activities have a high significance for process optimization [3]. Therefore, the application of smart building technologies, like IoT, AI and ML is becoming an important factor [4].

Many studies have been analyzing the impact of digitalization on work processes. These studies assume that routine-tasks will be most affected and conclude that there will be drastic changes and shifts in required skills [5], [6], [7], [8]. Frey's and Osborne's study [8] showed how susceptible different jobs are to computerization in the US. They estimated that computers would probably substitute 47% of all jobs. On basis of technological progress in ML, Mobile Robotics, they determined the probability of computerization for over 700 occupations. Furthermore, the study of Stopajnik et al. 2017 [2] shows the impact of digitalization on the Facility Service industry. They estimated that typical FS activities [9] are at very high risk of being automated. E.g. Installation, maintenance and repair work have a 50% probability to be automatized, janitors and cleaners have a probability of 66%, and first-line supervisors of housekeeping and janitorial workers show a probability of 94 %. [2], [8] to be automatized.

TABLE I. COMPARISON BETWEEN THE NUMBERS OF EMPLOYEES FOR BUSINESS ECONOMY IN GENERAL AND FOR THE FS SECTOR IN THE UNITED STATES AND THE EUROPEAN UNION, FROM 2014 [2]

Number of employees	***EU***	***US***
Total number of employees in Total business economy	135.601.377	90.337.386
Total number of employees in Facility Services	14.438.876	9.008.432
Proportion of employees in Facility Services	10.65 %	9.97 %

978-1-5090-6684-1/18/$31.00 ©2018 IEEE

These existing studies only give a macro-economic view on the changes within FS [2], [7], [8], [10] and cannot be used as general proof for the usage or feasibility of technologies in the area [6]. Nevertheless, an estimation of relevant technologies is needed to depict how these technologies will affect the industry. Consequently, the research objectives of this paper are to provide an evaluation of the relevant smart building technologies. The research questions are:

1) Which smart building technologies are essential to optimize the Facility Service provisions?

2) Which ones are already in use and which ones will become feasible on a short-term basis?

3) What FS are affected and by which technologies?

Hence, the aim of the next chapter is to explain how the mixed-method research approach is used to answer the scientific questions. Then the chapter 'results' describes the relevant smart building technologies and the effected services. The 'outlook' analyses the need for further research.

METHODOLOGY

There are currently three major research paradigms: quantitative research, qualitative research and mixed-method research. The characteristics of qualitative research are induction, discovery, exploration and theory/hypothesis generation. The researcher acts as the primary 'instrument' of data collection and qualitative analysis. The major characteristics of quantitative research are a focus on deduction, confirmation, theory/hypothesis testing, explanation, prediction, standardized data collection and statistical analysis [11]. Referring to both, quantitative and qualitative methods have particular lacks of strengths [12].That is why the authors used the 'Mixed research' method. It is a type of research in which qualitative and quantitative methods, techniques or other paradigm characteristics are mixed in one overall study [12]. Its inquiry includes the use of induction (discovery of patterns), deduction (testing of theories and hypotheses) and abduction (uncovering and relying on the best explanations for understanding one's results). The goal is to profit from the strengths and minimize the weaknesses of both research methods (quantitative and qualitative) in single research as well as in across studies. Using a mixture of the methods mentioned above allows researchers to combine and match design components that offer the best chances for answering their specific (research) questions [11]. Based on the Mixed Method Research, this study includes quantitative and qualitative research phases.

The used methodology consists of three research steps.

1) Qualitative pre-study: As a first step, a literature review was carried out to define relevant smart building technologies in the area of FS. Based on the results, a questionnaire was developed to determine the technical and economic feasibility of the technologies. The survey was carried out in spring 2017. Fifty German speaking Facility Managers from the healthcare industry were interviewed. The result was a list of smart building technologies and the estimation of their feasibility.

