SMART OFFICES

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Abstract:

Technology appears to be changing the most fundamental truth about commercial real estate, namely that value is mainly based on location. Technology is nowadays increasingly used to upgrade real estate and new concepts are emerging, among which smart offices. Smart offices are office buildings that are equipped with technology. They aim to make communication between human and computer more natural, make office work easier and meet the goals that buildings nowadays have, which are energy and efficiency, longevity and comfort and satisfaction. The contractor of this research, JLL, works for both real estate users and – investors. This study examines what factors make smart offices attractive to these users and investors and whether this leads to a price premium (eventually) being paid by them. By making use of interviews with stakeholders in the smart office market this question was examined. For occupiers sustainability and additional cost savings, the improved comfort and improved satisfaction are factors that make smart offices attractive. For investors it seems easier to rent office floors in smart buildings. Also the lower vacancy risks and the ability to maintain your property in a predictive way are factors that make smart offices attractive to investors. Both occupiers and investors indicate that location factors are still more important than technology in a building. Moreover, investors indicate to look at the tenant's characteristics and the duration of the lease contract. For tenants, the willingness to pay a price premium for smart property differs. Investors are not willing to apply sharper yields for smart offices yet. Nevertheless, how the attractiveness of smart offices, for users and investors, will develop in the (near) future is still quite uncertain since the market for smart offices is an upcoming market. More research on the topic needs to be done to examine whether the expected improvements that smart offices will bring about actually make a significant difference.

Key words: Smart offices, offices, real estate, rent, pricing, price premium, users, investors.

Preface

The graduation research that lies ahead is written commissioned by the company JLL and Utrecht University. In February 2019 my internship at JLL with the research team started. During my internship I learned a lot about commercial real estate and data. Through the JLL network, I was able to get in touch with various people in the real estate world who have enriched my thesis results. During the internship I was also allowed to follow various assignments and departments, which made me realize better what I want and what I like. Finally I was offered a job with the JLL research team. A great start to my career in real estate.

I would like to thank my university supervisor, dr. G. Wijburg, for his guidance, critics and feedback. Without his guidance and help this thesis was probably hard, or impossible, to complete.

I would also like to thank my supervisors at JLL, dr Kal and dr Boonen, for the company, the feedback, the network and the opportunity to get started within the team. Partly thanks to them, my internship period was an unforgettable time. Moreover, I would like to thank Sven Bertens for the job within the research department. I'm very grateful for this opportunity.

Enjoy reading!

Babette

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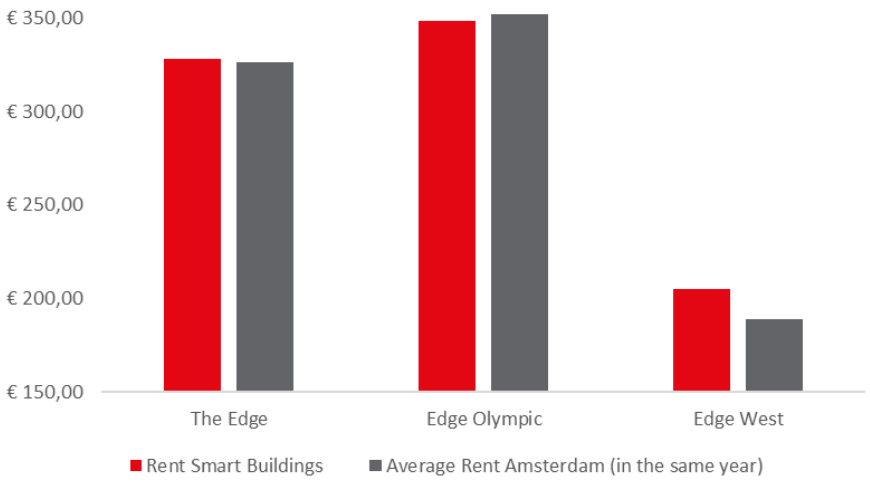
Introduction

1. Motivation and problem definition

"Technology appears to be changing the most fundamental truth about commercial real estate, namely that property value is mainly based on the location", according to Deloitte (2016). Technology is nowadays increasingly used to upgrade real estate. This has led to phenomenon's like "smart buildings" and "smart offices". Smart offices are technically innovated buildings with an office destination or use. In smart offices, occupants can work as in traditional offices. The 'smartness' of the building observes the occupant to anticipate on his intentions. Internet is getting more involved in the occupants' activities to support daily tasks. Systems can communicate with occupants (Gal, Martin & Durand, 2000). Different kinds of smart devices communicate with each other to make life of occupants more comfortable and make office work easier. Occupancy detection plays a role in smart office applications such as controlling heating, ventilation and air conditioning. Possible features of smart offices are: self-adjusting lighting and window shades, personalized heat and light settings that can follow one around the building, lighting systems that mimic natural daylight, heat and lighting systems that adjust automatically according to weather and occupancy, an app for booking desks and meeting rooms, meeting rooms where the screens work seamlessly with your device and many more (Worktech Acadamy, 2017). Confidence in smart offices is based on the expectation that these innovations in offices will trigger benefits for a company or an organization. Smart offices are also expected to raise productivity and wellbeing, to appeal to new talent and raise employee loyalty (JLL, 2017). Next to the assumption that smart offices can raise productivity and wellbeing of their occupants, they are expected to be more sustainable than normal offices (Worktech Acadamy, 2017).

Although smart offices are a relatively new topic, different studies have already elaborated on it. Chen, Jiang & Xie (2018) present a review on building occupancy estimation and detection. They compare different sensor types for the estimation and detection of occupancy. Gal, Martin & Durand (2000) elaborate on the features of smart offices. Buckman et al. (2014) elaborate on the idea of an intelligent building. Rafiq et al. (2017) and le Gal (2005) describe what smart buildings and smart offices look like and what features they can have. Most studies that have smart offices as topic are more or less technically-oriented (Chen, Jiang & Xie, 2018; Gal, Martin & Durand, 2000; Buckman et al., 2014; Rafiq et al., 2017 & le Gal, 2005). The existing literature is vague in terminology and terminology also changes over time. Therefore this study will try to form a new definition of smart offices. Moreover, the literature does not elaborate on the attractiveness of smart offices for their users and to a lesser extent on the financial attractiveness of investing in smart offices. This study will try to fill this knowledge gap and determine which factors make smart offices attractive and to what extent users and investors are willing to pay a price premium for these modern offices. Users rent square meters in a building and are the demanders of space. Investors often finance construction and are therefore partially determinative in what is being built. Constructors subsequently construct the buildings that are demanded by both users and investor (Geltner et al., 2014). For this reason it is useful to investigate to what extent smart offices are seen as an attractive property type among different parties in the real estate market and to what extent they are willing, or would be willing, to pay a prime premium for smart offices compared to traditional offices. Since JLL is the contractor of this research and works for both users on the user market and investors in real estate, this research will focus on the attractiveness of smart offices for both users and investors.

Figure 1: Rents paid for Smart Offices (Source: JLL Data, 2019, own editing).



For this research, three cases have been investigated, namely the Edge, Edge Olympic and Edge West. The Edge buildings, that were developed by OVG, are nowadays known and marketed to be smart buildings. In agreement with the JLL research department, it has been agreed to investigate these cases and especially the stakeholders around these cases. There are only a few offices in the Netherlands that are known to be "smart". Methodologically speaking, these three buildings are therefore considered to be representative enough for the smart office market in the Netherlands. Moreover, this research is not about the specific buildings, but about the opinions, wishes and expectations of users and investors regarding these offices. The main objective of this study is to explore an upcoming market. The method used for this study is similar to the 'extended case study method' that Burawoy (1998) uses, namely a theoretically informed, exploratory study, in which not so much 'the' market for smart offices is mapped, but in which theoretical expectations about market forces, macro versus micro and objective versus subjective, are nuanced within an emerging market that is still small in the Netherlands. In addition, an attempt is made to either confirm or reject these expectations. Further explanation of the choice for the research units and participants can be found in the methodology. JLL data shows that in the cases of The Edge and Edge West, tenants pay a higher rent per square meter than tenants that rented office space in Amsterdam that same year. Since there are only three buildings that are now marketed as being smart, no significant conclusions can be drawn from these numbers. Also, not all the data concerning this buildings is available. Therefore, this research will investigate the following questions using qualitative methods. The central question associated with this research is the following:

"***What factors make smart offices attractive to occupiers and investors and to what extent does this lead to a price premium (eventually) being paid by them?"***

The main question is investigated using the following sub-questions:

- What are smart offices?
- How does pricing of real estate come around according to macro theories and valuation methods?
- What factors determine the attractiveness of (smart) property for both occupiers and investors?
- To what extent are different parties willing to pay a price premium for smart offices and what macro or micro forces are decisive regarding this decision?

2. Research objective

Developments in the equipment of buildings, including offices, affect different parties on the real estate market. The aim of this study is to find out what the different parties consider to be a smart office, what factors of smart offices are expected to be value-adding and seen as attractive by both occupiers and investors and to what extent the different parties are willing to pay a price premium for these smart buildings. This research describes the working of general models like the four-quadrant model of DiPasquale & Wheaton (1992) and pricing models that, for example, valuators use to value buildings. Models like these explain forces of the real estate market to a certain extent at the macro level. However, there are also developments at the "micro-level" of the market. For example, supply and demand for offices is also driven by the preferences and the wishes of users and investors, the introduction of new technologies by the developer and "marketing" practices within real estate consultancy. Real estate consultants have an important role in creating the "illusion of a market" and the rise of that market (Aalbers, 2018) and also this influences preferences that stakeholders have. In this research, an attempt will be made to nuance macro theories such as the four-quadrant model and to supplement existing information with additional insights concerning the wishes and preferences of users and investors or to come to a more comprehensive explanation of why investors and users possibly prefer smart offices over traditional ones and whether and to what extent they would be willing to pay a premium for this. It will be investigated whether different parties are willing to pay a price premium for smart offices and what factors are decisive for potentially paying such a price premium. The contractor of this research is JLL. Because developments in the equipment of buildings can have a certain value for occupiers and investors, it is of great importance for a consultant to provide their clients with a well-considered advice and make clients better off so that they place a high value on services of the consultant (Aalbers, 2018), JLL in this case.

3. Societal relevance

Through the use of data, technology in office buildings, smart offices came into being. A smart building or a smart office can control operations like air-conditioning, fire safety, lightning and more. Smart offices enhance mobility and apply personalization with the use of, for example, location sensors, to improve occupant satisfaction and productivity. Other returns that smart buildings may bring include a happier staff and a broader appeal to both incoming talent and forward-looking (corporate) tenants (JLL, 2017). Next to the assumption that smart offices can raise productivity and wellbeing of their occupiers, they are expected to be more sustainable than normal offices (Worktech Academy, 2017). The built environment, including both commercial real estate and residences, consumes around 40% of the energy in the world to accommodate comfort for their occupants. Due to the concerns about the world's energy use and the current demand for sustainable developments, energy-efficient buildings are getting more attention. To make buildings more energy efficient, smart options are important features (Akbar et al., 2015). The demand for office buildings is dynamic and occupiers and investors often have specific and changing requirements, which may not always be supplied by "traditional" office buildings. In short, there is an incentive in the market to keep developing new buildings, offices, often in combination with the application of new technologies. Although much research has been done into energy efficiency, the research into smart offices is still in its infancy. It is claimed that buildings that lack smart equipment are more likely to suffer when it comes to asset classification, valuation, rental rates or brand perception (from current and potential future employees and from clients) compared to modern buildings that do have smart equipment. The smart building technology of today is more easily available and is also getting more affordable than it was before, with shorter paybacks and improved return on investment. However, each business is different and smart systems are still relatively new (JLL, 2017). It is therefore relevant to investigate to what extent the above goes for different parties that operate on real estate markets, especially for clients of JLL which are both (office) users and investors.

4. Scientific relevance

The literature relating to real estate provides an holistic approach to the real estate market and the various parties that are active in this market (Geltner et al., 2014), what their needs are and what their customs are. This research combines the subject of the relatively new smart office development with the existing knowledge about different parties on the real estate market, their demands and their expectations. Furthermore, this research investigates to what extend both occupiers and investors are willing to pay a price premium for buildings that have smart equipment and what factors are decisive for possibly paying a price premium. Existing literature that elaborates on smart offices is mainly technically-oriented (Chen, Jiang & Xie, 2018; Gal, Martin & Durand, 2000; Buckman et al., 2014; Rafiq et al., 2017 & le Gal, 2005). Buckman et al. (2014) give an explanation about intelligent buildings. Rafiq et al. (2017) and le Gal (2005) elaborate further on smart buildings and smart offices. The terminology is however vague and due to many definitions, the idea of smart offices has lost its focus. Therefore a new definition of smart offices will be given in the theoretical framework that will be handled throughout the research. Also, participants will be asked what they consider to be a smart office. Geltner et al. (2014) give an holistic overview of the real estate market using the four-quadrant model of DiPasquale & Wheaton (1992). Both parties that are investigated in this research, namely the occupants and investors are described in this model. However, the existing literature does not yet combine smart property with its attractiveness for occupant and investors. To determine this attractiveness, this research will also investigate the factors that make smart offices an attractive property type and the extent to which occupants and investors are willing to pay a price premium to use or buy them. this research will, ultimately, investigate to what extent macro theories, like the four-quadrant model or pricing models, can be applied and to what extent micro-factors such as preferences and wishes of both users and investors explain the demand for- and attractiveness of smart offices. Regarding the literature it can be expected that the attractiveness of smart offices for users leads to a greater demand, higher rents that will be paid for them as a short term consequence, greater prices that investors are willing to pay and ultimately, more construction of smart offices. However, the wishes and preferences of users and investors are also expected to influence the final outcomes. Branding and marketing of new trends steer these wishes and preferences. This research will investigate this interaction between the macro and micro forces on the market for smart buildings.

