

# How smart work environment applications can add strategic value

***Citation for published version (APA):***

Appel - Meulenbroek, R., Brugmans, L. J., Kemperman, A., & Dinnissen, L. (2019). How smart work environment applications can add strategic value. In *Proceedings CIB World Building Congress: Constructing smart cities* (pp. 1590-1601). School of Design, The Hong Kong Polytechnic University.

***Document status and date:***

Published: 01/01/2019

***Document Version:***

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

***Please check the document version of this publication:***

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

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# How smart work environment applications can add strategic value

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## Abstract

The way people work has changed and many corporate real estate (CRE) and facility managers (FM) are thinking about whether and how to implement smart-building applications in the work environments of their client. The data collected by these applications can be a valuable asset, however it is necessary to identify beforehand which type of data collection could provide which strategic value(s). Therefore, this study examined the expected strategic value of specific smart work environment applications for organizations from the perspective of CRE and FM professionals. A questionnaire was developed based on existing literature. In total, 122 CRE and FM experts participated and provided their perception of 20 different applications and 9 different strategic values. During follow-up expert interviews, the practical implications of the findings were discussed and translated into recommendations.

The smart applications that are expected to decrease real estate costs mostly relate to the automatization of facility services. Employee satisfaction is particularly supported by smart applications related to personal preferences and personalization (e.g. temperature control, smart coffee machine). The smart applications that are expected to support productivity mostly concerned either features of the work environment (automatic printer and meeting room allocation), ways to eliminate negative conditions (noise cancelling), or support in finding colleagues elsewhere in the building.

Although many studies have proven the effect of physical work environment characteristics on employees and/or on organizations, there is little insight into the effect of smart work environment applications on both. This paper has started to build theory on smart building applications. The findings in this paper are also relevant for CRE and facility managers and consultants as they provide insight in what their colleagues expect of different available smart work environment technology applications, to support their own decision making.

**Keywords:** smart buildings, facility management, strategic value, questionnaire, experts

# 1. Introduction

The world is continuously subject to change. After the first, the second, and the third industrial revolution, the fourth industrial revolution is about to happen. The third revolution revolved around the rise of computers and information technology, and one could say that currently the fourth revolution is happening: the physical, digital and biological worlds are merging through new technologies and this has an impact on all industries, economies and disciplines. Technologies such as robots, 3D printing, wearables, nanotechnology, virtual reality and self-driving cars are going to change the world drastically (World Economic Forum, 2016). Machines and other things are connected to the internet, called the Internet of Things, which enables them to communicate with each other.

A century ago, buildings were equipped with simple electricity, gas, and water systems. Nowadays, besides such systems, buildings have (automatic) lighting systems and controlled temperature and humidity systems. In the near future buildings will become intelligent, smart or even thinking buildings. Buildings will be able to react, adapt or even predict what a user needs or wishes through integrated systems in the whole building (Buckman et al., 2014). The term ‘intelligent building’ was first used in the United States in the early 1980s for buildings which included telecommunication facilities, building management and data networking services. The smart building is the next step. It uses the Internet of Things in order to provide even more comfort and satisfaction, and even less costs and energy consumption.

This research focusses on the work environment of the near future, the smart work environment, and examines the added value of such a building for end users. After all, it is already known that office and workplace design affect a company and its employees. Although several studies have proven the effect of elements of the physical work environment on employees and/or on organizations (e.g. Dul & Ceylan, 2011; Van der Voordt, 2004; Hoff & Öberg, 2015), there is little insight into the effect(s) of a smart work environment on both. Smart workplaces, the intelligent work environment or similar concepts are currently very interesting for computer science, computer-human-interaction and ambient intelligence (Mikulecky, 2012). Publications about these concepts are mostly written from a developer’s perspective, not from the perspective of an (end)user in an office building and the organization’s corporate real estate management (CREM) team. This could be explained by the fact that the smart work environment is still in its infancy and a relatively new subject for CREM departments and consultants. In the existing literature the theoretical value is often mentioned, such as user satisfaction and energy saving (Padmanabh et al.; 2009; Bhardwaj et al., 2010; Takeuchi, 2010). However, the real value is not yet known. The real value must be measured through case studies in different physical work environments, but for performing such studies there must be a sufficient amount of smart work environments available. So far, the amount of really smart work environments is still limited in the Netherlands (where this research is conducted), and presumably in other countries as well. Therefore, this research explores the expected strategic value of smart work environment applications by CRE professionals, as a starting point for further implementation of smart work environments for future research. Within a few years when more smart work environments and more smart applications will be implemented, the actual strategic value can be examined.