TABLE II. TECHNICAL AND ECONOMIC FEASIBILITY OF NEW TECHNOLOGIES

Technologies	**Technical feasible**	**Economic feasible**
	mean timeframe till feasibility	***mean timeframe till feasibility***
Sensors/IoT	0 – 0.55	0.73-1.79
BIM	0.33 – 1.09	1.94 – 2.24
Mobile Apps	0.36 – 0.45	1.03 – 1.33
Robotics	0.45 - 2.03	1.33 – 3.91
RFID	0.52 – 0.75	1.27 – 1.85
Digitalization / Automation	0.58 – 1.73	1.82 – 2.27
BIG Data	0.70 – 0.79	1.61 – 2.06
Virtual reality	0.91 – 1.00	1.82 – 2.42
Drones	0.91 – 2.00	1.97 – 3.52
Augmented reality	1.18 – 1.58	1.67 – 2.3

2) Quantitative literature analysis: As the pre-study was carried out with a sample of 50 experts but only in one industry, the results needed to be validated and updated in the next research step. Therefore, a profound analysis of more than 350 international cases, published in scientific journals, in strategy documents of well-established consultancies and in companies' white papers, was carried out.

3) Validation of results: The findings of the different sources (scientific journals, strategy papers, company white papers) were compared with each other as well as with the results of the pre-study, in order to validate the results.

Pre-Study

The pre-study is based on a survey of fifty facility managers in German speaking countries and was carried out in 2017. The selected sample consisted mainly of Facility Managers in the health care sector, as they face the highest pressure to optimize their operational costs and an increasing demand for FS due to legal regulation at the same time. The survey points out that IoT, Building Information Modeling (BIM), Mobile Apps, Robotics/Drones, Big Data, AI incl. ML are already technically feasible or will be in a short time. In addition, in the context of this paper the term IoT is condensed to IoT enabled sensors and other devices delivering data about the status of devices, usage etc.. As AI consist of a broad range of technologies, some elements mentioned more often by the experts and in the literature cases are analyzed in detail, like ML. All the other elements are subsumed under the acronym AI. Augmented (AR) and virtual reality (VR) will be technically feasible a bit later. The results of the survey regarding economic feasibility vary. IoT has the shortest pay off period, whereas mobile apps pay off in around a year. BIM and Robotics/Drones will pay off the latest.

Quantitative literature review

As the pre-study is based on a survey of fifty experts, but only analyses the German speaking countries, a quantitative literature review was carried out additionally.

The goal was to analyze and evaluate worldwide existing publications for existing and potential use cases of smart building technologies and of forecasts of the changes due to digitalization in the FS sector. Due to a high sample of more than 350 international cases an objective perspective was ensured.

In order to take into consideration the rapid development of the smart building technologies, the authors of the study assumed that publications of technology companies and journals are more important sources than those of books. Hence, the authors screened reports of the following areas:

- Scientific studies published in peer-reviewed journals,
- Strategy documents (scientific & strategy consultancies),
- White papers and business project descriptions (incl. press articles, promotion reports, project descriptions from councils and communities).

All publications date from 2010 to March 2018. The majority of the publications was issued in 2016/17.

Digital Reports like IEEE Xplore digital library, Harvard Business Review or Researchgate were significant resources to find scientific and technical content. This procedure resulted in n = 350 records. The authors identified that the journal IEEE provided most of the relevant publications.

To broaden the scope, reports from other industries using the technologies identified as relevant in the pre-study were included in the analysis too. This was done to enable relocating, that means changes of the location and production methodology [13], [14], [15]. In most of the analyzed articles, figures about the economic effects/benefits were based on the study of a single technology or one specific industry case.

The 'Grounded Theory' [16] was used to systematically analyze the reports and identify codes [17], [18]. The first step was to open code these reports. Then similar codes were clustered into categories. The FS categories identified were aligned with the EU standard 15221-4 [9] as this is the only standard accepted by more than one country. The standard defines the different FS in detail. The smart building technology categories of the quantitative study were compared with the technologies identified as relevant from the pre-study.