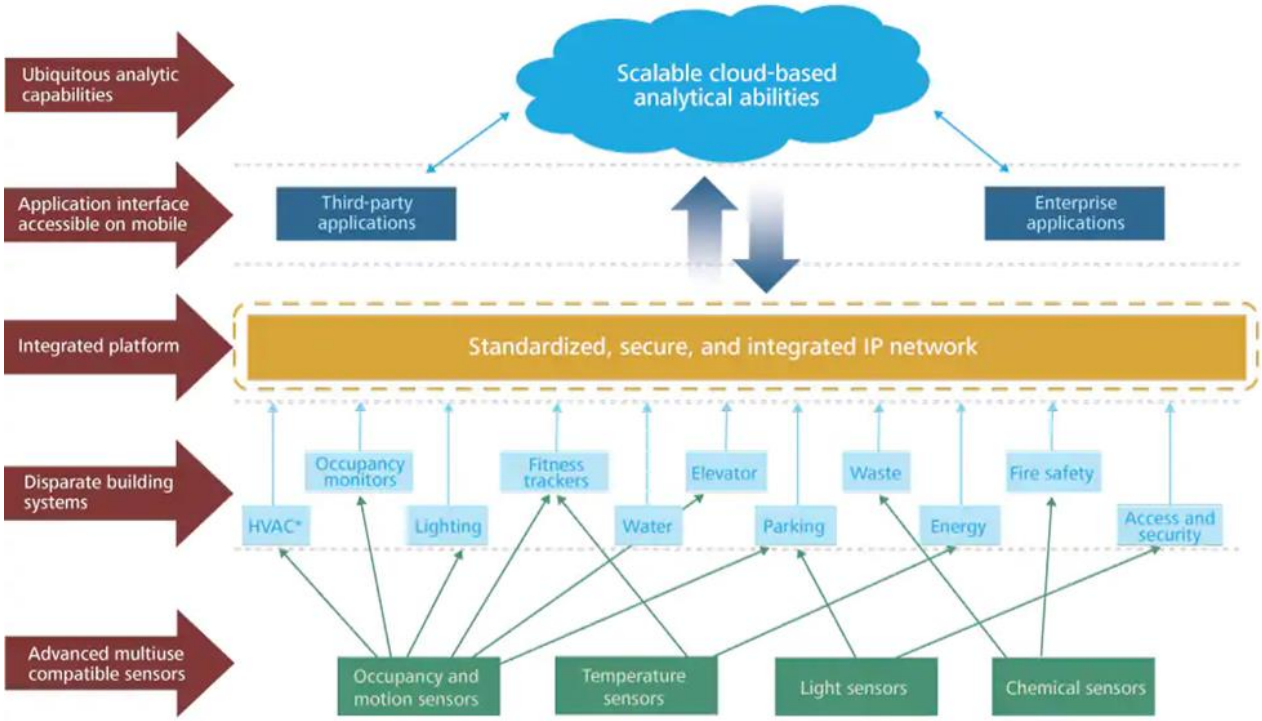
5. Reading guide

This research started with an introduction to the topic, smart offices, motivation, problem definition and research questions. Thereafter, a societal and a scientific relevance were given for the study. The next chapter elaborates on existing (commercial) documents, from for example JLL or Deloitte, that have smart offices as topic. The following chapter is the theoretical framework. The chapter “Different parties on the real estate market” in the theoretical framework describes the working of the real estate market, connections between the parties that operate on it and the preferences of occupiers and investors in general. Pricing mechanisms in real estate consultancy that influence pricing, like the appraisal of real estate objects by valuators, are described in the following section of the theoretical framework. Thereafter, micro-theories that elaborate on preferences and wishes of both users and investors are described. After the theoretical framework, the methods that are used for this research are described, followed by the results. Within the results chapter of this research, an attempt will be made to nuance macro theories such as the four-quadrant model and to supplement existing information with new insights. Finally, a conclusion is given concerning the research questions and a discussion is provided regarding the research process. After the discussion, the literature list can be found together with the appendices.

Smart offices – Context chapter

In this chapter, different insights from research reports from JLL and others will be discussed to give a broader view on the Dutch, European and international context of smart offices. Smart technologies are a new development in commercial real estate. Smart offices generate benefits, like the optimization of building operations, the improvement of workplaces and the improvement of people's experience by meeting expectations of a workforce that is more and more used to technology. According to JLL (2017) tenants and investors realize the advantages that technology can bring to real estate. Buildings that are not smart are expected to deal with decreasing asset classification, valuation, rental rates, or brand perception. This means that organizations, companies or building owners are soon to incorporate smart technologies or they may lose competitive advantage. Occupants are expecting interactive and personalized experiences that meet their changing preferences. Employees are becoming more flexible and prefer adaptable workspaces that improve comfort and productivity (JLL, 2017). In smart offices employees can, for example, use mobile applications to control the light, control heating or ventilation or to book meeting rooms. This makes more efficient, productive and cost-effective use of space possible. Data and technology make smart building technology solutions possible and enable to anticipate and respond the needs of consumers. Smart systems connect occupants with their environments and offer their users tools to eliminate "workplace friction". For example, they make it possible to regulate the temperatures or they help their users find parking spots. All these smart tools are expected to improve productivity of the users (JLL, 2017).

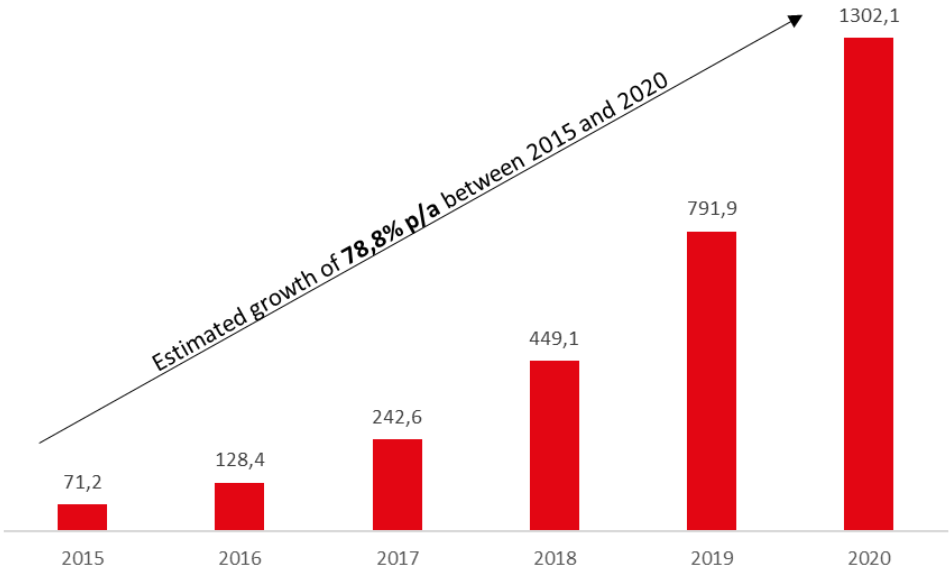
Figure 2: Internet of Things information value stack for commercial real estate (Source: Deloitte. 2016).



According to Deloitte (2016), the Internet of Things [IoT] impacts real estate. Applications aim to improve building operations, enhance relationships with tenants and create new opportunities in terms of revenues. Commercial real estate can implement technologies using IoT-enabled systems to make the performance of a building more efficient and also by using data generated by sensors to enhance the user experience. The IoT can enable devices to generate data and information and connect these devices for

analyses and action. Technology is used to communicate data about the condition, position, or other attributes of the object. Various sensors can track features such as motion, air pressure, light, temperature, water flows and enable building management systems to sense, communicate, analyse and act or react to people or other machines in an autonomous way (see figure 1). Costs of sensors and data equipment are falling. A study from Deloitte (2016) claims that technology has potential in real estate and that sensor deployment is expected to grow approximately with an annual growth rate of 78.8 percent between 2015 and 2020 (see figure 2).

Figure 3: Potential growth in IoT sensor deployments for CRE (Source: Deloitte, 2016, own editing).



According to Deloitte (2016) IoT applications enable companies to use data to differentiate and improve their product and services and to identify new opportunities in terms of revenues. So, technologies enable companies to create value through efficiency, through differentiation and trough new revenue sources**.**

Deloitte (2016) states that smart offices increase staff convenience by creating more comfortable workspaces that are customized and backed by insights on interaction and movement. Deloitte (2016) also claims that smart offices help to improve workplace efficiency and employee productivity by automating tasks, like swiping access cards and make work environments healthier. An example of a smart office is the Deloitte office building in Amsterdam. This building uses connected systems, for example the light, that are backed by technology that is able to transmit data. Smart lighting increases convenience for the users by enabling them to customize the brightness of the lights through their mobile phones. Moreover, sensors track air quality, temperature and humidity to create and maintain a healthier office climate (Deloitte, 2016).

Since occupiers expect more from the buildings they use, real estate owners must consider the implications that these growing expectations have for the built environment. (Future) occupiers of real estate demand facilities that can support modern technologies and can increase their satisfaction. Many companies are beginning to view facilities with an eye on attracting future employees and keeping them both engaged and productive. Digitalization is thus expected to impact talent in an organization. According to JLL (2017) multiple employees are willing to leave companies that aren‘t modernising in technical terms. So, keeping employees connected and productive creates advantage for an organization. Enhancing the human experience with smart building technologies is becoming a competitive strategy. A comfortable and technically modern environment can make a difference in the satisfaction of employees and in their productivity (JLL, 2017).

Moreover, organizations are under pressure to be energy efficient. Smart building systems are able to gather data that organizations need to track energy performance. Data concerning a building can also be used to create a smarter workplace. It can, for instance, tell you which spaces are being under- or over utilized, when spaces are being used, which spaces are being used and by whom. Information on how space is used can increasingly be based on data. By making use of the data, organizations can understand if features are enhancing productivity of the users. For example, data can show if certain rooms are actually being used or not (JLL, 2017), which makes it possible to close certain parts or floors of a building when occupancy is lower. Just like its users, the new-office style has to behave conscientiously, by being careful with energy and building materials. Companies invest in those new, "smart" offices to reach sustainability goals. In the Netherlands as well there is growing pressure from, for example, the national government to be energy efficient. By 2023 all offices must have at least energy label C. In 2030 it will be compulsory for all offices to have energy label A. Moreover, since 2018, the ING bank only finances buildings with a "green" energy label (Rijksoverheid, 2016).

According to JLL (2017), smart offices are potentially adding value to businesses. Values range from optimizing building operations to elevating everyday experiences. “Smart” is already getting attention among commercial property investors. Smart building technology is changing the built environment. JLL (2017) claims that valuation of a building in the near future will take the buildings intelligence into account because of the expectation that smart technology will create leverage for investors.

Technology also changes leasing models. Researchers are trying to quantify the impact of smart on rents and values of property. Benefits in terms of energy efficiency are already documented. Smart buildings seem to use less energy and have lower operating costs than ‘traditional’ buildings. This leads to greater returns and an increased market value. Concerning energy efficiency, research shows that energy efficient buildings sell at 2 to 17 percent premium than less modern properties. They attract 8 to 25 percent higher rents and they have 9 to 18 percent higher occupancy rates. According to this research, tenants are increasingly willing to pay a premium for modern, efficient buildings and facilities (JLL, 2017). As for the investors, lower operating costs are seen as value adding. Advanced control strategies can reduce costs for heating, ventilation and air conditioning [HVAC] between 24 to 32 percent. Smart building technology in combination with energy-efficient windows can reduce operational costs more to an extra reduction of 20 percent. So, smart buildings offer long-term advantage, according to research of JLL. However, there are property investors who hesitate to invest in smart technologies, these investors view technology as costly and see the payback period and return on investment as unpredictable (2017).

It can be concluded that smart (office) technologies are becoming a market differentiator in real estate for those who want to be more energy efficient, to enhance the workplace experience and make office life easier. For real estate investors, smart office technology is also a differentiator. Smart offices are expected to improve energy-efficiency, make savings on maintenance possible, improve workplace experiences, increase satisfaction and productivity and make a buildings’ value increase (JLL, 2017). There is potential for technology to be, at least, “as valuable to the building as the location of the building” (Deloitte, 2016). Whether this is actually the case, according to users and investors in the Dutch JLL network, will be examined further in this research. First, the theoretical literature will be examined, then the research methods will be explained, followed by the results of the empirical research. Finally, a conclusion and a discussion are given. It will be concluded if expectations that are sketched in both the commercial reports and the scientific literature are true and to what extent. The conclusion also gives feedback on the main and sub questions.

Theoretical framework

In this chapter, a theoretical framework is formed based on existing literature. The framework starts with a definition of offices and then distinguishes intelligent buildings, smart buildings and smart offices. This section gives different definitions and concludes with a new definition that will be followed during the research. Next, this chapter discusses the main parties that are active in the real estate market and the linkages between them according to general real estate theories. Thereafter, the chapter focuses on price forming for users and investors. Besides these more general theories and models, personal preferences of users and investors play a role in deciding whether to relocate or to invest. These wishes and preferences are elaborated on in the fourth section. The chapter concludes some more detailed research questions.

1. Smart offices

This research focuses on the market for offices. Before addressing "smart offices", the definition of an office will be given. Van Gool, Jager, Theebe & Weisz (2013) give the following definition for an office: *"An office is a spatially independent business asset that includes policy, organizational, commercial and administrative activities. That makes offices a consumer product."* (Van Gool et al., P.93, 2013).

1.1 Intelligent buildings

In the building sector, unclarity is noticed in terminology. This chapter will shed light on the term 'smart building' or 'smart office'. Technology is increasingly used in buildings. The term smart has been used interchangeably with intelligent. However, there is no clear distinction between the two terms. Intelligent buildings have been developed over the last decades, but recently, the term smart is being used more. Smart sensors and smart materials are recent technologies in buildings. In this section, different theoretical definitions of smart buildings and smart offices will be given. In Buckman's (2014) research, the term smart 'building' focuses on non-domestic buildings: buildings that have no residential purpose. The term smart 'office' focusses exclusively on office buildings (Buckman et al., 2014).

Buildings have changed in design and performance throughout time. Buildings are spatially fixed and immoveable. Traditionally, buildings are made of stones, bricks and glass. They deliver water, gas and electricity as basic services and they are in principle not hardwired with technology. Modern buildings, however, are getting more complex in, for example, technical terms. Drivers for the development of buildings revolve around adding more value to buildings for their users and make them a more 'attractive' investment for their owners. This value depends, to a certain extent, on the context of the building, like its location and the use that the building has, but it also depends on themes relating to the object itself, like the costs of the building over its lifetime, the buildings' performance, the comfort and satisfaction it creates for its occupants and more. Reducing the energy use of a building is nowadays an important trend in building design. Operating costs of a building are significant when they are compared to the capital cost. The value of a building is getting more important than its initial cost. It is therefore suggested that a better representation of the driver is to enhance the ability to maintain value over a long period, because of the longevity of buildings. So, intelligent features are becoming more than only the physical aspects of a building. Intelligent buildings are about extra qualities and strive for progression in productivity. Three drivers for building progression are longevity, energy and efficiency, comfort and satisfaction. So, an advanced building has minimal energy consumption, allows for maximal performance, comfort and satisfaction of users over a buildings' long lifetime (Buckman et al., 2014). Buildings can make 'progression' due to increased knowledge and the availability of new technologies and materials. Progression can be made in various ways. There can be an enhancement in the methods by which building operation information or data is gathered and responded to (intelligence), the interaction between

the tenant and the building (control); the form of the building (materials and construction); or an enhancement in how information about the building use is gathered and used to improve the performance of the tenant (enterprise) (Buckman et al., 2014).

Table 1: Ways to make building progression.

Intelligence	How building operation information or data is gathered and responded to
Control	The interaction between users and the building
Materials and construction	The physical form of the building
Enterprise	How information about the building use is used to improve occupant performance

These four methods, the so-called ways to make progression, develop both with and independent from each other (Buckman et al., 2014). Definitions of intelligent buildings have evolved since the 1980s. The definitions constantly change and are adjusted to the latest and most recent knowledge and experiences. Early definitions seem to focus on the technical control of, for example, heating and air conditioning, lighting, security, etc. These early definitions revolve around low user interaction with the building, while recent definitions seem to focus more on user interaction. Recent definitions of intelligent buildings have expanded in features that support the latest understanding of requirements and expectations. Due to changing definitions, the idea of an intelligent building loses clarity. Buckman et al. (2014) define intelligent buildings as buildings that have minimal energy consumption, allow for maximal performance, maximal comfort and maximal satisfaction of users over the long lifetime of the building (Buckman et al., 2014).

1.2 Smart buildings

In academic literature, there is a view that smart systems are a subdivision of intelligent buildings. However, there is little literature that supports this view. Smart buildings are seen as intelligent buildings, but they are more than that. A definition of a smart building is an 'intelligent building with integrated aspects of adaptable control, enterprise and materials and construction' (Buckman et al., 2014). In smart buildings, the four methods that are used to achieve building progression, discussed above, are depending on each other and developing with each other instead of independently. Gathered information from one method is used by the development of another. This is a distinction between intelligent buildings and smart buildings. The absence of a clear definition of a smart building, however, leads to an end goal which is also unclear and unclear methods by which this end goal can be achieved. Buckman et al. (2014) claim that putting clarification on the term 'smart building' is mainly done "to sell or rent more floor area in (office) buildings" and imply that making buildings smarter is a form of marketing. The increasing use of knowledge and information to stimulate building progression is emphasized in definitions and publications on smart buildings. Definitions of smart buildings build upon previous generations of building design but go further than that (Buckman et al., 2014). McGlinn et al. (2010) give the following definition of a smart building: *"A smart building is a subset of smart environments where smart environments can acquire and apply knowledge about the environment and its inhabitants to improve the experience in that environment".* Smart buildings integrate intelligence, enterprise, control, materials and construction as a complete building system, with adaptability at its core. The end goal of a smart building is meeting the, previously mentioned, drivers for building progression which are energy and efficiency, longevity and comfort and satisfaction (Buckman et al., 2014).