## 2. Literature review

### 2.1 Strategic values of workplaces

CREM is: ‘the management of a corporations’ real estate portfolio by aligning the portfolio and services to the needs of the core business (processes), in order to obtain maximum added value for the business and to contribute optimally to the overall performance of the corporation’ (Krumm et

al., 2000). Value can be added by aligning the real estate portfolio and services to the needs of the core business. In general, value has many meanings and usages. In FM and CREM, added value can be defined as the trade-off between the advantages of FM and CREM interventions and the sacrifices made for these interventions (Jensen et al., 2012). The advantages refer to the needs and wants of the client, customer and end-user; the sacrifices can be both a monetary sacrifice and a non-monetary sacrifice such as time spend (Coenen et al., 2013). Basically, value can be divided into exchange value and use value (Jensen, 2010). Exchange value represents the worth of something. It focusses on costs and the relation between output and input. Exchange value can be created by an increase in product value and a decrease in value of resources, i.e. reducing costs by increasing efficiency. Use value embraces personal belief and social behavior: it only concerns the output. Use value can be created through improved output by increased effectiveness (Jensen, 2010). Besides use and exchange value, other types of value are distinguished by different authors. For example, Jensen et al. (2012) distinguished six types of value: use value, exchange value, customer value, social value, environmental value, and relationship value; and McMillan (2006) distinguished (besides use and exchange value), also image value, social value, environmental value, and cultural value.

Nourse and Roulac (1993) were the first who developed a list of possible real estate strategies with which the company's overall business goals could be supported and thus value could be added. Later, De Jonge (1996), Lindholm et al. (2006), Den Heijer (2011) and many others have made contributions to this subject. Some authors use the term real estate strategies, others added values and some combine those terms (real estate added values or added values of real estate). In this paper, the term strategic value is used. Strategic value concerns value that evolves out of the real estate strategies. Van der Zwart (2011) made a summary of different studies on strategic values. The most often mentioned real estate strategies were: 'reduce costs', 'increase flexibility', 'increase value of assets', 'control risks', 'increase productivity', 'increase employee satisfaction', 'support culture', 'stimulate innovation', and 'support image'. The more recent studies added 'support sustainability' as important strategy, because this has become increasingly important for the building industry.

## **2.2 Smart building applications**

The concept intelligent building was first used in the early 1980s and since then many meanings have been given to the concept (Ghaffarianhoseini et al., 2015). The first definitions of intelligent building focused on the role of technologies. Later, the definitions focused on the role of user interactions and the quality of life and nowadays, the capability to learn has been added to the definitions (Wong et al., 2005). With this shifted focus, intelligent buildings became smart buildings. Ghaffarianhoseini et al. (2015) have done an extensive literature study about the different definitions of smart buildings. They summarize the definitions in three clusters: performance-based, system-based, and service-based definitions. Performance-based definitions focus on the building performance and the expectations and the demands of users; system-based definitions concentrate on the technologies and the integrated intelligence in the building connected to the occupants responses; and service-based definitions focus on the quality of services in the building. But there is no standard definition for smart buildings, because smart buildings evolve and change throughout time; what is smart now can be ordinary within a few years. Smart buildings 'should therefore be treated as a dynamic and evolutionary entity rather than a static and fixed one' (Ghaffarianhoseini et al., 2015, p.16).

A smart work environment is generally defined as a physical work environment that senses information about the environment and the user in it and subsequently uses this information for an action (Cook et al., 2009; Reijula et al., 2011). The emphasis in this definition is placed on the

interaction between environment and user and according to Wong et al. (2005) that matches with older definitions of smart buildings, as the newer definitions focus on the capability to learn. Reijula et al. (2011) conducted an extensive literature study about the objectives of a smart work environment. A smart work environment should amongst others enhance the workflow and productivity. The employees' well-being, creativity, satisfaction and health should also be improved. In addition, a smart work environment should be sustainable and functional. Based on an extensive literature study, Ghaffarianhoseini et al. (2015) summarized several goals which a smart building should achieve. According to their overview, a smart building should be a building that improves the well-being and the productivity of its occupants, while reducing costs, improving operational effectiveness and efficiency, offering technological facilities and supporting sustainability. These goals are very similar to the general strategic real estate values identified in the previous section.