For each of the sources/cases the following data was collected:

- ID
- Short description
- Client and supplier (of case)
- Current FS that is mentioned in the case [9]
- Smart building technologies used
- Link to reference

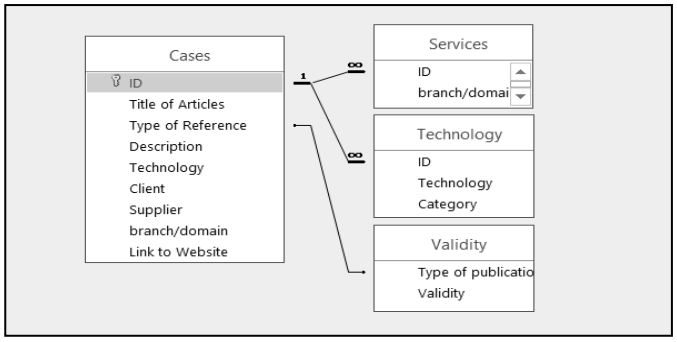

Fig. 1. Structure of database

Then the data was inserted into an Access database to compare the different types of reports in a traceable and transparent way.

Fig. 1 shows the data structure of the database. Beside the main table 'cases' including the attributes mentioned above, three other tables are in use. The table 'services' and the table 'technology' were set up as own tables to make it possible to link several services and/or technologies to one single case. During the grounded theory based analysis of the cases, it was ensured that the m:n relation of services and technologies is used properly. That means that after the coding it was safeguarded that all services identified in the case are supported by all technologies identified and vice versa. This enabled the authors not only to determine the relevant smart building technologies and the effected services due to the use of emerging technologies, but also to conclude which services are affected by which technologies. The last table 'validity' was used to cluster the type of publications according to their validity. Scientific papers were rated the highest followed by strategy documents. White papers were rated the lowest. In the chapter 'Results' only scientific papers and strategy documents are used as references to prove the validity of the conclusions.

Validation

As a last research step, the results from the different types of publications (scientific papers, strategy documents and white papers) and the pre-study were compared to analyze, whether they show the same conclusions or not. If all outcomes stress the importance/feasibility of the same smart building technologies, this would then validate the results drawn from the different steps.

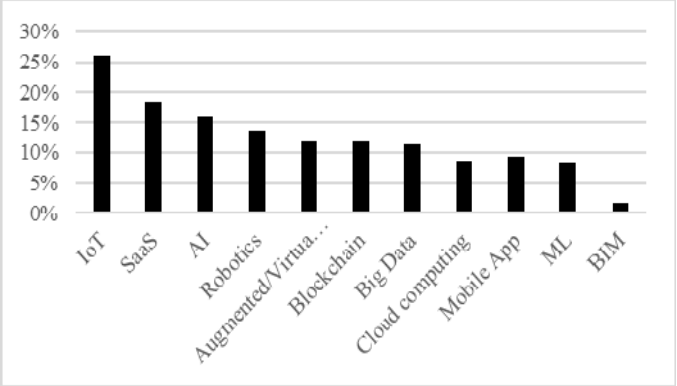

Fig. 2. Smart Building Technologies according to the number of mentioning in publications as a percentage of the number of cases analyzed

TABLE III. FIRST THREE PLACES OF AFFECTED FS ACCORDING TO MENTIONING IN THE DIFFERENT TYPE OF PUBLICATIONS

Ranking	Type of publication			
	All	***Scientific Studies***	***Strategy documents***	***White paper***
1	Maintenance and operation	Energy	Maintenance and operation	Maintenance and operation
2	Energy	Logistics / Safety / Security	Procurement / Finance	Energy
3	Safety	Maintenance and operation	Logistics	Safety / Security

RESULTS

The results of the quantitative literature review regarding the relevant smart building technologies are shown in Fig. 2. The figures show the occurrence rate of the smart building technologies within all the reports analyzed as a percentage of all analyzed use cases.

Software as a Service (SaaS) and cloud computing were not in the scope of the pre-study as they are more a way to provide software, than a tool themselves. Consequently, in the following only the technologies themselves are analyzed, whereas the two software Platforms SaaS and cloud computing are omitted because their task is to support all smart building technologies.