Table 2: Goals of smart buildings.

• (Energy) efficiency
• Longevity
• Comfort and satisfaction

Smart buildings provide solutions that are based on platforms where energy is efficiently optimized, the comfort and safety of the user are ensured and assets performance is maximal (Rafiq et al., 2017). Smart buildings are automated, intelligent buildings and they can have several features, including:

> "Intelligent sensors, smarter heating, ventilation and air conditioning (HVAC), safer and healthier working environment, smarter security systems, optimization of quality services, cost reductions, reduced water and energy consumptions, enhanced allocation of resources, predictive maintenance, building management and automation, equipment control regulation and configuration, room and light control, health monitoring and more." (Rafiq et al., 2017).

1.3 Smart offices

Smart offices are smart buildings with an office use. In a smart office, occupants can work as in normal offices. The smartness of the office can, for example, observe and track its users. Computers are involved in user activities and systems can interact with users using voice or movement (le Gal, Martin & Durand, 2000). There are different perceptions of smart offices. However, they all share a common objective to make communication between human and computer natural and to make office work easier (le Gal, 2005). For example, Mizoguchi et al. (1999) state that research of smart offices is about both constructing an electronic environment and about dynamically changing the environment that supports activities through interactions between human and robotic devices. The environment is constantly changing and people seek for ways to improve this environment to make work go more smoothly and easily.

> "A smart office is a future office where various information appliances, such as robots, cameras, sensors, projectors, blinds, screens and lights are connected by a network and where these information appliances can be controlled in the same way. This office is an experimental environment to clarify how information appliances should cooperate to support activities." (Mizoguchi et al., 1999).

A more recent definition comes from le Gal (2005): *"Smart environments combine perceptual and reasoning capabilities with the other elements of ubiquitous computing in an attempt to create a human-centred system that is embedded in physical spaces".* However, a smart office is not just a smart environment. Smart offices are not only dealing with heaters, switch lights, display videos, etc, but they are also supposed to be useful for the work that is daily done in these offices. Smart offices, therefore, deal with software and hardware heterogeneity. Offices can be meeting rooms, workplaces, discussion places or rooms for demonstration. A smart office is therefore supposed to transform easily and automatically for its different purposes. According to le Gal (2005), different abstraction levels to the office configuration are desirable because not every user has the same computer or programming skills. Smart offices support multiple people who prefer different forms of interaction. In short: a smart office can support its users with everyday tasks by automating some and making communication between the occupant and the machines easier (le Gal, 2005).

There is not one clear definition of a smart office. Definitions include different forms and levels of computer-enhanced offices. For example, interactive offices are offices where occupants interact with offices application, using communication means. Context-aware offices adapt to the environment in offices. Ubiquitous computing provides a different way to interact with offices and makes computers invisible for the occupant. Intelligent offices can perform a task themselves, they can, for example, communicate information to users. All smart office types have a common objective: making communication between users and computers more natural and make office work easier (le Gal, 2005).

In this research, the value of smart offices will be determined for both investors and users. However, terminology tends to be vague and changes over time. To be consistent, one concluding definition of smart offices will be formulated and maintained throughout the rest of this research: “A smart office is a building with an office use. Offices can be meeting rooms, workplaces, discussion places or rooms for demonstration (le Gal, 2005). Smart offices aim to make communication between humans and computers more natural, make office work easier and meet the goals that buildings nowadays have, which are energy and efficiency, longevity and comfort and satisfaction. The smart office is an office where various information appliances, such as robots, cameras, sensors, projectors, blinds, screens and lights are connected with each other by a network and these information appliances can be controlled in the same way. Possible features of a smart building can include Intelligent sensors, smarter heating, ventilation and air conditioning (HVAC), safer and healthier working environment, smarter security systems, optimization of quality services, cost reductions, reduced water and energy consumptions, enhanced allocation of resources, predictive maintenance, building management and automation, equipment control regulation and configuration, room and light control, health monitoring and more. Different abstraction levels of smartness are desirable (Rafiq et al., 2017)”.

2. Different parties on the real estate market

Markets are basic social and economic phenomena. A market is a mechanism that voluntarily trades goods and services between various owners (Geltner et al., 2014). This chapter will elaborate on three real estate markets, the user market, the investment market and the construction market. Finally, this chapter will describe the whole real estate system, following Geltner et al. (2014).

2.1 The user market

The user market is the market for the use of real estate and can also be referred to as the occupier market. Demanders in this market are, in the case of offices, individuals or firms who want to use space for production or consumption. Suppliers in the user market are owners of real estate that rent space to tenants. Users pay rent as a price for the use of a unit of space. Rent is usually calculated and quoted annually and per square metre, however, there are also other methods to quote rent. Rent is determined through supply and demand. If demand rises and supply of space remains the same, rents increase. This also works the other way around (Geltner et al., 2014). In the user market, supply and demand depend on the location and the type of space. Users demand buildings with a specific use and location. Supply consists of buildings with a specific use and cannot be moved. This makes user markets are segmented. Segmentation can lead to a difference in rents. Space-markets tend to be metropolitan areas. However, also in a metropolitan area, there can be different subspace-markets. Large commercial space-market types are offices, retail and industry. All these markets have different demanders, demand features, suppliers and supply features. Demand for a specific type of space can grow or decline. Change can be due to various reasons. Growth in demand for office space can be due to the need for office workers. This example is shown in a figure. The demand function (figure 1) is a straight line that goes down. When, for example, the number of employees of a company is increasing, more space will be needed, but cannot be supplied in the short term. A higher demand for (office) space leads then, in the short term, to an increase in rent. The supply function can be drawn as a kinked line (figure 2). The supply line starts as a vertical line at the current amount of space. The vertical line indicates that when demand declines, space can barely be reduced in the short term because of longevity. The supply function for each product is the long-run marginal cost function for producing additions. Marginal costs are the costs of developing new buildings. A rent level that stimulates new development is the replacement cost level. If rents are below these so-called replacement costs, developers will not undertake new developments with profit. The following figures represent both the demand line and the supply function (Geltner et al., 2014). The next section will elaborate on the investment market and on different types of investors that are active in this market.

Figure 4: The (moving) demand line (Source: Geltner et al., 2014).

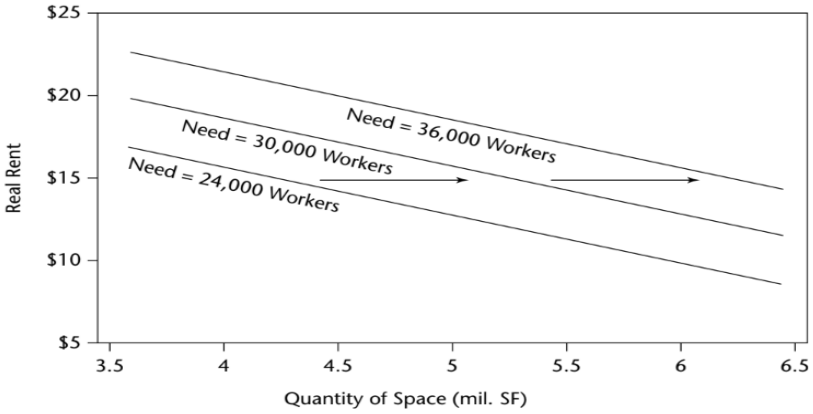
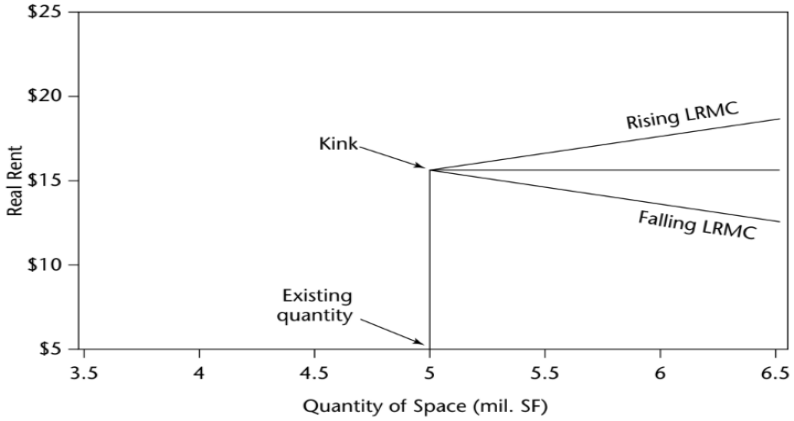


Figure 5: The (kinked) supply curve (Source: Geltner et al., 2014).



2.2 The investment market

The investment market is also an important market in real estate. The investment market in real estate is the market for the ownership of assets or 'shares', of real estate. Real estate assets are land parcels and buildings. The investment market can also be called the 'property market'. Assets on the investment market symbolize "claims to future cash flows". Cash flows are rents an asset can generate. Rents are paid out by users. From this viewpoint, real estate assets are comparable with other capital assets like, for example, stocks and bonds. The investment market in real estate can be viewed as a part of the capital market, the market for all types of assets. A distinction between the investment market and the user market is that users require physical elements of real estate, a specific use in a specific location. Investors on the demand side of the investment market, are looking for future cash flows and require financial features more than physical features (Geltner et al., 2014).

2.2.1 Capital markets

Capital markets can be divided into public or private markets and they can be divided into whether assets are traded in equity or debt. Real estate investments are present in all the categories on the capital market. For example, commercial buildings, residential homes and parcels of land are bought and sold in private markets among different owners and buyers who found each other with the help of, for example, brokers in (Geltner et al., 2014). Examples of assets in all categories are given in the table below.

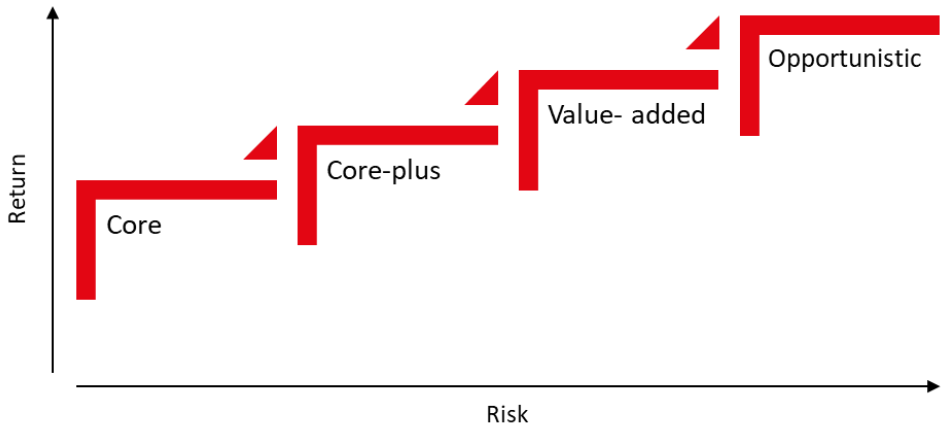
Table 3: Public and private markets and equity and debt assets.

	Public markets	Private markets
Equity assets	• Stocks • Real estate investment trusts (REIT's) • Mutual funds	• Real property • Private equity • Hedge funds
Debt assets	• Bonds • Mortgage backed securities (MBS) • Money instruments	• Bank loans • Whole mortgages • Venture debt

2.2.2 Different types of investors

Demand in the investment market consists of investors or users who want to buy property. On the supply side are other investors, users or developers who want to sell space. The balance between supply and demand for real estate assets determines the value compared to other forms of capital assets. Values are determined by potential investors who are estimating the level of the cash flows that the property can generate and the riskiness. To value property, it is common to speak in terms of property value per dollar of current net rent or income. When doing this, prices of different property pieces, with different sizes, on different locations, can be compared more easily. In commercial property markets, a measure that is used to describe values is the capitalization rate. This measure is the rent that property generates divided by the asset value or price. This capitalization rate is similar to a yield which is the amount of current income an investor generates per dollar of value of the investment. The cap rate is determined by the opportunity cost of capital, growth expectations and risk (Geltner et al., 2014). CRE is increasingly owned by (international operating) real estate funds, these funds own large portfolios of different properties. The properties can be concentrated in one region but funds are increasingly owning properties globally and more indirectly (Aalbers, 2018). Institutional investors are mainly looking for mid- to long-term investments, this is increasingly made possible through indirect investments in real estate (Wijburg et al., 2018). This theory relates to the risk-return ladder. At the bottom of this ladder are the core investments, investments with less risk. However, they are also expected to generate smaller returns. When you go up the ladder both risk and potential returns increase (see figure 6).

Figure 6: Risk & Return ladder (Source: Investorpedia, 2018, own editing).



2.3 The construction market

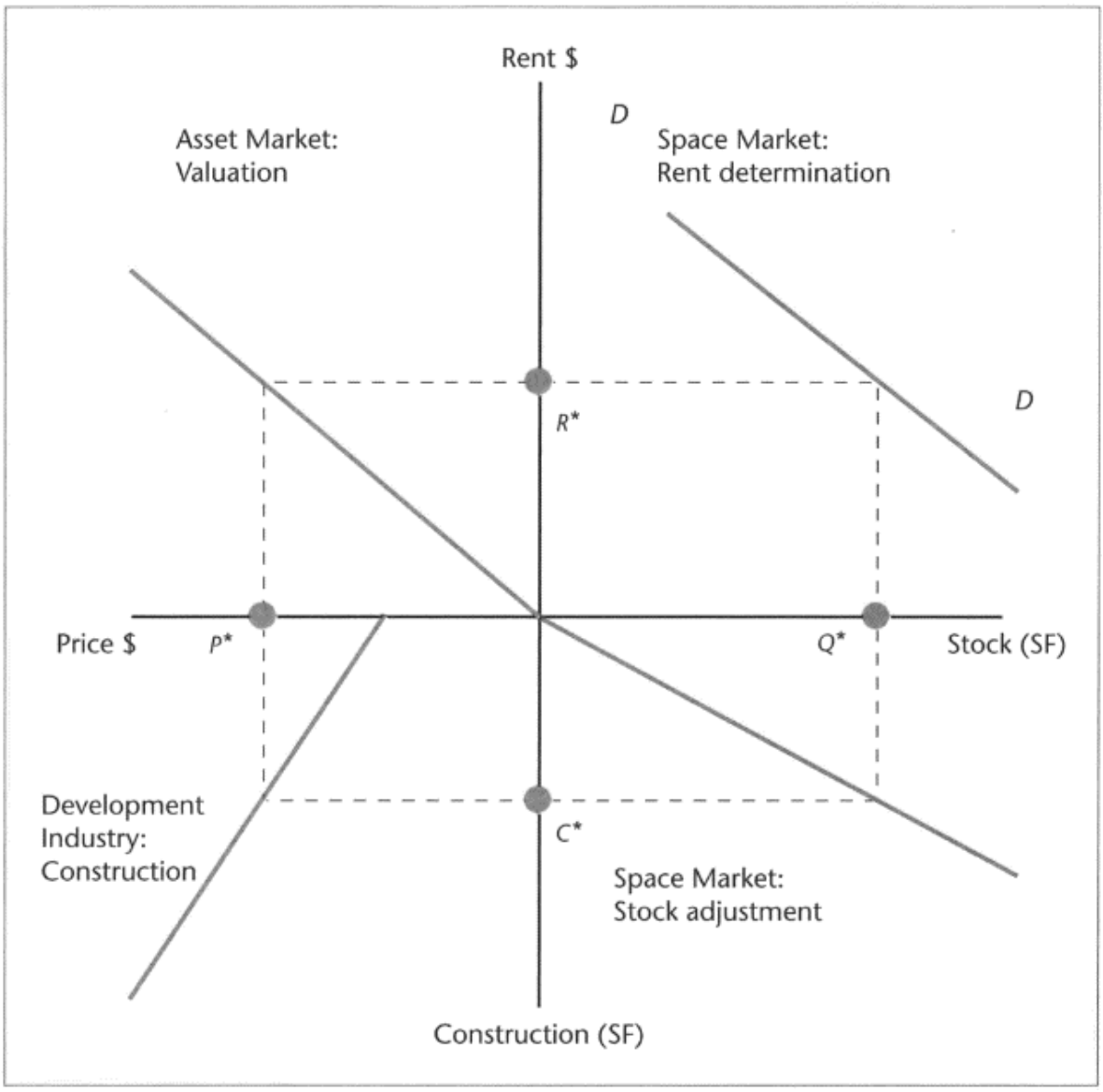
The user market and the investment market are directly linked in a short-run relationship. Both markets are also linked to the development industry in real estate. However, this relationship occurs over the medium to long run. The development or construction market will be discussed in this section. In the construction market, new space is constructed and existing buildings are converted or renovated. Additions to office stock are mainly required because of economic growth or other economic changes, like changes brought about by technological change. Demand for built space supports the development industry. This makes the development industry the most cyclical market within real estate. Development is linked to the economy with a delay because development takes time. The development market can be seen as the converter of financial capital into physical capital. Developers succeed when the value of the new property exceeds its development cost when the project is finished (Geltner et al., 2014).