It is not the work environment itself, but the features and facilities within the work environment sense and use the information about the environment and the user. Twenty types of smart applications were formulated, based on literature research and an extensive search of the internet for the latest applications under development. The smart applications were translated into encapsulating definitions by means of satisfying the definition of the smart work environment, by combining specific technologies into more abstract applications, and by disregarding specific technological details. For example, there are many manners how thermal comfort can be improved at the workspace. There exist computer mice, keyboards, desks, and chairs with heating functions, and there are possibly more features which can ensure and/or improve the employee's thermal comfort at the workspace. Since this research examines the strategic value of the smart work environment by means of smart applications, it is not necessary to examine the value of each specific feature part or technique. In addition, specific technological details are disregarded, since such details are not important for the research. All smart applications meet the requirement that they can take action without intervention from human beings, since 'smart' concerns the capability to autonomously collect and apply knowledge (Cook et al, 2009; and Reijula et al, 2011). This led to the following list:

1. **Meeting room allocation**, automatic allocation of a meeting room based on the users' schedule, preference and availability of meeting rooms.
2. **Workspace allocation**, automatic allocation of a workspace based on the users' preference, schedule and availability of workspaces.
3. **Parking space allocation**, automatic allocation of a parking space based on the users' schedule, preference and availability of parking spaces.
4. **Workspace personalization**, automatically adapting adjustable parts of the workspace, e.g. desk height and digital photo frames, to the current user.
5. **Noise cancelling**, automatically cancels out unwanted sounds by detecting communication partners (requires headphones).
6. **Colleague locator**, ability to locate a specific employee in the office
7. **Air quality and temperature control**, automatically controlling temperature and air quality in building sections depending on the level of occupation.
8. **Personal air quality and temperature control**, automatically controlling temperature and air quality at workspace depending on users' preference
9. **Light control**, automatically controlling lighting in building sections depending on sunlight intensity
10. **Personal light control**, automatically controlling lighting at workspace depending on users' needs, e.g. different lighting after lunch.
11. **Cleanliness control**, robot vacuum cleaners detect the need and appropriate time for cleaning and clean accordingly.

12. **Smart coffee machine**, which knows the employee's coffee preference and makes it automatically when approaching the machine
13. **Waste basket monitoring**, waste baskets are monitored and indicate the need for emptying.
14. **Greenery monitoring**, office plants are monitored and indicate the need for watering to the facility management.
15. **Toilet and washroom monitoring**, a door sensor keeps track of the people using the restrooms and signals staff when cleaning is required (e.g. after 50 uses).
16. **Robot security guards**, self-guided robot security that activates when sections of the building are closed for the day.
17. **Dynamic evacuation**, adjusts evacuation signals depending on the direction of the threat and the number of people
18. **Sensor based elevators**, elevators that detect the upcoming need for an elevator and act accordingly.
19. **Food and beverage adaptation**, food and beverage orders are adapted to the number of people in the building and their personal preferences.
20. **Automatic printer**, selects the appropriate printer based on your location and print job.

### 3. Research approach

In order to examine the relationship between strategic values and smart applications, a questionnaire and interviews are used. Since both a qualitative and a quantitative research method are used, it can be said that the main question is answered by the so-called mixed research method. This method provides data from different perspectives which is very useful for exploratory research since the method explores as many issues as possible within the timeframe of the study. The questionnaire was distributed among attendees of the CoreNet Global Summit (15-16 September, 2016 in Amsterdam). CoreNet Global is a non-profit association of executives responsible for the real estate asset strategy, consultants, researchers, and service producers in the area of real estate and FM. According to the organization, there were 583 attendees representing 26 countries. In total, 177 questionnaires were distributed during those two days and 122 attendees filled in the questionnaire. So, 30% of the attendees received a questionnaire and the response rate of the distributed questionnaires is 69%. Though it was a Global Summit, 46.6% of the respondents are Western Europeans, and a mere 14.7% are non-European respondents. Almost 73% of them is male and only 27% female, with an average age of 44 (SD = 9.5). As the conference was held in the Netherlands, 27% had a Dutch nationality, and another 20% was from Western Europe. The rest of Europe represented 50%, and only 15% was from outside Europe (mostly from the USA). Work experience was on average 16 years (SD = 8.7), so it appears to be a very knowledgeable sample. Almost half of the respondents (44%) was a CRE or facility manager, 40% a real estate consultant and 10% a manufacturer of office products. The rest had other occupations, such as academia or architecture. They mainly work for (very) large organizations, since only 22% worked for an SME (<250 employees) and 42% for organizations with more than 25,000 employees. After the standard demographic questions, the survey asked for reasons to implement smart applications in general, which strategic values are most important to their organization and which strategic value is supported most by each smart application and how much (in their opinion). For this last question, the format as shown in figure 1 was used.