Relevant technologies

The ranking in the different type of publications analyzed is similar at the top level:

In all the publications and in the pre-study the smart building technology IoT is mentioned the most. In the pre-study, the experts estimated this technology as already technically and economically feasible. The reason for this is the enormous price reduction of sensors and IoT devices. The availability of self-sufficient devices, which produce the energy they need by themselves and can be easily connected to the WIFI of the buildings, enables the use of IoT in addition. Thus, there is a consensus of all studies regarding the usability of IoT as smart building technology [19].

In general, AI is mentioned very often. It is more in the focus of white papers and strategy documents than of scientific articles. In the last year AI/ML tools made great progress. They are mainly used to analyze the data generated by the IoT devices and identify patterns [20]. The capabilities of Big Data and AI/ML tools in this area increased. Several device producers, like Fujitsu, already include AI/ML features in their devices. An example for that are surveillance systems that can automatically inform security staff of dangerous events. There exist cameras, which can detect when someone leaves their luggage behind and disappears. If so, a mechanism is triggered to instantly send a SMS to the security staff including the precise location of the event. Furthermore, the health condition of patients can be automatically recognized and in case of an emergency, the responsible people will automatically be informed [21]. Further, it must be stated, that availability of AI/ML over SaaS platforms like IBM Watson increased and their costs decreased at the same time. These platforms support for instance predictive maintenance. Several use cases describe the analysis of IoT data to detect failures of equipment even before they happen. Moreover, the AI/ML software also includes the scheduling of the maintenance employees [22], [23].

Therefore, Big Data, AI and ML are mentioned quite often. In the expert interviews one year ago, the experts estimated the technical feasibility within one year, but the economic feasibility was between 1.7 and two years. That is in line with the results of the qualitative study. It is subject to further research, if these technologies are also economically feasible now. Several new product offers from large FS companies (e.g. Kone, ISS) are based on the new technology [24]. This development points into this direction.

Robotics take the third place in the qualitative analysis of all publications. They are mainly in the focus of scientific papers. The experts could not give a precise evaluation of this technology. Their answers were between 0.5 and two years regarding the technical feasibility and 1.3 and almost 4 years for the economic feasibility. Robotics and drones were mainly used to carry out repetitive work. New versions are more flexible and can cooperate with the FS personnel. Examples for use cases are lawn mowing but also cleaning robots [25]. Several of the cases describe a combination of robots and drones (e.g. a cleaning robot/drone that can fly and clean large glass facades [26]).

The experts did not mention Blockchain. Nevertheless, it is in the focus of strategy documents and scientific papers. This technology provides many use cases in the area of FS. Smart contracts and trusted data about equipment and maintenance

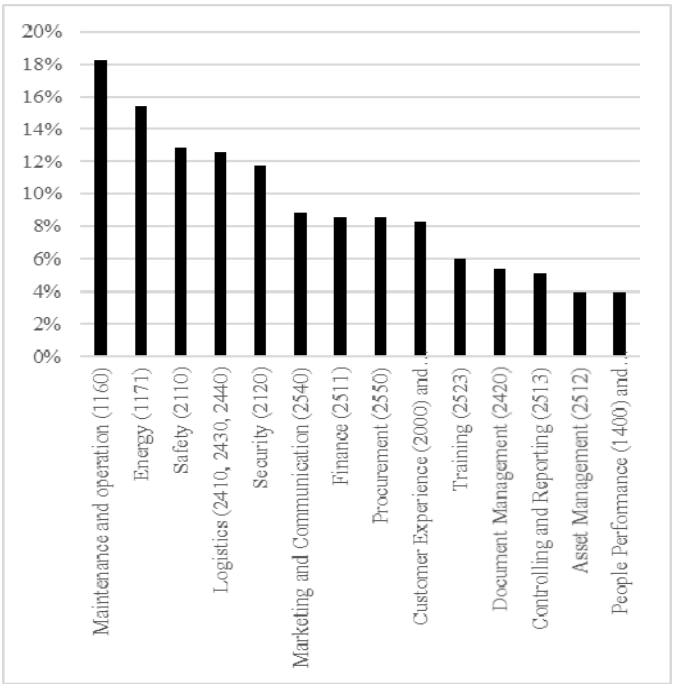

Fig. 3. Affected Facility Services [9] according to number of mentioning in publications as a percentage of the number of cases analyzed

are only two examples that were mentioned more than twice [27]. AR and VR were often discussed in white papers but not in other sources. BIM was in the top two of the the FM experts' ranking regarding feasibility, whereas only six cases could be found in the quantitative analysis.