2.4 The real estate system and the four-quadrant model

The user market, the investment market and the construction market together form the real estate system described by Geltner et al. (2014). This system is also linked to other systems like the national and the local economy and capital markets. In the user market, demand and supply interact with the stock of space. This interaction between supply and demand determines rent levels. Economies determine the need for space. The amount of space that is on the supply side is determined by completions in the construction market. The user market makes up the cash flows that real estate produces. These cash flows are income for investors and interact with cap rates that investors require to determine values. In the investment market, supply and demand are made up by investors. Desires and perceptions that investors have about the risks and returns of the investments in real estate assets, compared to other types of investments, determine the cap rates investors require. A determinant of the cap rate is also the estimation of future rents. Thus, the user market and investment market interact to produce real estate values. These values are input for the development market. Space is rented out in lease contracts, usually from five to ten years. In the system, a negative feedback loop is noticed that dampens the mechanisms. When supply or demand threatens to lose balance in user markets, the effects on cash flows for investors will lead to a pricing response in the investment market. If parties look forward in their responses, the negative feedback loop will keep demand and supply in balance. However, investors and developers mainly react in the short term. This undermines "self-regulating" and results in crises (Geltner et al., 2014).

A visual overview of the system, its markets and relationships, is designed by DiPasquale and Wheaton (1992) and is called the four-quadrant model. This overview helps to understand how components evolve using relationships that complete the linkages between the user market, investment market and construction market. The model is valuable in analysing effects on the long run in the user market and investment market. The concept represents the market cycle for supplying space to match the demand. The equilibrium in the model is symbolized by a rectangle between four points that lay in the different quadrants. The sides of the rectangle cross the axes. In the rectangle the points Q, R, P and C are indicated. The northeast quadrant symbolizes rent in the user market. The horizontal line beneath the user market is the stock of space. The vertical ax is the rent. This quadrant symbolizes the classic supply and demand graph. The rent in equilibrium R occurs at an amount of space at Q. The northwest quadrant in the figure is the investment market. In this quadrant asset valuation takes place and property prices are determined based on rents. The line this quadrant is symbolizing the cap rate. When the line is steeper, the cap rate is higher, meaning there is a lower property price per dollar of rent. When a horizontal line is drawn from the rent R on the vertical axis to the line of the cap rate in the northwest quadrant and a vertical line is drawn from that point to the axis of property prices, the property price can be determined by using rent. P thus symbolizes the property price. The two northern quadrants are the short-run link between the user and the investment market (Geltner et al., 2014).

Figure 7: Four-quadrant model (Source: DiPasquale and Wheaton, 1992).



The southern quadrants symbolize the effect in the long run, namely the impact that construction has on the built environment. The southwest quadrant represents the development industry. Property prices are in a relationship with the amount of development. The line represents the amount of construction at a given property price. Higher property prices will lead to more construction at point C. This line represents the rising long-run marginal costs in the supply of built space. More long-run supply elasticity would lead to a more steeply falling line. The development line crosses the property price axis at a positive value because property prices that lie below a particular amount will not lead to construction. Then it would be unprofitable in this case to develop new space. The quadrant in the southeast of the model completes all relationships. The line here connects the rate of construction to the total stock in the user market (Geltner et al., 2014). Since this research focuses on users and investors, the construction market is to a lesser extent taken into consideration.

3. Pricing of real estate & valuation methods

This chapter focuses on the pricing of property for both tenants and investors and to what extent these pricing models can be used for valuing smart offices. As elaborated on before, ownership of land and buildings gives the right to the owner to develop it, occupy it or lease it. Occupiers need buildings as production factor and investors require real estate as an investment. Resources are scarce and costs that are allocated to one use cannot be allocated elsewhere. In economic markets, parties behave competitively. Businesses have different requirements and preferences and different budgets that influence the price that can be paid for a piece of real estate (Wyatt, 2013).

3.1 Rent

In office markets, space can be sold, bought, let and rented. These activities occur because of demand and supply of office space. Pricing of property for occupants is usually the rent they pay for using that piece of property, but some occupants own their property. Rent is quoted annually and per square meter. However, there are also other methods (Geltner et al., 2014). In the property market, land owners offer properties and businesses demand them. The short term demand curve, that is shown in the previous section, represents consumer behaviour. It is a downward-sloping line that shows that possible occupiers demand a greater supply of space at lower prices than they do at higher prices. The supply curve symbolizes the quantity of property available for rent or sale at various prices. The higher the price that can be asked, the greater the amount of space that will be supplied in the long term. The equilibrium rent is where demand for property crosses the supply line at a given quantity of space. Price directly varies with supply and indirectly varies with the demand for space. A piece of property has value when it has utility and value is created when property is scarce. The value will be determined by these factors together with opportunity costs and budget constraints. The interaction of these factors in the concept of demand and supply creates value. All units of property are unique. They vary in quality, location, legal restrictions and external influences (Wyatt, 2013). The rent level that will be paid for office space depends on various characteristics: the lease agreement and the tenant in question, characteristics of the object itself, the location of the object and the current market situation (Weterings et. al., 2009). Remøy (2010) claims that demand is based on three different aspects: the building itself, the location and the market. Several office characteristics are taken into account by Remøy (2010) that can cause an organization to (re)locate. Building facilities play an important role for organizations to accommodate themselves. Characteristics that are mentioned are, for example, a parking at the office, a reception, meeting rooms, a fitness area, a coffee corner and more. Nowadays, technology developments are changing occupiers' demand. A relation is indicated between vacancy rates and building facilities, whereby building facilities have to fit the demands of users (Remøy, 2010).

3.2 Interest and pricing of real estate

Whatever the demand for space is, supply remains fixed in the short run. With higher demand, there will be a higher rent that investors can receive for the same supply. This section elaborates on price forming for real estate assets on the property market. Property markets are diverse, less structured markets where relatively fewer transactions occur. Transactions can be seen as unique transactions. Investors think of real estate as an investment and the value of this investment depends on the ability of this property to deliver a return. The occupier market drives expectations for how an investment is going to perform. Thus, rental values are determined by forces of supply and demand in the user market and values are determined by potential investors who are estimating the height of the cash flows that property can generate and the risk. To value a piece of property, it is common to speak in terms of property value per dollar of current net rent or income. When doing this, people can compare prices of different properties more easily (Geltner et al., 2014). In a valuation, an appraiser gives an 'independent' value for a building, taking into account market conditions and

property characteristics. The market value is the value that a buyer may want to pay for a property on the free market. However, the value given by the appraiser is never completely independent since the human factor is involved. Important valuation methods in (commercial) real estate (ten Have, 2011) will be discussed:

- **The comparative approach:** In this approach, an object is valued based on comparable buildings for which the rental or selling prices are known. In the valuation of the appraised, adjustments are made for deviating characteristics. This approach consists of the comparative method, the rental value method, the capitalization method and the multi-regression method (ten Have, 2011).

- **The income approach:** In this approach, objects, like offices, in this case, are valued based on future incomes and expenses. A rate of return requirement is used to calculate the value of the object. Four methods can be distinguished within the income approach: the BAR method, the NAR method, the DCF method, OCF method and the means rental method (ten Have, 2011).

- **Cost approach:** The third method is the cost approach, where objects are valued based on the costs to build or rebuild the valued property. Costs include land costs, construction or development costs and other additional costs. A distinction can be made between the cubic meter method, the construction cost method, the retrospective method, the corrected replacement value method and the residual land value method (ten Have, 2011).

When valuing offices, the BAR, NAR and DCF methods are generally used, supported by the comparative method. When using the following methods, rental value and initial yield are important parameters. Rental value and initial yield are determined using the comparative approach: With the comparative approach, a value is based on realized transactions. A comparison is made between more or less equivalent properties. The rental value is determined based on the rental value method, which compares similar properties with the rental price per square meter per year. Initial yields are established similarly. Adjustments can still be made for value-influencing characteristics (ten Have, 2011).

3.2.1 Capitalization rate and BAR method

In the investment market, capital values are based on expectations of occupier activities. It can be assumed that price determination in the property market is based on rental values. Capital values bear a relation to these rents. An assumption that investors need to make when valuing real estate is to choose an appropriate capitalization rate (CAP rate). The CAP rate is the rate that is applied to net operating income (NOI) to determine the present value of real estate. If a piece of real estate, for example, is expected to generate a net operating income of one million euros over the next ten years and is discounted at a cap rate of 14%, the current market value of this piece of real estate would be 1.000.000€/0.14=7.142.857€. So, the NOI divided by the CAP rate equals the current market value. The CAP rate can also be referred to as the BAR or the yield (Wyatt, 2013). The IRR depends on the nominal interest rate and the risk premium for the investment in real estate, which is considered acceptable by the investor and depends on the property type and the tenant (Investorpedia, 2018). To profit, investors have to determine the value of real estate and make estimations about returns these investments will generate, via appreciation, through rental income or by using a combination. The CAP rate is an important assumption an investor should make when valuing property. The CAP rate is the rate that is applied to net operating income (NOI) to determine the value of real estate. It is a relatively simple method and results of valuation are easily communicable. However, the method does not provide insight into cash flows. The BAR method falls, according to ten Have (2011), under the income approach. The value of an object is determined by capitalizing the gross rental price with a BAR (gross initial yield). The gross initial return is a reciprocal of a gross return requirement. A BAR of 5 percent means that the

rental value is multiplied by capitalization factor 20. A BAR of 10 percent means that the rental value is multiplied by capitalization factor 10 (ten Have, 2011). The formula of the BAR method is the following:

Value = (Rental Income/BAR) – Buyer Costs.

3.2.2 NAR method

The NAR method is somehow similar to the BAR method, but here the net rental value is capitalized based on a net initial yield. Beisdes, the capitalized value is corrected for capital corrections. Capital corrections are, for example, overdue maintenance, potential vacancy costs and the difference between the rent realized and the rental value (ten Have, 2011). The formula of the NAR method is the following:

*Value = ((Rental value – Operating costs) / Net initial yield) -/+ (Cash value * Capital corrections)*

3.2.1 DCF method

In the Discounted Cash Flow method, a period of usually 10 years is assumed. A purchase investment is made at the beginning of the period, whereby cash flow is received over the next 10 years. The object is assumed to be sold at the end of the consideration period. The investment at the start of the consideration period is determined by a discount rate. The cash flow is discounted at the end of each year by the discount rate. The final value of the property, at the end of year 10, is determined by the exit yield. During the consideration period operating costs, maintenance costs and any additional costs for renovation or large-scale maintenance are taken into account (ten Have, 2011). The formula for the DCF method is the following:

$DCF = (Cashflow1 / (1 + Ydcf)^1) + (Cashflow2 / (1 + Ydcf)^2) + … + (Cashflow\ t / (1 + Ydcf)^t)$
Whereby Ydcf = Discount rate.

3.3 Integrating smart in valuation models

The literature indicates that smart solutions possibly have a surcharge on (rental) prices. Due to the profits, tenants could be willing to pay a higher rent for smart office space. The cap rate is estimated by the investor and smart features can reduce risk by increasing the rentability. In the previous section, three methods for valuing an office building are described. When it comes to “smart”, maintenance costs could be integrated into valuation models to estimate possible extra incomes. Although smart is an emerging topic in the real estate market and literature, it is still a new topic that is still in its infancy and there is no quantified method for implementing “smart” in appraisals. These difficulties resemble the difficulties of integrating sustainability into valuation models. Warren-Myers (2013) mentions three shortcomings that must first be addressed before sustainability can be fully integrated into an appraisal model. These shortcomings can also be applied to the subject of smart. Appraisers should gain more knowledge concerning sustainability or in this case smartness. Also, appraisers must be able to identify smart attributes of an object. Finally, appraisers must develop the skills to translate smart attributes into market values. Another problem that is noticed in valuing property is subjectivity in valuations (Deenen, 2017). New methods, however, already have emerged that include sustainability in valuation models, these methods could possibly be applied to smart as well. These methods are a direct adjustment of valuation parameters, like gross/net rent and risk premiums, lump-sum adjustments to valuation results or the calculation of a smart correction factor that corrects the valuation results (Sayce, Ellison & Smith, 2004). The described implications must be taken into account when valuing smart property. The DCF method is seen as the most suitable method for implementing sustainability, because it sets out future cash flows, so that sustainability investments and savings can be made transparent (Sayce, Ellison & Smith, 2004). It is therefore assumed to be the most suitable method for valuing smart property as well.

4. Preferences and wishes of occupiers and investors

Next to the general working of the real estate market, general models and processes, it is assumed that preferences and wishes of users and investors in real estate also play a role in deciding whether to relocate or not or to invest in a piece of property or not. To what extent this is true for users and investors of smart buildings in the Netherland will be examined during the remaining of this research. Wishes and preferences of users and investors relating to real estate, according to the literature, will be elaborated on in this section. Heeg & Bitterer (2015) claim that new standards and norms emerge because of the working of consultants, who are regarded as market-making intermediaries. They are leading in the creation of new arrangements. They state that the implementation of international design and building practices has a connection with the globalization of investments in real estate and the efforts of property consultants who spread information about building norms and set the rules for buildings.