The data of the questionnaire was analyzed by means of statistical analyses, using SPSS. By means of descriptive statistics, SPSS calculated what the most important reason is for implementing smart applications in general, and which strategic value is supported most by each of the twenty applications. In addition, the one-way ANOVA and independent sample t-test were carried out to check for differences in demographic and organizational characteristics in relation to the rating of

strategic values for their importance for implementing smart applications in general. Furthermore, the Pearson product–moment correlation test was carried out to see if there is a correlation between the way CREM and FM ranked the importance of the nine strategic values for implementing smart applications in general and the current strategy of their organization.

# Smart applications	Which strategic value?	How supportive?						
		Not at all						Extremely
<i>Example</i>	<input checked="" type="checkbox"/> F	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1 Meeting room allocation, based on the users' schedule, preference and availability of meeting rooms	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2 Workspace allocation, based on the users' preference, schedule and availability of workspaces	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 1: Example of questioning smart applications

Subsequently, the results of the questionnaire were discussed in five separate expert interviews in order to examine the practical implications of the relationship between the strategic values and the smart applications. Four of the experts were CRE managers from large corporates and the other was a project developer. All interviews are recorded and afterwards typed out word-for-word in the same language as the language in which the interview was held. These transcripts were analyzed by means of labeling different codes to units. For this, inductive code development was used which means that the codes were developed by reading the data.

## 4. Research findings

### 4.1 Results of the questionnaire

The results of the questionnaire showed that ‘employee satisfaction’ was regarded as the most important reason for implementing smart applications in general, in accordance to all types of respondents. Next followed ‘flexibility’ and ‘productivity’. Not everybody agreed that productivity would be a reason for implementing smart applications, as Western Europeans indicated it to be significantly less important than other Europeans ( $F(2, 112) = 2.449, p = .091$ ). Similarly CREM/FM attached more importance to it than consultants ( $F(2, 110) = 2.884, p = .060$ ). The stimulation of innovation received a fourth place as important reason. Again, CREM/FM significantly think this is less a reason for implementing smart applications than consultants ( $F(2, 111) = 5.030, p = .008$ ).

Moreover, there are interesting correlations between the current strategy of organizations (or the opinion about companies in general by consultants) and their believed support of smart applications for the strategic values. Except for ‘reduce costs’, ‘increase flexibility’ and ‘support image’, when the company/consultant adheres to a strategy, they think that the same strategy is an important reason for implementing smart application (correlations were between  $r = .317$  and  $.567$ ). Additionally, those aiming for ‘increase innovation’ saw ‘flexibility’ as an important reason for implementing smart applications ( $r = .393$ ).

By far, ‘employee satisfaction’ is most often chosen as a value that is best supported by 11 of the 20 smart applications (see Table 1). Many respondents chose this strategy (=N in table 1) and also the expected level of support was high (=Mean, on a 7 point scale). This is in line with the result that ‘employee satisfaction’ is regarded as the most important reason for implementing smart applications in general. As visible in Table 1, employee satisfaction is particularly thought to be supported by the

smart applications ‘workspace personalization’, ‘personal air quality and temperature control’, ‘smart coffee machine’, ‘food and beverage adaptation’, and ‘personal light control’. These five smart applications relate to the personal workspace (the climate around the workspace and the workspace itself), and food and beverage facilities. They all relate to personal preferences, as the workspace can be personalized with three of the five smart applications; the canteen takes the personal preferences of employees into account; and the coffee machine brews the preferred coffee variant of the employee when approaching the machine. These results are in line with other studies, as for example the importance of ergonomics and the adjustability of, and the workspace (desk and chair) itself are proven to be conducive for employee satisfaction (Kim & De Dear, 2012; Batenburg & Van der Voordt, 2008), just like facilities for coffee and tea, and (personal control over) the indoor climate (Batenburg & Van der Voordt, 2008). The interviewees added that giving employees choice through control makes them complain less, explained by one of them as follows:

*“there was a really good cooling installation in the headquarter of a bank and that cooling installation has the feature that no windows can be opened otherwise the internal climate was disrupted. However, every large window has a tiny window which can be opened. This tiny window does not control the internal climate, but it is made for the employees so they can have control. It is just the experience of opening a window.”*

However, one of them also warned about too much control:

*“when there are too many options, I would have to think too much and I would not know what to do, so I would do nothing.”*

The second most often mentioned strategic value to be supported by smart applications is ‘increase productivity’. The smart applications mostly are aspects beyond the personal workspace, namely features of the work environment (automatic printer and meeting room allocation), eliminating conditions caused in the work environment (noise cancelling), and finding colleagues elsewhere in the work environment (colleague locater). That ‘meeting room allocation’ is expected to increase productivity is in line with existing literature as productivity can be improved by offering decent accommodation that is supportive for the primary processes (Van der Zwart, 2011). Moreover, the last two are in line with literature as well, as the behavioral environment (interaction and distraction) is more important for productivity than the physical environment (comfort and office layout). Particularly eliminating distractions is conducive for productivity (Haynes, 2007).

All interviewees were also enthusiastic about the colleague locater increasing productivity. One of them explained it as follows:

*“you don’t feel connected to a group of 2,5 thousand. You feel connected to your team of 10 people, [...] so it is important to find your team. So when you enter (the office building) in the morning, for me it would be valuable to see where my team is.”*

About the automatic meeting room allocation they showed more differences in opinion, as one of them mentioned:

*“the automatic assumption that you need a meeting room is something that bothers me.”*

The smart applications that are expected to reduce ‘real estate costs’ mostly relate to the automatization of facility services (e.g. cleaning, waste). Some of these were also related by several respondents to support of sustainability. However, a lot less respondents think that the smart applications are likely to reduce costs. The interviewees were also skeptical. For example regarding waste basket monitoring for cleaners, he said:



*“that man of woman is already on that floor, he/she is cleaning, maintaining the coffee machine and then he/she leaves. The question is if perceiving a full basket is enough to reduce the amount of cleaner... perhaps it is possible in the end, but then you have to apply this principle to other things.”*

Increasing innovation was the fourth reason to implement smart applications, but the applications tested here were not really perceived as able to do so. Reducing risk was generally not ranked very high as a reason for implementing smart applications, however robot security and dynamic evacuation were two applications often perceived as able to do so. One of the interviewees added:

*“within a few years, you cannot find anyone who is willing to the night security, so you have to search for other solutions such as robots security guards.”*

## **4.2 Results of the interviews**

The interviews showed some further insights. First of all, when considering the implementation of smart applications in an organization a viable business case is needed. Business cases are generally made on a monetary level, therefore it is necessary to monetize the added value smart applications provide, especially increased satisfaction. Another point of attention for business cases is that it could be important to consider a long running time. The investment cost for smart applications can be quite high since these applications are generally new and innovative. Therefore a longer business case can provide the adequate time to break even, according to the interviewees. They did point out that when an office feature is already sufficiently well-developed, and when it does not cause any (large) problems, it is difficult to improve or to save money by making it ‘smart’.

They also mentioned three focus points that make it more likely for smart applications to increase satisfaction. First of all, it is desired that the smart application gives personal control or perceived personal control to the employees, providing that the application must be as simple as possible in order for employees to not waste time trying to understand and/or control it. Secondly, when the smart application concerns a satisfier, i.e. a user’s preference, it is likely that it increases the employee’s satisfaction more, than if the smart applications concerns a dissatisfier. Thirdly, it is important that both the result and the process of the smart application are visible for employees.

In addition to the three focus points, the interviewees mentioned three points of attention. First, automatic allocation is a sensitive discussion point. They assumed that allocation of a parking space is highly desired while allocation of a workspace is less welcomed. Secondly, robots are only interesting when they can save money, when they have a certain added value compared to human beings and/or when human beings can or will not do the job. Third, privacy legislation is increasing and should always be checked before implementing a smart application that concerns personal data. And last, whether or not a certain application supports productivity or satisfaction depends on many other things too, such as personal needs, how often one uses it, familiarity with the application, and characteristics of the office building.