Affected services

The results of the quantitative literature review regarding the affected services are shown in Fig. 3. The numbers behind the services are the service codes of EN15221-4 [9] and define the service like 'security', 'energy' in detail. Two additional services were included, namely 'customer experience' and 'people's performance'. These items do not only have a link to service codes but are also indicators for the performance of the service products (cmp..Figure E.1 Facility Management Cycle [9]).

Figure 3 shows the occurrence rate of the affected services within all reports analyzed. The usage of IoT, that delivers information of the status of equipment and of AI/ML tools supporting e.g. predictive maintenance, optimizes 'Maintenance and operation'. IoT sensors help to improve 'Energy' consumption as they provide an accurate picture of the usage and therefore deliver information about optimizations. 'Safety', 'Logistics' and 'Security' can be enhanced by the use of Big Data, AI and ML. Together with Blockchain, these tools optimize 'Security', 'Finance' and 'Procurement'.

Relationship services affected and technology influence

In general as well as in strategy documents and in white papers, FS 'Maintenance and operation' is pointed out to be mostly affected by smart building technologies. IoT, Robotics, AI/ML, mainly affect 'Maintenance and operation'. These technologies focus on supporting predictive maintenance and therefore affect this service enormously [24], [28]. For example, KONE uses the IoT enabled sensor data of the elevators to predict failures in advance. KONE uses IBM Watson as ML tool to detect patterns between sensors data and failures. E.g. the doors' closing speed predicts malfunctions of the light grid securing users in the elevator. Using IoT together with ML, the elevator company guarantees an availability of 24 hours, seven days a week. Case studies point out that with this high availability the number of elevators required can be reduced. In addition, the satisfaction of users can be increased due to failure free usage.

As scientific papers rank AI/ML lower, 'Maintenance' is also ranked only as number three in this type of publications.

According to scientific papers and white papers the FS 'Energy' is highly affected too. The service provision is highly changed by the use of IoT and Big Data [29]. Instead of calculated data, IoT provides current data and allows interacting immediately. Based on the IoT data, benchmarks can be generated automatically. This delivers detailed usage data, which allows more efficient energy optimization. IoT data can also be used for optimized control. Some examples are:

- The detected number of people in a room can be used to regulate the HVE to an optimum level.
- In not used meeting rooms, lights and ventilation can be shut down to a minimum when no presence of users is recognized.

'Safety and security' are also ranked under the Top 3 in most of the publications categories. Especially IoT reporting the current status, Robotics taking over risky work and Mobile apps covering safety aspects affect the FS 'Safety' [30].

IoT and Blockchain impact the FS 'Security' to a high degree [31]. 'Logistics' and 'Procurement' ranks within the Top 3 in scientific papers and strategy documents. Robotics, like autonomous vehicles, IoT and Blockchain, have a big impact on 'Logistics' [32]. Blockchain, AI and Mobile apps can help to optimize 'Procurement' [33].

Conclusion and outlook

The pre-study and quantitative literature review showed that smart building technologies are already used extensively and have a big impact on the Facility Service (FS) provision. IoT use cases are widely spread and technically and economically feasible. Whereas the pre-study stated the importance of Mobile apps and BIM, the quantitative review identified Big Data, AI, ML and Blockchain as important smart building technologies beside IoT. According to the quantitative study, the services effected most are 'Maintenance and operation', 'Energy', 'Safety', 'Logistics', 'Security', 'Finance' and 'Procurement'.