4.1 Preferences of occupiers

Occupiers require offices that meet their needs. Sanderson & Edwards (2016) state that aspects that impact occupiers satisfaction are the building itself, the location of the building and the amenities, the communication with the property manager so that their needs are understood and their requests are responded to. The loyalty of an occupier is created when occupiers believe that rent and service charges provide value for money. Moreover, social responsibility is also seen as important among tenants. As for the building itself, users find it important that the building meets their requirements. This can be in the field of energy labels, facilities that the building has, conveniences that the building is equipped with, or maintenance costs. Smart buildings can reduce (maintenance) costs when it comes to energy for example. When the monthly energy bill turns out to be lower, tenants may be willing to pay more because it will pay out indirectly. Social responsibility can be achieved by, for example, taking the environment into account. The empathy of the landlord is important for a tenant to recommend the landlord. Lastly, Sanderson & Edward (2016) state that it is especially important that tenants have the idea that they receive value for their money. Clear communication, documentation and efficient legal processes create the perception among occupiers that they receive value for their money (Sanderson & Edwards, 2016). As discussed in the first section of the theoretical framework, the idea that a building is (energy) efficient, that it enhances the longevity and that it improves users' comfort and satisfaction, are important factors to choose a building over another building as well (Buckman et al., 2014).

4.2 Preferences of investors

Investors need occupiers to maximize occupancy and income (Sanderson & Edwards, 2016). Real estate as an asset has the potential to create relatively high rates of return on money that is invested. Real estate is also seen as considerable because of the financial leverage and it offers both value appreciation and inflation protection. However, real estate also comes with risk, caused by its illiquidity and there is a possibility of a loss of income or capital. According to Nappi-Choulet (2006) property investors in urban regeneration essentially seek speculative developments and short-term investments. Since property investment is opportunity driven, it needs to bring returns that reflect the risk. Real estate investments are illiquid and it is uncertain how various property market cycles will perform, therefore the required rate of return to invest in real estate should include a premium. Returns can be enhanced when investors take advantage of market cycles or diversify the risks. Positive leverage means that cash flows for the property are greater than the interest rate that is paid on debt. For investors, positive leverage is important because it makes equity returns bigger and therefore makes an investment in real estate attractive. Nappi-Choulet (2006) claims that the decision to invest is dominated by considerations relating to the expected return, the security of the investment and the spreading of risk. Due to the high volatility in markets and periodic crises in real estate, investors are increasingly looking for "safe" investments with a certain added value that create value for the long term. Smart offices, but also buildings

that meet progressive ecological conditions, therefore become more attractive in relative terms. Incremental investments in technology or ecology increase the value of the property and therefore possibly the cash flow. The more speculative investors mainly look from a portfolio perspective; buy low and sell high. A more opportunistic approach. But some investors, such as pension funds, are not prepared to take such risks and go for safer investments (Investorpedia, 2018).

As discussed above, consultants and real estate professionals create the illusion of a market and set the rules for buildings. In this way, for example, sustainable or social buildings can become the norm. New institutions can change for example the norm, the design, the outlay and the sustainability of office markets. The new standards are there to meet the expectations of users and investors. This is also how new technologies are adopted. New technologies are increasingly seen as necessary to meet expectations in terms of profits and minimize the risks for investors. Also, implementing new trends like sustainability or technology makes it possible for investors to receive awards. According to Bitterer & Heeg (2015) an award confirms that is the investor has a "trophy" building. Investors are interested in receiving awards for their building because it guarantees the design, the credibility, the sustainability and the technical reliability of the building. Buildings that meet the expectations and the norms are demanded by investors because these buildings attract international and safe tenants, they are expected to obtain rising rents and resale values. Besides, norms that originated in other countries travel to other places and set new expectations. In another study, Bitterer & Heeg (2015) claim that real estate professionals made it possible to compare property worldwide. Political, economic and social conditions are transformed into numbers to compare objects. However, they state that some characteristics, like knowledge on different national locations, are difficult to deal with in comparisons and calculations. Thus, local characteristics are still important for investors. Parties as investors and consultants bring a certain subjectivity to the market in terms of intermediation because they set their financial standards and try to create a certain market product that does not respond to real market demand, but that can offer financial or strategic gain for themselves (Halbert & Attuyer, 2016). Both users and investors have their preferences. Additional insights will be obtained from qualitative research to enrich the existing literature.

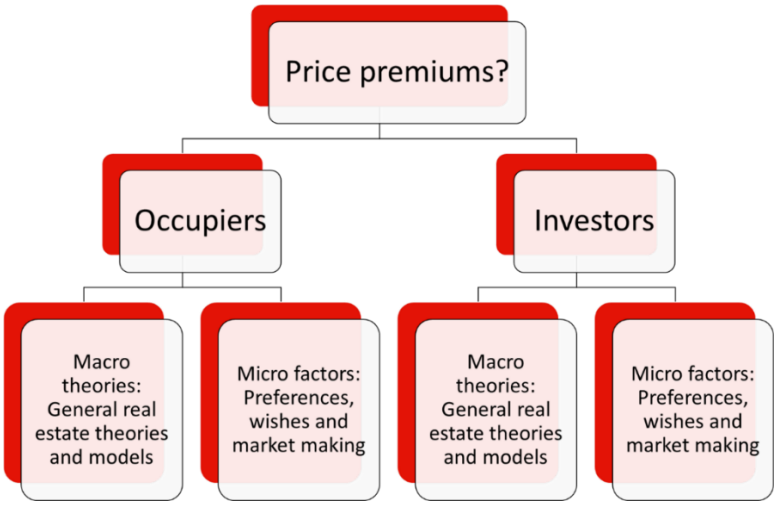
5. Theoretical overview & schematic representation

In the first section of this theoretical framework, the concepts "intelligent buildings", "smart buildings" and "smart offices" were elaborated on. Thereafter the real estate market and the different parties that operate on this market were described, with a special focus on occupiers and investors, using the four-quadrant model. Also, pricing mechanisms for occupiers and investors were described. Although "macro models" like these explain the forces of the real estate market to a certain extent at the macro level, it is expected that at the "micro-level" of the market, supply and demand for real estate is, to a greater extent, driven by the preferences and the wishes of occupiers and investors, branding or marketing practices, the emergence and deployment of new technologies, such as smart offices and more. These personal preferences and wishes were described in section four of the theoretical framework. With the results of this research, an attempt will be made to nuance macro theories. Regarding the literature, it can be expected that market forces, as described in the four-quadrant model, work but that users' and investors' preferences and wishes are playing a role as well and therefore also influence market outcomes. During the remainder of this study, it will be examined which factors are more dominant. Macro theories versus micro theories are therefore balanced here. An overview of the approaches within these categories is given below. Note that approaches within the categories may overlap.

Figure 8: Macro theories vs micro-factors (Source: own material).

Figure 8 represents a schematic overview of this research and symbolizes the assumed price forming of real estate for both occupiers and investors and which factors determine whether a premium is possibly paid. Expectations represented in this model are partly based on general literature models and pricing mechanisms and partly on other factors that are assumed to influence whether occupiers and investors are willing to pay a price premium for property or not, their personal preferences. The dependent variable in this study, "price premiums", is both the rental price of offices and the gross initial return that an investor has calculated for an office building. It will be considered which forces are dominant in the choice for smart offices for both users and investors. This research will in the basis consist of interviews with experts on the topic. More specific questions are formulated in the following section. Thereafter expectations will be presented, coming from the literature, that will be tested during the research.

Figure 9: Schematic representation (Source: own material).



6. Questions

Based on the literature review, it is expected that smart offices are seen as an attractive company location for occupiers or an attractive investment for investors. In the first section, it was analysed how intelligent buildings may provide added value for users and (therefore) for investors as well, as the building is likely to perform better in technical terms and is possibly able to obtain higher rents. Thereafter, general workings of the real estate market and valuation methods have been described. However, it is expected that the wishes and preferences of users and investors are equally important for the experienced attractiveness of offices and ultimately for whether parties are willing to pay a price premium for the square meters office space or for the object. These wishes and preferences will be attempted to track down through interviews with those wo are involved. Because this study is in the basis a qualitative study, no hypotheses were formed. However, some more operationalized and specific questions were formed. Further operationalization will be done in the methodology chapter. The main question of this study is: ***What factors make smart offices attractive to occupiers and investors and to what extent does this lead to a price premium (eventually) being paid by them?*** The main question is investigated with the help of the following sub-questions:

- What are smart offices?
- How does pricing of real estate come around according to macro theories and valuation methods?
- What factors determine the attractiveness of (smart) property for both occupiers and investors?
- To what extent are the different parties willing to pay a price premium for smart offices and what macro or micro forces are decisive regarding this decision?

Questions that will be examined during the interviews, concerning users' and investors' expectations regarding smart offices, are:

- Are smart offices contributing to energy efficiency?
- Are smart offices contributing to the longevity of a building?
- Are smart technologies contributing to the comfort and satisfaction of the users?
- Are smart offices expected to create more value for money?
- Are smart offices expected to add value to commercial real estate stock?
- Are smart offices expected to be less risky in terms of vacancy?
- Are smart offices expected to generate higher rents?
- Do smart offices have lower maintenance costs?

All in all, the attractivity for both users and investors largely determines the willingness to pay a price premium for smart offices. Therefore, two general questions are added about pricing.

- Are users willing to pay higher rents than in a traditional office?
- Are investors willing to pay sharper yields for a smart office than for a traditional office?

The next chapter elaborates on the methodology that was used for this research.

Methodology

This chapter elaborates on the strategy and methodologies that were used for this research. The choice of methods, analysis and data will be discussed that were used to achieve optimal research results. The reason for carrying out this study from the point of view of the real estate user and investor is related to the fact that the contractor of this study, the research department of JLL intended to conduct a detailed investigation into the expectations towards smarts offices of the user and the investor, which factors make real estate 'smart' to them and to what extent the parties are willing to pay a price premium for 'smart property'.

1. General research strategy, method and topic

During the design of the research proposal, it was considered whether the questions would be answered by using quantitative or qualitative methods. Both types of research are called research strategies. Quantitative research methods mainly use structured data collection. Qualitative research uses both structured and flexible research methods. The description of, opinions, experiences, a situation or person is often central to qualitative research (Boeije et al., 2009). The qualitative research method was chosen because there are nowadays only a limited number of “smart offices”. Participants opinions and experiences concerning these buildings are important and participants, who are experts on the topic, can submit subjects, that are important according to them, themselves. This is useful for investigating which factors make smart property attractive to different parties. In this way, the scientist can obtain new insights. The choice for qualitative research is related to one goal of this study, namely finding explanations for certain choices made by occupiers and investors or even the developer and to find out what factors exactly make smart real estate attractive to them (Boeije et al., 2009). This study will mainly focus on the qualitative part because in this research there are only three office buildings that are seen and marketed as ‘smart’ and only those three cases are examined. Three cases are not enough to draw significant conclusions from with quantitative research methods and therefore this research will make an in-depth investigation on these cases by using qualitative research methods. However, three cases may not be sufficient for a qualitative study as well to draw conclusions about theoretical assumptions and market developments concerning smart offices, but this is not the intention of the research. The aim of this research is, however, to investigate a market that is growing strongly in the Netherlands and that is currently still in its infancy. The market for smart offices. That is why a theoretical approach has been chosen in this study in which macro versus micro and objective market forces versus subjective market forces are investigated and weighed against each other. The research is therefore limited to three buildings that are currently classified as smart and those involved with these buildings, including users, investors and the developer and their vision of the emerging smart office market are being investigated.

As for the research specific methods, this study makes use of a literature investigation and in-depth interviews. The in-depth interviews will be conducted with occupiers and investors within the network of JLL and the developer (OVG) of smart buildings, that currently, during this research, sold Edge West, a smart office that is not yet refurbished. Also, other relevant stakeholders were approached for an interview, like the developer of an application that the Edge building runs on and a valuator of JLL that made an appraisal of Edge West. The interviews focus on what makes smart property attractive to the parties, the expectations of the different actors on the future of smart offices, the pros and cons of these smart buildings and whether the different parties were willing to pay a price premium for a smart piece of real estate. A research topic gives direction to the process of data gathering (Bryman, 2015). The topic of this study is smart offices. Smart offices are operationalized in accordance with the research department of JLL and are decided to be the “Edge” buildings that are developed by OVG: De Edge, Edge Olympic and Edge West. The smart offices market is an upcoming market in the Netherlands. The main objective of this study is therefore to explore this market.

2. Operationalisation research questions

This section focuses on the operationalization of the central question and sub-questions that form the guideline for this research. The central question in this research "***What factors make smart offices attractive to occupiers and investors and to what extent does this lead to a price premium (eventually) being paid by them?"*** was investigated with the help of the following sub-questions:

- What are smart offices?
- How does pricing of real estate come around according to macro theories and valuation methods?
- What factors determine the attractiveness of (smart) property for both occupiers and investors?
- To what extent are the different parties willing to pay a price premium for smart offices and what macro or micro forces are decisive regarding this decision?

The first sub-question of the research "what are smart offices?" was partly discussed in the context chapter and the theoretical framework. The general theoretical context has already been outlined here. However, the terminology differs and is sometimes vague. The concepts were therefore additionally discussed with the interviewees themselves, to test or nuance the general expectations and theoretical principles, as in the extended case study method of Burawoy (1998). This method is a research method that focuses on a detailed study of concrete cases with a view to "extract" general principles from specific observations. Expectations are drawn from literature investigation. Participants, among which the developer, occupiers and investors, were asked what smart offices are to them and what features are important to them for an office to be "smart" to finally answer the first sub-question and to supplement the literature. Smart offices in the Netherlands are the Edge, Edge Olympic and Edge West. All these offices are projects of OVG development, located in Amsterdam and are marketed as being "smart". The Edge buildings have even been called "the smartest office spaces ever constructed" (convene, n.d.). The buildings and the employees in the buildings rely on a smartphone app that checks its employees' schedules, allocates parking spaces and assigns the workspace based on each workers' preferences. Many sensors gather data to improve building processes and services, assessing which areas need cleaning and for example, which can be shut down to save energy (convene, n.d.). Since there is, as concluded in the theoretical framework, no clear boundary between a "smart" office and a "traditional" office, the designated smart offices, that are mentioned above, have been agreed in accordance with the research department of JLL. Moreover, the research department of JLL (Amsterdam) could obtain some data from these buildings and arrange some in-depth interviews with relevant involved parties in the development, the use of - and the investment in these buildings. Using another definition or bearing another opinion, one can also consider other buildings to be smart. This research, however, focusses on these three cases and the future of smart buildings in general. It is not stated here that these are the only existing smart offices.

The second sub-question "how does pricing of real estate come around?" was outlined in the theoretical framework. The framework described a general macro theory of the real estate (office) market following Geltner et al. (2014). Thereafter, valuation methods were discussed that are used to value property. There are many methods to estimate the value of pieces of real estate. To get a good overview of the valuation methods and the integration of new developments, such as developments in technology, an additional and context sketching interview is conducted with a valuator of JLL. The valuator, that also valued Edge West, was asked how the valuation of Edge West differs from the valuation of other modern office buildings and how they integrate smart technology in an appraisal. The findings are discussed in the results chapter.

The third question investigated which factors determine the attractiveness of smart property for occupiers and investors. Expectations were formed during the literature investigation. The final results were determined in the interviews. Characteristics that have emerged during the literary investigation were used as

tools to operationalize this question. The results elaborate on the factors that do make smart offices attractive to users and investors and on factors that were expected to make smart offices attractive but do not seem to be relevant anymore after investigating the smart office market practice. Also, factors that were not expected from the literature investigation have been discussed by giving participants enough space to submit topics and other information themselves.