Table 1: Which strategic values are best supported by each smart application

	Costs	Flexibility	Value	Risks	Productivity	Satisfaction	Culture & image	Innovation	Sustainability	
	N Mean	N Mean	N Mean	N Mean	N Mean	N Mean	N Mean	N Mean	N Mean	
Meeting room allocation	8 6.25	18 5.61			32 5.75	15 5.60				
Workspace allocation	9 6.33	15 5.20			24 5.83	26 5.62				
Parking place allocation	11 5.27	9 4.56	2 4.50		5 4.60	39 3.95	2 3.00		3 3.67	
Personalization		5 4.60			11 5.36	53 4.72	2 4.00	1 4.00		
Noise cancelling		1 3.00		1 1.00	42 5.29	28 5.25			1 7.00	
Colleague locator		9 5.00			32 5.16	16 5.25	8 3.63	7 4.57	1 4.00	
Air/temperature control	9 5.78	1 5.00	1 5.00	1 5.00	15 5.73	36 5.33	1 5.00		9 6.00	
Personal air/temp control	1 5.00				7 4.43	63 5.33			2 4.00	
Lighting control	13 5.54		1 6.00		17 5.29	18 5.28	2 5.00	3 5.33	19 5.26	
Personal light control	1 4.00			2 5.50	15 5.20	48 5.27		1 5.00	4 5.00	
Cleanliness control	28 4.50		1 6.00	2 5.00	3 4.00	23 4.91	9 4.00	1 4.00	4 4.25	
Smart coffee machine					5 5.00	57 4.00	4 5.50	2 5.00	4 5.25	
Waste basket monitoring	27 3.67				2 2.00	14 3.79	3 4.00	2 4.00	25 4.24	
Greenery monitoring	23 3.70				1 6.00	10 4.00	6 3.50		32 4.38	
Toilet monitoring	18 4.61	1 3.00	1 5.00	1 4.00	1 6.00	32 4.78	7 5.00	2 4.50	8 4.50	
Robot security guards	20 3.65			39 3.90	2 4.50	4 5.00	1 6.00	3 2.33		
Dynamic evacuation	1 3.00			66 4.79	3 4.00	2 6.50			1 4.00	
Sensor based elevators	15 4.67	1 4.00	2 4.00	6 4.00	16 4.75	22 4.36	1 5.00	2 3.00	8 4.63	
Food/beverage adaptation	8 3.50	1 3.00	1 5.00	1 3.00	3 5.67	50 4.44	2 4.00		7 5.29	
Automatic printer	5 5.60	9 4.78		1 3.00	42 4.19	8 5.00	1 5.00	1 5.00	5 5.60	
Total	197	70	10	119	278	564	49	25	133	
Average mean	4.69	4.34	5.07	3.92	4.94	4.92	4.47	4.25	4.82	
	N ≥ 50		40 ≤ N < 50		30 ≤ N < 40		20 ≤ N < 30		N < 20	

## 5. Conclusion

The results of the questionnaire and the interviews show that the smart work environment is mainly expected to increase employee satisfaction, especially the following three smart applications: automatically controlling temperature and air quality at the workspace depending on users' preference; automatically adapting adjustable parts of the workspace to the current user; and a smart coffee machine which knows the employee's coffee preference and brews it automatically when approaching the machine. Food and beverage adaptation to the number of people in the building and their personal preferences and automatically controlling lighting at workspace depending on users' needs, complete the top 5 for satisfaction. Additionally, it is expected that smart applications will also increase productivity and reduce costs, although minimally in comparison to an increase in satisfaction. The smart applications that are expected to support productivity most relate to aspects beyond the personal workspace, namely features of the work environment. Those expected to decrease costs mostly relate to the automatization of facility services.

Regarding limitations, different approaches were used to search for relevant smart applications. Besides scientific literature and web sites, professionals related to real estate management and/or facility management in combination with ICT, IoT, and/or other technology knowledge were consulted and lectures concerning the subject were attended. Though it is expected that this research considered the most well-known and most used smart applications, it remains unsure if the smart application list is complete and correct. Also, it is likely to change a lot over the coming years, as new innovations arrive to the market.

The results of this research are relevant for CREM and FM, and consultants as they gain insight in what their colleagues appreciate and expect of particular smart applications in the work environment. They can use this knowledge for their own business decisions and consultancy. The results of this study are also relevant for the developers of smart applications as the results provide them with insight about which smart application is worth developing further and which smart application might be less worth developing further or perhaps should be placed in the market more clearly.

Future studies could repeat the study with larger samples, in different countries, and with new smart applications. As employee satisfaction scored highest, it would also be interesting to ask end users for their opinion, since they are the subject of most smart applications. Additionally, pre-post studies with actual measurements of satisfaction and productivity would be interesting to create a business case.

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