By analyzing the results of the quantitative study in the database, it was possible to identify which technologies affect which services to what extent. The application of IoT as a data deliverer and Big Data/ML as a tool to analyze the gained data helps to improve processes of 'Maintenance', 'Energy', 'Safety' and 'Security' in a disruptive way.

The analyzed cases do not specify the impact or changes in detail. Nevertheless, they provide a solid basis to identify the relevant technologies, services and their interrelation.

This research also shows that the effects of digital transformation on FS processes are not yet fully acknowledged and will need further research. Most of the companies still use a lot of standard technology to provide FS. Other technologies like AI, ML develop so rapidly, that their usage possibilities cannot be evaluated properly. This postulates the need for further research and the application of smart building technologies in practical use cases, especially to prove their economic feasibility. Based on this research and further studies, the demand and extent for trainings for service employees also needs to be estimated to enable them to use the new technologies.

REFERENCES

[1] Österreichisches Norminstitut, 'ÖNORM EN 15221-1', in Facility Management Teil 1: Begriffe, vol 1, 2007.

[2] Stopajnik, E.; Redlein, A., 'Current Labour Market Situation and upcoming Trends in the European Facility Service Industry, *Institute for Facility Management*; TU Vienna, Austria, pp. 34-42, 2017.

[3] Chotipanich, S., 'Positioning facility management, in *Facilities*, vol. 22(13), pp. 364-372, 2004.

[4] Selinger, M., Sepulveda, A., Buchan, J., 'Education and the Internet of Everything: How ubiquitous connectedness can help transform Pedagogy', Cisco Consulting Services and Cisco EMEAR Education Team, 2013. [online]. Available: http://www.cisco.com/web/strategy/docs /education/education_internet.pdf (accessed on 12th March 2018)

[5] Čas, J., Rose, G., Schüttler, L., 'Robotik in Österreich, 'Kurzbericht – Entwicklungsperspektiven und politische Herausforderungen', Endbericht. Bericht-Nr. ITA 2017-03; *Institut für Technikfolgen-Abschätzung* im Auftrag von: Bundesministerium für Verkehr, Innovation und Technologie, 2017.

[6] Nagl, W., Titelbach, G., Valkova, K., 'Digitalisierung der Arbeit: Substituierbarkeit von Berufen im Zuge der Automatisierung durch Industrie 4.0. ', *Institut für höhere Studien (IHS)*, Vienna, 2017.

[7] Stopajnik, E.; Redlein, A., 'The Development of the Outsourced Facility Service Industry in Europe''; *JFMA*, vol 1(1), pp. 1-5, 2017.

[8] Frey, C.B., Osborne, M.A., 'The future of employment: How susceptible are jobs to computerisation?'' [online]. Available: http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_ (accessed on 3rd January 2018)

[9] Österreichisches Norminstitut, 'ÖNORM EN 15221-4', *Facility* Management Teil 4: Taxanomie, Klassifikation und Strukturen im Facility Management, vol 1, 2007.

[10] Peneder, M., Bock-Schappelwein, J., Firgo, M., Fritz, O., Streicher, G., 'Österreich im Wandel der Digitalisierung', *Österreichisches Institut für Wirtschaftsforschung*. Wien, 2016.

[11] Johnson, R. Burke, Onwuegbuzie, A. J., Turner, L.A., 'Toward a definition of mixed methods research'', *Journal of Mixed Methods Research*, vol 1(2), pp. 112–33, 2007.

[12] Johnson, R. B., Christensen, L., 'Educational Research: Quantitative'', Qualitative and Mixed Approaches. 3rd edition, *SAGE Publications*, Thousand Oaks, 2007.

[13] Hammer, M., Champy, J. (1993), 'Reengineering the Corporation- A Manifesto for Business Revolution'', New York, 1993.

[14] Servatius, H.-G., 'Methodik der strategischen Technologie Managements - Grundlage für erfolgreiche Innovationen.' Berlin, Germany, 1985.

[15] Kröger, F., 'Duale Restrukturierung - Wettbewerbsfähigkeit durch west-östliche Arbeitsteilung, Stuttgart, Germany, 1994.