The last sub-question “To what extent are different parties willing to pay a price premium for smart offices?” was also examined using interviews. Participants, both tenants and investors, were asked what their expectations towards the pricing of smart offices are and to what extent they would be willing to pay a price premium for these smart features. The fact that the research units are all in Amsterdam and that they were all developed around the same time, makes comparison easier and more reliable. The research units are compared to "traditional" offices that are also located in Amsterdam to eliminate the location factor in the comparison since the literature stated that real estate markets are usually metropolitan areas (Geltner et al., 2014). However, since there are only three buildings that are designated as “smart” in this research, there cannot be drawn any valid conclusions from comparing their data to data of “traditional” buildings in its surroundings. Therefore it was decided to conduct interviews with stakeholders and gather in-depth data on the three cases. The interviews will investigate why tenants and investors chose “smart” over “traditional”, how they see the future of smart offices, what factors make smart property attractive to them and whether they are willing to pay a price premium for an office that is smart or not. All research units are thus located in the Amsterdam region and the buildings have been or will be delivered between 2014 and 2021. The Edge was delivered in 2014, Edge Olympic in 2018 and Edge West is expected to be delivered in 2021 (OVG, n.d.). Pictures of the three Edge buildings, developed by OVG, are presented below and on the next page. Edge West, however, is not delivered yet.

Figure 10: The Edge (2014). (Source: OVG, n.d.).

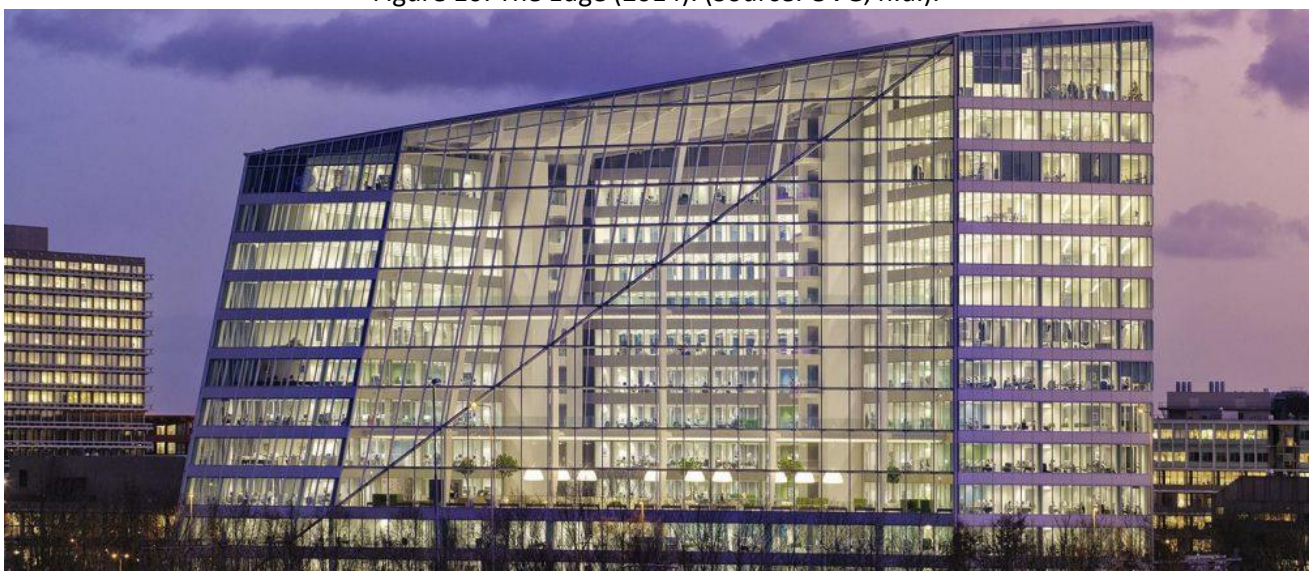


Figure 11: The Edge Olympic (2018). (Source: OVG, n.d.).

Figure 11: The Edge West (Expected delivery year: 2021). (Source: OVG, n.d.)

3. Qualitative research

As stated above, this study uses a qualitative research approach. In the basis, this study is a qualitative and explorative research because yet little is known about the “smart office” topic. This study has an explorative and inductive character and attempts to form theory. However, the last sub-question has a more deductive and testing character. This study uses interviews to examine the research question. The interviews have a semi-structured character. This implies that the content of the questions, the sequence and the possible answers are not already fixed. The advantage of a semi-structured interview is that the interviewee has space to enrich the already existing knowledge of the subject with their own insights, opinions and experiences (Boeije et al., 2009). The interviews are focused in such a way that questions were asked about macro versus micro forces and price premiums. The research is based on general theory and the research has focused on macro-forces on the one hand, micro-forces on the other. The research continued until the theoretically introduced approach could be nuanced and sharpened. This approach is similar to the "extended case study method" of Burawoy (1998). In this way, the general research objective can be achieved, namely to explore or nuance theories about market forces within an emerging market that is still small in the Netherlands.

A topic list brings structure to an interview and contains themes, topics and possible questions for the interview. The use of a topic list ensures that the same topics and themes are addressed during the interviews, however, there is enough space for participants to give their own input (Boeije et al., 2009). The topic list can be consulted in the appendices.

The first sub-question will be answered by asking participants what smart means to them and which features they consider making real estate smart. The first sub-question belongs to the first topic: “what are smart offices, according to the stakeholders?” For the second sub-question, that is already partly answered in the theoretical framework, an additional interview will be held with a valuator working at JLL, here it will be asked how valuators integrate smart, technical or sustainable features in valuation models. The interviewed valuator did the appraisal of the yet to be transformed office building Edge West. This interview will moreover be used to “test” the interview questions. The third sub-question investigates which factors determine the attractiveness of smart property for occupiers and investors. This question will also be handled in the interviews in the first topic of the interview “what are smart offices”. Characteristics that have emerged during the literary investigation will be used as tools to operationalize this sub question. The last sub-question was also dealt with using of the interviews. Participants will be asked what their expectations towards smart offices are and to what extent they would be willing to pay a price premium for these “smart” features, or to what extent, they expect others to pay a price premium. This is handled within the second topic: “Pricing of (smart) real estate and factors that determine attractiveness.”

Finally, it will be explained how the selection of the experts took place. At the end of this section, the group that participated is shown in a schematic overview. The selection of participants is based on people's knowledge about the subject of smart offices, so there was a selective approach of respondents. Both investors and users, as well as the developer of the office buildings and the developer of the application that smart buildings run on, were approached for an interview. An additional interview was moreover held with a valuator working at JLL. Since only three buildings are covered in this research, the search was relatively easy. Many of the approached happened to be companies in the JLL network, which made it easier to approach these experts. participants were approached both by telephone and by e-mail. Speaking with these people was, next to the aim of this research, also part of the internship assignment. Part of the assignment was furthermore to provide

feedback to the interviewees. Therefore the research continued with questioning participants until the research questions could be answered and saturation was achieved.

Two investors, the investors of the Edge and Edge Olympic, have been interviewed. Edge West is recently sold by developer OVG. The consultant that guided this transaction has also been interviewed instead of the investor since the investor is a Korean party that was difficult to reach. OVG has also been approached for two interviews and also the developer of an application, designed for users of the Edge, was approached. Different users of the office buildings have been approached among which someone from Deloitte, someone from Henkel and someone from Intertrust. Interviews were conducted with persons within the companies of the users that are involved in the housing and relocation of the company or in the case of Deloitte, someone from the real estate department. In addition, an interview was conducted with a valuator from JLL. The developer of the buildings, OVG, also happens to be a tenant in the Edge Olympic. The experts were contacted by mail and by telephone. The topic lists can be found in the appendices and the transcripts of the interviews are attached separately. For privacy reasons, the participants are no longer quoted by name in the remainder of this study, but by the position they hold, the company they work for or by the group to which they belong. These groups are: “valuator”, “developer”, “investor” and “occupier” or “user”.

Table 3: Overview interviewees

Name	Name company	Function interviewee	Date interview
Jeffrey Verburg	JLL	Valuator	22-05-2019
Just Peereboom	OVG (Edge)	Developer	24-05-2019
Peter Sagius	OVG (Edge)	Developer	27-05-2019
Anne Wernand	Mapiq	Developer application	28-05-2019
Linus Nilsson	Nuveen Real Estate (TH)	Investor	21-05-2019
Geoff de Booij	Deka Investment	Investor	20-05-2019
Reinoud Plantenga	Warburg-HIH Invest Real Estate	Investor (consultant)	17-06-2019
Wendy Ritt	Intertrust	Occupier	06-06-2019
Felix van Katwijk	Deloitte	Occupier	16-05-2019
Anita Pelder	Henkel	Occupier	17-06-2019

4. Reliability and validity

Reliability handles both concepts concerning this research. Reliability means that the research should be repeatable and generate the same results when repeated (Bryman, 2015). Qualitative research, however, observes from the perspective of the researcher and it is therefore difficult to guarantee complete reliability. Qualitative research can be made more reliable by trivialisation (Bryman, 2015). Results were coupled back to the research- and valuation department of JLL and confirmed by people working is these departments. In this study, the expectations regarding the future of smart offices and important factors of smart real estate were investigated based on the opinion of both users, investors, the developer, the developer of the application that smart buildings run on and an additional interview with a real estate valuator. By consulting the opinions of different groups, the reliability will moreover be increased. Moreover, interviews were held until saturation was reached and additional interviews did not add any new information.

Validity refers to the integrity of the conclusions that have emerged from an investigation. validity applies to both the design and the methods of your research. Validity means that the research findings truly

represent the phenomenon the researcher claims to measure. Bryman (2015) distinguishes four types of validity: construct validity, internal validity, external validity and ecological validity. Construct validity states that the research results are reliable. Internal validity is related to causality investigates to what extent can it be said that the independent variable is at least responsible for the variation identified in the dependent variable. External validity means that the research results can be generalized and applied to a larger group than the sample. The ecological validity of a study means that the methods, materials and setting of the study must approximate the real-world that is being examined. The construct validity was attempted to reach by continuing to conduct interviews until the moment of saturation was reached. Given the limited knowledge about smart offices and in particular the limited data, it is not possible to say with certainty whether research results meet the internal validity requirement. Moreover, there was only a limited time frame for the empirical research. This too can have jeopardized the internal validity. The external validity is the extent to which the results of a study can be generalized to other situations, people and moments. At this moment, the analysed cases cover the whole market for smart offices in the Netherlands. Therefore it can be stated that for this moment, the external validity requirement has been met. Ecological validity means that the research results are consistent with everyday practice. This requirement has been met, the study was conducted in everyday practice (Bryman, 2015).

5. Data processing

The interviews were transcribed using OTranscribe. The transcripts are attached separately. Data coming out of the interviews was processed by using codes to analyse the texts. The text was manually coded. Codes were formed based on the literature investigation. These codes served as handled throughout de remainder of the study. Connections between codes were also made. This made it possible to place the codes and the belonging quotes in an hierarchical order. Prior to coding, categories have been drawn up based on the theoretical framework and the conceptual model. The categories are the themes of the research and they correspond to the topics of the interviews. This way of coding is called thematic coding. There is open, axial and selective coding. With open coding, the text fragments were given labels/codes. These codes indicate per quote which theme it falls under. Some fragments fit different themes. With axial coding, the codes are compared with each other and associated codes are summarized in an umbrella code. Structure is applied in the final phase. “Rough” aspects are made more specific and compared - and related to other concepts. Finally, the findings are elaborated on the basis of these concepts with a view to the problem definition (Boeije et al., 2009 & Bryman, 2015). An overview of the codes can be found in the code scheme in the appendices. The interviews with users, property owners and OVG, the developer, the developer of the application and the valuator were all analysed and coded in Microsoft Word.

Results

This research was a theoretical exploration of market dynamics (macro versus micro, objective versus subjective) in an emerging but still small market in the Netherlands. Results that emerged from the interviews will be discussed in the following sections. After every sub-section, a reflection on the literature will be made.

1. The meaning of smart offices according to the interviewees

According to the interviewees, there is not one clear definition of what a smart office is, which was already expected from the literature investigation. The participants concluded that a smart office is something that is not well defined and that more interpretations can be made. Some of the participants, both the interviewed investors as the interviewed users mentioned the possibility that the idea of smart offices is partly a branding or marketing tool of their developer, OVG. A new development that makes them more innovative compared to other developers. However, the participants did acknowledge that the smartness of the building has to do with technology and the Internet of Things and improve comfort and satisfaction. Both the investors as occupiers think that these offices have the aim to make office work easier. When asked what features of a smart office were, participants gave examples like smart office lightning, ventilation, heating cooling, smart tv-screens, the possibility to perform actions via an app and more. An investor at Deka described a smart office as a *"computer with a roof".* All participants associate smart offices with interaction between the building, internet and the office worker. This corresponds to the more recent literature, that states that smart offices focus on user interaction.

Moreover, all participants made, when asked what they consider to be a smart office, a connection with sustainability, which is, according to them, one of the main goals of smart offices. An interviewed investor from TH Real Estate, moreover, associated smart offices with the trend of flex-working. Occupiers indicated that the goal of locating to a smart office is to make office work easier for the users. An occupier at Henkel, who rent office space in the Edge, believes that by connecting everything in the office with each other and by making use of the internet, it is possible to save costs. Also for the developer of – and expert on the Edge buildings, OVG, there is not a clear definition of a smart office. However, the developer tries to describe smart offices as: "IoT" enabled buildings that make life of the user easier and buildings that are more sustainable.

"*What a smart office is? That definition will be determined in the future. We develop buildings that contain more smart technology to make office work more easy for the user and to make a building sustainable. That is now seen as "smart office". The use of localization in buildings in particular is what users want. Where is a lot of occupation and where not? That helps with the performance of a building. Use a building more optimally through technology."* – Developer.

As stated above, the link with sustainability was made multiple times during the interviews. It is, according to the interviewees, a "must" to become more sustainable for the build environment because of new regulations, to get banks to finance and to get tenants to lease office space. Innovation is, according to the developer, expected to be crucial in making the build environment more sustainable and also in making office work more productive.

"A smart office is an office where things can be arranged online. Like in our office: lights can be regulated, temperatures can be determined and more. You create savings with these innovations. Furthermore, it is especially important that sustainability is also considered. This is receiving increasing attention nowadays and is a very important factor for smart offices." – Tenant.

Important features that smart offices have are, according to the developer, the localisation of people in buildings but also the automatization of things like coffee machines, elevators and more through the help of internet. The developer of the online platform that smart offices run on, Mapiq, names four components of the smart office application, which are meetings, individual work, the localisation of colleagues and personal control of for example heating, cooling, ventilation and the blinds.

Findings versus theory

- According to the interviewees, there is not one clear definition of what a smart office actually is, which was already expected from the literature investigation (le Gal, 2005). More interpretations can be made.
- Smart offices aim to improve comfort and satisfaction, make office work easier and focus on interaction. This was already expected from the literature (Buckman et al., 2014).
- Sustainability is seen as the main goal of smart technologies in buildings. The importance of sustainability was already emphasized during the literature investigation (Buckman et al., 2014).

2. Pricing of real estate

The general working of the real estate market is described following the four-quadrant model and valuation models. An additional interview was held with a valuator of JLL to investigate whether smart offices are valued differently. Insights of this interview were useful for further investigation of the research and the continuing of the interviews. It is, according to the valuator difficult to say something about the pricing of real estate concerning smart buildings, since the current market is tight and the economy is in a time of prosperity. The interviewed investors confirmed that pricing differs depending on the state of the economy. Also, the valuator thinks that it is difficult to say something about the pricing of smart offices since the development of these buildings is relatively new and there are only three Edge buildings, that are branded to be smart nowadays.

According to the valuator, there are no parameters yet for integrating the smartness of the building in a valuation model, such as there are no developed parameters for integrating the sustainability of the building in valuation models. However, the quality of the building is considered when valuing a piece of real estate. Thus, more modern and high-quality buildings will have a higher value, per square meter, than their obsolete counterparts, according to both the valuator and the investors. The rents that are paid for the objects do, according to the interviewees, not significantly differ. However, a difference is noticed in rent prices that are paid for Edge West and other rents in Amsterdam and Sloterdijk and also in the appraisal of the object compared to other objects in the surroundings. This can be due to the fact that the building will be completely

renovated and therefore will be a more modern object than other valued objects in its environment. For the other cases, the Edge and Edge Olympic, no (significant) higher rents were paid.

All interviewees, among who the valuator, concluded that besides the modernity of the building and the possible smart features that an office building can have, location is still the most important feature of the value of an office building. All the interviewees confirm this and claim that rent and pricing depends most on the location of the building. This is corresponding to the literature investigation but contrary to the commercial reports. An addition that was made by the investor at Deka is that, for their company, the most important factor, when purchasing a real estate object, is the indicator of the crisis. Sometimes this company therefore buys assets with contracts when there is a good party renting in the building who has signed a long-term contract, even if this is at a somewhat lesser location. Concerning the indicator of the crisis, this investor thinks it is also important that you can transform a building easily to another use.

Findings versus theory

- There are no parameters yet for integrating the smartness of the building in the valuation model, such as there are no developed parameters for integrating the sustainability of the building in valuation models according to the interviews. This is contrary to literature of Sayce, Ellison & Smith (2004) that state that new methods have emerged that include sustainability in valuation models.
- However, the quality of the building is considered when valuing a piece of property. Thus, more modern and high-quality buildings will have a higher value, per square meter, than their obsolete counterparts.
- The location of a building remains the most important aspect when determining its value. This corresponds to literature from Weterings et al. (2009) but is contrary to literature of Geltner et al. (2014) that claims that investors don't require physical features of an asset like its location.

3. Factors that determine the attractiveness of smart property

Factors that influence the attractiveness of smart offices are described here. Concepts coming from the literature study were used as handles. However, also new insights were obtained from interviews.

3.1 Sustainability, longevity, comfort and satisfaction

As concluded in the first section of this chapter, interviewees associated smart offices most with sustainability goals. This link was made most in the interviews. One of the tenants, from the company Intertrust, mentioned that: *"improvements in sustainability must be supported by improvements in technology"*. Moreover, all users claimed that a higher degree of sustainability creates a good image towards customers and consumers. If it can be stated in the brochure that the company is sustainable and smart, this can lead to a greater appreciation at their customers and consumers and creates so-called "social responsibility". In addition to the sustainability aspect, smart technologies can also help to save costs. Both the tenants and the developer evoked the example of being able to close certain parts or floors of a building on days when occupancy is lower. The interviewee from Henkel, a tenant in the Edge building, indicated that they track pollution, energy and water numbers and that, since the company relocated to the Edge, these numbers have improved and they have become more

sustainable. As for the investors, the sustainability question is viewed up on differently. One investor claims that the smart office is actually not that sustainable. Especially not regarding service costs. Sustainability features require many adjustments to the building. All these adjustments have costs, which are calculated in the service costs that need to be paid. Only one investor had a different viewpoint and claimed that Edge buildings are very sustainable and contribute to the energy issue in a positive way.

Whether smart technologies contribute to the long-term longevity of buildings is viewed upon differently by the interviewees. Also, smart offices are a relatively new development and therefore there cannot be drawn any valid conclusions with regard to the longevity of the buildings over time. However, interviewees were still questioned about their expectations. A tenant that has just signed a new lease contract for Edge West expects that the more technology you put into a building, the more things can go wrong with this technology. This user expects that the technologies will expire faster and need to be updated more regularly. However, the same user also thinks that in smart offices there can be better anticipated on maintenance and this means that maintenance can also be spread better over time, which is expected to increase the longevity. The latter is in agreement with the developer, who claims that you can continue to update your buildings by using the sensors. The developer also talks about predictive maintenance: *"you can measure a lot of things in the installations themselves. Before things break, you can send a technician to ensure that it doesn't break".* One of the investors had a different viewpoint on this and expects that the inside of an office building needs to be emptied after 10 or 15 years anyway when the old lease expires and the tenant moves out. According to this investor, the tenant will in most cases relocate because moving to a new office location is made attractive by means of gifts or incentives from the investor. The expectation of this investor is therefore that the layout of an office will have to be replaced completely anyway. However, this investor also indicates that these are just expectations and that how it really will turn out is still in the future.

Interviewed users frequently mentioned they expect smart offices to make office work easier and make communication between the users and computers more natural. Also, all the participants claim that the comfort and satisfaction of users is enhanced in smart buildings. However, there is only a limited amount of years that generated feedback of the satisfaction of users in these buildings, since smart buildings, as defined in this research, are relatively new. The developer of the smart buildings said that they measure satisfaction by means of taking surveys among the users of the buildings. According to the developer, users of smart buildings are more happy than users of traditional buildings. These surveys were done among users of the Edge and Edge Olympic. The developer of the application that smart features run on thinks that the experienced "satisfaction" of users is actually partly the "image" you create when you occupy a smart building. The interviewee indicated that it is primarily a sign of being a good employer. Also, interviewees indicate that being smart is the new "norm". Real estate consultants have an important role in creating the "illusion of a market" and the rise of that market (Aalbers, 2018), this is what happens when branding new trends in office markets.

An interviewed investor indicated that the office building they invested in, the Edge, is especially a satisfying workplace because of the natural lightning and because users have the feeling that it is not too crowded in the building even though there are over 4000 employees working there. Moreover, it is according to the interviewees, a good place to bring your customers to and also a place that employees are proud of. An interviewed tenant thinks that the experienced satisfaction is mainly a psychological trigger. According to this

interviewee, the feeling of being in control of your environment has a “placebo effect” and makes people feel more comfortable and satisfied. According to an investor, some of the features that are offered in smart offices are not used by everyone: there are only few who use the application and there is no need to save on cleaning costs in this building because the building is always "crowded". Also the feature to book meeting rooms is, according to the interviewee, not used. The interview with a Deloitte employee revealed that there are several apps. Many are not used yet. Ideally, all apps should be integrated into each other. However, this is still very difficult according to the interviewee.

“Edge is a very pleasant building because it is very light, open and spacious. I think that is primarily the basis why people like working here. nowadays it is a bit on the busy side. this makes it a little less pleasant. However, you can ease the pain of the “crowd” with smart components”. – Tenant

Users require offices that meet their needs. Sanderson & Edwards (2016) state that aspects that impact occupiers satisfaction are the building itself, the location of the building and the amenities, the communication with the property manager so that their needs are under stood and their requests are responded to. The loyalty of an occupier is created when occupiers believe that rent and service charges provide value for money. According to the interviewed occupiers they do think that they are receiving more value for their money. Both tenants that rent office space in the Edge state that they think that they receive more value for their money. Also the interviewee from Intertrust indicates that they will receive more value for their money in the new smart building compared to their current office building. However, the location of Edge West, where Intertrust will rent office space after the refurbishments, is in Sloterdijk and therefore cheaper per square meter than their current location. Tenants that chose to relocate to a smart building also seem to be attracted by the fact that the building has smart features. However, when asked, they indicated that the location of the building and the accessibility were still more important. Besides, tenants were especially interested in the modernity of the buildings and the energy label and not in the smart features in particular.

3.2 Added value, risk, rents and maintenance costs

Stakeholders were asked whether they expect smart offices to add value to the commercial real estate stock. An investor working at Deka found that smart technologies do not add value in the sense of whether buildings are worth more, but thinks that if you do not have a smart building in the long run, your building will be worth nothing. The investor expects that at some point in the future the majority of the market will consist of smart offices, but the value will not be more than the value of a traditional office. If you don't have smart features, then you will be lucky only in very exceptional cases, according to the investor. For example on very extraordinary locations like the Canal belt – or the Zuidas in Amsterdam. According to all interviewed investors and the consultant that guided the transaction of Edge West, the smart technology development is similar to the development of giving labels to buildings like, for example, BREEAM. If you rent out a building and you are not certified, you simply do not participate in the investors’ experience. Unless it is a “very special building in a very special place”. The same thing will happen to the smartness of the building, according to the investors:

“In the future, every office will be a smart office. Otherwise you will no longer participate. It is not that smart generates more rent, but if you are not smart then you simply do not participate anymore. Then you can no longer rent your building.” – Investor.

According to the consultant that guided the buyers of Edge west, smart features do add value to the commercial real estate stock. The total stock improves in quality according to him. The smarter a building is, the more efficient it is in dealing with energy. For this reason, smart offices are seen as valuable. There are pioneers in renting, buying and developing smart offices, like there always are. The process of becoming smart will take a long time, like every process in the real estate market. But, ultimately, the whole crowd will come along and the whole market will, slowly become smart, according to the investors.

From the literature review, it could be expected that smart offices have a lower risk to deal with vacancy. According to the investor at Deka it is, indeed, easier to sell and rent a smart office, but not at higher prices. This investor thinks that it is just that one push that convinces people. Tenants will rent a floor just a little easier because they think smart is a good thing to have, for example for on the brochure. Tenants can then tell employees that they are technologically and sustainably responsible. Moreover, they can tell their customers. This makes them seem "social responsible" according to the interviewee and this is expected to be the trigger for them to rent in a smart office. Another investor, at TH real estate, thinks that smart offices have been developed to attract the best talent. There is a lot of talent and companies want to create the best workplaces to attract this talent. Technology plays an important role in creating these workplaces. All investors claim that smart offices are easier lettable than traditional offices because smart technologies are increasingly required by tenants*. "I think that smart offices deal with less vacancy. I do see the added value of it and I think many other tenants do, too."* – Tenant

From the literature review, it could be expected that smart offices generate higher rents than traditional offices. However, investors say that it is not the case that tenants are willing to pay more for the smart element. But by applying smart technologies in office buildings you can improve the densification. In the end, this makes it possible to generate higher rents because people will need less square meters. This is confirmed by a co-worker of Deloitte, that claims that by using smart technologies, you need less square meters than without smart technologies because the technologies make it possible to use space more efficiently: *"This was also a reason for us to relocate. We wanted to use the space more efficiently. This may be possible in a smart office like our Deloitte head office*". However, opinions regarding the rents smart buildings can generate differ, one investor thinks that smart offices do not generate higher rents while another investor claims that there will be a slight premium that is paid for smart buildings by tenants in the future. Receiving higher rents would be an attractive factor for investors. The investor from Deka indicated that they are not yet receiving higher rents per square meter and they also don't expect that smart offices will create higher rents in the future: "*It is not that smart offices generate more rent, but if your building is not smart, then you simply do not participate anymore. You can then no longer rent out your building. In the end everyone will get a smart office. Of course you always have some pioneers. But no. Smart does not generate higher rents."* – Investor.

In terms of maintenance costs, the developer of the smart buildings argues that using sensors and technology, you are also able to save more costs. The developer calls this predictive maintenance, which was also mentioned to be a possible pro of smart offices during the literature investigation. Being able to anticipate on maintenance in turn saves costs, according to the developer and the revenues will therefore outweigh the possible extra costs for sensors and technology. The maintenance costs are, according to the investors not significantly more expensive. Both the investors and the developer indicate that technology and sensors are

becoming smarter and cheaper. Tenants, on the other hand do not elaborate on maintenance costs since they don't know the details. Investors of smart buildings indicate that the maintenance cycles are still uncertain. This can only be determined after a few years. Investors expect that the more technology you put into it, the more can break. However, they do think that you can maintain your property more efficiently and predictably. An investor from Deka said that, whether you have smart features like sensors or not, after 10 to 15 years you will have to vacate your office building anyway, when a new tenant enters it. According to this investor, a smart interior will therefore not last longer than a traditional interior. A claim made by another investor from TH real estate was that maintenance costs depend on the construction of the building, costs will therefore differ per office building. The users that were questioned during the research expect that, with the arrival of smart offices, more predictive maintenance can be carried out in the future.

What mainly emerged during the interviews with the investors was that the most important factors regarding an investment are the location of the investment, which tenant is renting in the building and the duration of the lease contract, whether the investor thinks that there is a small premium in rents that tenants are willing to pay for a smart office and a sharper yield that investors are willing to pay or not. The building being smart is mainly seen as a "nice side effect". This finding is corresponding to the literature from Weterings et al. (2009) but contrary to literature of Geltner et al. (2014) that claims that investors don't require physical features of an asset like its location. A short summary with a reflection to the theory is given on the next page.

Findings versus theory (users)

- For occupiers sustainability seems the most attractive factor of smart property, next to the impact that smart offices have on comfort and satisfaction. This was already expected from literature from Buckman et al. (2014)
- An additional finding was that occupiers indicated that by using smart features in an office building, it is possible to save various sorts of costs. This was not expected from the literature review.
- Moreover, occupiers claim to receive more value for their money. This is in agreement with literature from Sanderson & Edwards (2016).
- Occupiers do not expect an enhancement of the longevity of office buildings due to smart technologies.
- Location and accessibility remain more important than the object itself.

Findings versus theory (investors)

- Opinions on whether smart offices are adding value to real estate differ among investors although it was expected that investors would think of smart offices as value-adding and as a diversifier to outstand others (Bitterer & Heeg, 2015).
- Opinions regarding rents smart buildings can generate also differ.
- All investors claim that smart offices are easier lettable than traditional offices, this is advantageous for the investor since they require a steady income (Sanderson & Edwards, 2016).
- Smart offices make "predictive maintenance" possible. This was expected from reviewing both literature and commercial documents (Deloitte, 2016).
- New standards and norms emerge because of the working of consultants, who are regarded as market making intermediaries, this corresponds to literature of Bitterer & Heeg (2015).
- Location and the tenant in question remain more important than the object itself.

4. Price premiums and forces that are decisive regarding this decision

The attractivity for both users and investors largely determines their willingness to pay a price premium for smart offices. Therefore, some general questions were added to the interviews with regard to rent and pricing. During the research it was investigated whether users were willing to pay higher rents than in a traditional office and whether investors were willing to apply sharper yields or pay more for a smart office than for a traditional office.

As for the tenants, they find smart offices an attractive development. According to the Intertrust company, smart offices are an actual topic. It is, according to Intertrust, good in terms of sustainability issues to rent smart office space and it creates a good image towards customers. Furthermore, there are other advantages that smart offices have, like making office work easier and saving costs. However, according to this tenant, they were not willing to pay significantly more rent per square meter. The choice to relocate had more to do with the modernity of the building and with the value for money on the new location, Edge West. That the buildings are modern and have a good quality plays a role in the choice of the office building but not to the extent that the companies are willing to pay more per square meter. Also, all tenants were, due to various reasons, forced to move to another building. Intertrust decided to relocate because there were too much investments that needed to be done in the original business location. Henkel, on the other hand, a company that rents office floor in the Edge on the Zuidas, was willing to pay a price premium for the fact that the office building is smart. This has mainly to do with the expectation to save costs in the long run and the requirements of sustainability improvements, also demanded by their consumers. The interview with an employee of the company Deloitte revealed that it is difficult to express the benefits of smart in a possible "price premium": *"There are a lot of benefits that you cannot translate into money, such as employee satisfaction, becoming more sustainable or improving your image".*

As for the investors, they are not yet willing to pay a price premium or apply a sharper yield for smart property. The investor at Deka said that they did not purchase the Edge because it is smart. It has more to do with the fact that they have to put away a lot of money every year, the so-called “investment pressure”. Money from people has to pay off and that's why they buy real estate. What Deka considers to be important when purchasing real estate is the indicator of the crisis. Sometimes they therefore tend to buy contracts when there is a good party renting in the building who has signed a long-term contract, even if this is at a somewhat lesser location. Deka also finds it important to buy at a good location. This is all related to the literature of Weterings et al. (2009). The investor is not willing to pay a sharper yield for the smart element. However, because the Edge is a good quality building, with good tenants and in a good location, Deka sees this office building as a "good” or “attractive” investment. The investor thinks that it is not the case that other investors are willing to apply a sharper yield, but does think that these buildings will be easier to lease out in the future. Nuveen Real Estate, an investment company that has bought Edge Olympic, was also not willing to apply a sharper yield because of the smartness of the building: *“it is probably nothing that we would attribute a lower yield to, no, we increasingly expect every new building we buy to be smart nowadays”.* The consultant who guided a Korean investment company in the transaction of Edge West, working at Warburg, doubts whether the investors they guided were willing to pay a price premium for the office building or not. The quality of the building, the tenants and the duration of the lease contract were, according to this interviewee, more important. However, being smart is seen as a “nice side effect” and a good “marketing tool”.