[16] Glaser, B. G., Strauss, A. L., 'The discovery of Grounded Theory: Strategies for Qualitative Research', Chicago, Aldine, pp.196.

[17] Strübling, J., 'Was ist Grounded Theory?', Grounded Theory. Qualitative Sozialforschung, *VS Verlag für Sozialwissenschaften*, Wiesbaden, 2014.

[18] Corbin, J., Strauss, A.L., 'Basics of qualitative research: Techniques and procedures for developing Grounded', Thousand Oaks, CA: *Sage*, 420-421, 1990.

[19] Xu, L.D., He, W., Li, S., 'Internet of Things in Industries. A Survey', *IEEE Transactions on Industrial Informatics 10*, pp. 2233– 2243, 2014.

[20] Moreno, M., B. Castaño, D. Barrero and A. Hellín, 'Efficient services management in libraries using AI and wireless techniques', *Expert Systems with Applications*, vol. 41, pp. 7904–7913, 2014.

[21] Fujitsu, 'Fujitsu Develops Technology to Recognize Patient Status Using a Camera', [online].Available:http://www.fujitsu.com/global/about/resources/news/press-releases/2014/0513-02.html (last retrieved on 23th April 2018)

[22] Bonomi, F., Milito, R., Zhu, J., Addepalli, S., 'Fog computing and its role in the internet of things' in *2012 Proc. 1st Ed.MCC Workshop Mob. Cloud Comput*, pp. 13 – 16, 2012.

[23] Y. Sun, H. Song, A.J. Jara, R. Bie, 'Internet of Things and Big Data Analytics for Smart and Connected Communities' in IEEE Access, vol. 4, pp. 766-773, 2016.

[24] Kone, 'KONE revolutioniert die Anlagenwartung mit individualisierbaren Serviceverträgen und 24/7 Connected Services', [online].Available: https://www.kone.at/news-und-referenzen/pressemitteilungen/kone-care-und-24-7-connected-services.aspx (last retrieved on 23th April 2018)

[25] S. Min Moon, C. Shin, J. Huh, K. Won Oh, und D. Hong, Window Cleaning System with Water Circulation for Building Facade Maintenance Robot and Its Efficiency Analysis, Bd. 2. 2015.

[26] Wei Wang, Boyan Tang, Houxiang Zhang, Guanghua Zong, 'Robotic cleaning system for glass facade of high-rise airport control tower', Industrial Robot: An International Journal, Vol. 37 Issue: 5, pp.469-478, 2010.

[27] Wellers, D., Elliott, E. Noga, M, '8 Ways Machine Learning is improvin g companies work processes', HBR, [online].Available: https://hbr.org/2017/05/8-ways-machine-learning-is-improving-companies-work-processes (accessed on 25th February 2018)

[28] Johansson, S., Vogelgesang, U., 'Automating the insurance industry', McKinsey Quarterly [online].Available: 'https://www.mckinsey.com/industries/financial-services/our-insights/automating-the-insurance-industry (last retrieved on 25th February 2018)

[29] Krishnamurthy, R., Desouza, K. C. 'Big Data Analytics: The Case of Social Security Administration', Information Polity, vol. 19 (3/4), pp. 165-178.

[30] VMWARE, 'Delhi International Airport takes off with VDI', [online]. Available: https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/files/in/pdf/customers/vmware-gmr-dial-14q3-en-case-study.pdf (last retrieved on 25th March 2018)

[31] Lu. S, and Wang, X. Toward an IT-enabled Business Model for Perishable Food Transportation .Advance Journal of Food Science and Technologym 11(3): 190-194, 2016

[32] Voshmgir, S., 'Blockchains, Smart Contracts und das Dezentrale Web' Technologiestiftung Berlin, Blockchains, Smart Contracts und das Dezentrale Web, 2016, pp. 17-35.

[33] Deloitte, 'Blockchain in commercial real estate' [online].Available: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-fsi-rec-blockchain-in-commercial-real-estate.pdf (last retrieved on 12th February 2018)