It can be concluded that general models like the four-quadrant model or valuation models do indeed work. Changing requirements of users regarding offices lead to investments in property by investors. This, in turn, leads to the de development of new (smart) buildings. Valuation methods do not take smart features into consideration when valuing property yet. On the micro level of the market other factors influence supply and

demand, like preferences and wishes of those who are involved, marketing practices and more. However, in the results it was seen that macro- and micro-forces overlap. Results, moreover, show that other factors are mainly decisive in determining the willingness to pay a price premium. These factors are the location and accessibility of the property for occupiers and the location and characteristics of the tenant for investors.

Findings versus theory (users)

- It is difficult to express the benefits of smart in a possible "price premium".
- Smart offices are a good company location in terms of sustainability issues, renting office space here creates a good image towards customers, they make office work easier and it is possible to save costs (Buckman et al., 2014)
- Some tenants are willing to pay a price premium for "smart", other are not.
- Tenants believe that they receive more value for their money in smart buildings (Sanderson & Edwards, 2016).
- However, tenants find location the most important feature of their office building, this was expected from literature from Weterings et al. (2009) and Remøy (2010). For the location tenants would be more willing to pay a price premium.

Findings versus theory (investors)

- Investors are not willing to pay a premium or apply a sharper yield for smart. This is contrary to literature of Bitterer & Heeg (2015) who state that technologies are necessary to obtain expected profits, minimize risk and make it possible to receive awards.
- Investors do not expect to receive higher returns with smart offices. This is contrary to literature of Nappi-Choulet (2006) who claims that the decision to invest is dominated by considerations relating to the return. Smart offices are thus not yet seen as property that creates higher returns.
- However, investors think that smart office floors are easier lettable than traditional office floors.
- Location and the renting tenant remain more important factors.

Conclusion

This study aimed to find out what factors of smart offices are expected to be value-adding and seen as attractive by office users and investors and to what extent they are willing to pay a price premium for these smart buildings. In the theoretical framework the development of “smart offices” was elaborated on. A new definition of “a smart office” was formed that was handled throughout the study. Thereafter the real estate market and the different parties that operate on this market were elaborated on, with a special focus on occupiers and investors, using the four-quadrant model. This visual overview helped to understand how components dynamically evolve using relationships that complete the linkages between the markets. The model is valuable in analysing effects on the long run of the user and investment market. The chapter “pricing of real estate and valuation methods” describes pricing mechanisms for occupiers and investors. Theories like the four-quadrant model, but also pricing or valuation models, explain the forces of the real estate market to a certain extent at the “macro-level”, but at the “micro-level” of the market, supply and demand for real estate are also driven by preferences and wishes of occupiers and investors (Weterings et al., 2009), the introduction and the acceptance of new technologies, “marketing” practices within real estate consultancy (Aalbers, 2018) and more factors. The “micro-factors” that are assumed to determine attractiveness for both occupiers and investors, personal wishes and preferences, are also described in the theoretical framework and were investigated during the interviews as well. It was expected that general models are valuable, but that in practice, preferences of occupiers and investors outweigh the general models. Regarding the results of this research, however, it can be concluded that general models like the four-quadrant model or valuation models do indeed work. Changing requirements of tenants, regarding the buildings they occupy, lead to investments in smart property by investors. This, in turn, leads to the de development of new smart buildings. Valuation methods, however, do not take smart features of a building into consideration when valuing property yet. On the micro-level of the market, there are, as expected, also factors that influence supply and demand, like preferences and wishes of the involved parties, marketing practices and more. However, this research has shown that other factors are mainly decisive, including the location and the accessibility for occupiers and the location and characteristics of the tenant for investors. Location characteristics are, such as the layout of figure 8 shows, both macro and micro factors. In the following sections, the sub-questions are dealt with sequentially. Finally, feedback is given to the main question of this study.

Interviewees consider smart offices to be offices where technology connects users with the internet. Smart offices are seen as “IoT” enabled buildings that make office work easier. Also, these offices are a means of improving sustainability according to the interviewees. Regarding the results of the interviews, it can be stated that for occupiers sustainability seems the most attractive factor of smart property, next to the impact that smart offices have on comfort and satisfaction since they are believed to make office work easier. Regarding sustainability, all occupiers find this an important feature because of the sustainability requirements that are becoming more strict and because it creates a good image towards their customers. Occupiers realize that improvements must be made in the field of sustainability and that technology is the means to reach improved sustainability. An additional finding was that both occupiers and other relevant stakeholders indicated that by using smart features in an office building, it is possible to save various sorts of costs. Regarding comfort and satisfaction, the results indicated that occupiers already experience improved comfort and satisfaction and this improved satisfaction is also expected to increase in the (near) future. Moreover, they claim to receive more value for their money. However, results refer to a period of just a few years. Also, since the Edge buildings were delivered only since the year 2014, there cannot be drawn any valid conclusions concerning the longevity of the buildings over time. Interviewees do not expect significantly better longevity for smart office buildings compared to traditional offices. Next to the described findings, it must be stated that the location of the office building and the accessibility were more important. Besides, interviewed tenants

were interested in the modernity of the new building and the energy label and not in the smart features in particular. As for the investors, opinions regarding whether smart offices are adding value to the real estate stock differ. One investor thinks that offices are getting better in quality through the addition of smart features. Another does not expect the value of the real estate stock to increase but thinks that in the long term the majority of the real estate stock will be smart to a certain extent. The trend that real estate becomes smart is compared to giving energy labels to buildings. Now it is the case that without a sufficient energy label, a building does not longer fully participate in the market. The same is also expected for having smart features. The reason that smart offices are seen as value-adding by some, has to do with the fact that a smart building is, in general, more energy-efficient than a traditional building. Opinions regarding the rents smart buildings can generate also differ. One investor thinks that smart offices do not generate higher rents while another investor claims that there is a slight premium that is paid for smart office buildings by tenants. However, all investors claim that smart offices are easier lettable than traditional offices because smart technologies are increasingly required by tenants. In terms of maintenance costs, the term "predictive maintenance" was discussed, which was already expected from the literature investigation. Being able to anticipate on maintenance saves costs in the long run. The revenues will, therefore, outweigh the possible extra costs for sensors and technology. Both the investors and the developer indicate that maintenance costs for smart offices are becoming less expensive since technology and sensors are becoming smarter and cheaper. However, it is difficult to say anything about maintenance costs since the buildings analysed in this study are relatively new. Also here it must be noted that the most important factors, for an investor, regarding an investment, are the location of the investment, which tenant is renting in the building and the duration of the lease contract. The building being smart is mainly seen as a "positive side effect" by investors.

The attractivity for both users and investors largely determines the willingness to pay a price premium for smart offices. As for the users, the willingness to pay a price premium for smart offices differs. Tenants from the Edge claim that they were willing to pay a price premium for the fact that the building is smart, because of technical features, possible cost saving and because of the company's image. The tenant that signed a lease contract for Edge West in Sloterdijk on the other hand, was not willing to pay a price premium for smart features. This difference could also be due to the different locations where the buildings can be found. Investors of smart offices are not yet willing to apply a sharper yield for smart property. They indicate that location factors, the tenant and the duration of the lease contract are more important to them. This finding corresponds to literature from Weterings et al. (2009). Being smart is rather seen as a positive side effect.

Getting back to the main question of this study: "*What factors make smart offices attractive to occupiers and investors and to what extent does this lead to a price premium (eventually) being paid by them?",* it can be concluded that for occupiers the sustainability factor and the additional cost savings, the improved comfort and the improved satisfaction are the factors that make smart offices attractive. They also find that they receive more value for money in smart offices. For investors, it seems easier to lease out office space in smart buildings. Also, the lower vacancy risks and the ability to maintain your property in a predictive way are factors that make smart offices attractive to investors. Nevertheless, how the attractiveness of smart offices, for occupiers and investors, will develop in the (near) future is still quite uncertain. Also, both occupiers and investors indicate that location factors are still more important than technology in a building. This is in agreement with literature from Weterings et al. (2009) but contrary to the literature where it was stated that investors are mainly looking for future cash flows and require financial features more than physical aspects like for example, the location (Geltner et al., 2014). Besides, investors indicate to look at the tenant's characteristics and the duration of the lease contract. Users' willingness to pay a price premium for smart offices differs. Investors are not yet willing to apply a sharper yield for smart buildings. For the time being, technology does not yet change the "most fundamental truth" about commercial real estate: that value is mainly based on the location (Deloitte, 2016).

Discussion

For this research, various parties were interviewed to find out which factors make smart offices attractive to tenants and investors and to find out to what extent they are willing to pay a price premium for smart offices. Before this, both commercial documents and scientific literature were consulted. Several studies have already elaborated on smart offices but they are more or less technically-oriented (Chen, Jiang & Xie, 2018; Gal, Martin & Durand, 2000; Buckman et al., 2014; Rafiq et al., 2017 & le Gal, 2005). This study, therefore, adds the attractiveness of this property type for users and investors as JLL works for both parties. To determine the attractiveness for both users and investors, literature of, among others Geltner et al. (2014), ten Have (2011), Weterings et al. (2009) and Nappi-Choulet (2006), was consulted.

The interviews were done with different stakeholders, in different roles, among which occupiers, investors and the developer. The stakeholders that were interviewed are representative of the market for smart offices. These people have been carefully selected to provide the most inclusive picture possible of the market for smart offices. Based on this, it can be stated that if this research were to be repeated, the results would be the same and, therefore, the results of this research would be valid. Also, the research is done in everyday practice which enforces the ecological validity.

The answers to the interview questions showed that smart offices are seen as an attractive office location for users and to a lesser extent as an attractive investment asset for investors. A possible explanation for this result is changing demands and requirements that users and investors have. For occupiers, the sustainability factor and the additional cost savings, improved comfort and the improved satisfaction are the factors that make smart offices attractive. For investors, it seems easier to rent office floors in smart buildings. Also, the lower vacancy risks and the ability to maintain your property in a predictive way are factors that make smart offices attractive to investors. However, the fact that investors are less enthusiastic about smart offices could also indicate the traditional character of the average investor. The result may also underlie that offices in Amsterdam are attractive to users and investors anyway since Amsterdam is the most popular location for offices and especially the Zuidas, were the Edge and Edge Olympic are located (Nu.nl, 2019). Also, the economy is in a time of prosperity which means that it is easier for investors to rent out their buildings and companies can spend more money.

This research attempted to complement the existing literature on smart offices, which is still in its infancy, on the value of smart offices for users and investors, the factors that make smart property attractive to them and on whether they are willing to pay a price premium for offices that are equipped with smart technologies. It must be borne in mind that this research has focused solely on the opinions and experiences of those closely involved and not on the opinions of those not involved in the market for smart property.

Qualitative research methods were used for this research. It was therefore not possible to draw significant conclusions from large collections of data in areas such as user satisfaction, sustainability or rent or price levels. The advice for follow-up research is, therefore, to conduct a similar study using quantitative research methods to find out whether the expected improvements that smart offices will bring about make a significant difference or not. Also, the smart office market is still in its infancy and there are only a few buildings that can be seen as smart. Another advice for follow-up research would, therefore, be to undertake new research when the market for smart offices is bigger and more mature.

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Appendices

1. Topic lists interviews

Topic 1: Smart offices

1. What is a smart office according to you?
2. Why did you invest in / (re)locate to / develop a smart office
   a. Were you willing to pay a higher rent? (Tenants/occupiers)
   b. Were you willing to apply a sharper yield? (Investors)
   c. To what extent do construction costs differ? (Developer)

A smart office is a building with an office use. Offices can be meeting rooms, workplaces, discussion places or rooms for demonstration. Smart offices aim to make communication between human and computer more natural, make office work easier and meet the goals that buildings nowadays have, which are energy and efficiency, longevity and comfort and satisfaction. The smart office is an office where various information appliances, such as robots, camera, sensors, projectors, blinds, screens and lights are connected with each other by a network and we can control these information appliances in the same way. Possible features of a smart building can include Intelligent sensors, smarter heating, ventilation and air conditioning (HVAC), safer and healthier working environment, smarter security systems, optimization of quality services, cost reductions, reduced water and energy consumptions, enhanced allocation of resources, predictive maintenance, building management and automation, equipment control regulation and configuration, room and light control, health monitoring and more. There are different forms of smart offices and different abstraction levels of smartness are desirable.

3. According to the literature several features are seen as important for smart real estate. Which features do you find important? *Unimportant *Neutral *Very important
   Intelligent sensors
   smarter heating,
   ventilation and air conditioning (HVAC)
   safer and healthier working environment
   smarter security systems, optimization of quality services
   cost reductions, reduced water and energy consumptions
   enhanced allocation of resources
   predictive maintenance
   building management and automation
   equipment control regulation and configuration
   room and light control
   health monitoring
   reduced CO2
   Other:

4. To what extent do you think “smart technologies” contribute to energy efficiency?
5. Do you think “smart technologies” contribute to longevity of a building or do you think that technologies will expire faster and need to be updated more often?
6. To what extent do you think “smart technologies” contribute to comfort and satisfaction of the users?
7. How do you see the future of the office market the coming 10/20 years and what is the role of smart within this future?

Topic 2: Pricing of real estate & factors that determine attractiveness

2. How do you incorporate “smartness” in you valuation model? (for valuators)
3. To what extent do you expect that smart offices generate higher rents?
4. To what extent do you expect that smart offices have lower vacancy risk?
5. To what extent do you expect that smart offices are easier lettable?
6. To what extent do you expect smart offices to add value to commercial real estate stock?
7. To what extent do you expect that investors apply sharper yields for smart property?
8. What do you think will happen to the maintenance costs of smart property?
9. How will smart offices develop in the future relating to rents, yields and capital value?
    a. What will happen to “traditional” office buildings?

2. Code tree/scheme

Table 3: Overview categories and codes

Category	Code	Objective
Definition smart office	• Defenition_Notclear • Defenition_Sustainability • Defenition_Marketingtool • Defenition_Technology • Defenition_Interaction • Defenition_Easierworking • Defenition_Features	Text part is coded when talking about how the interviewee would define a smart office or what properties a smart office should have according to the respondent
Pricing	• Valuing_Difficult • Valuing_Noparameters • Valuing_Qualitybuilding • Valuing_Location • Rents_Nodifference • Rents_Location • Rents_Qualitybuilding • Rents_Tenant	Text part is coded when talking about rents that are paid for the properties in question and about pricing. The aim of this category was to find out to what extent rents and pricing depend on the smartness of a building.
Sustainability	• Sustainability_Positive • Sustainability_Negative • Sustainability_Image • Sustainability_Savecosts • Sustainability_Extracosts	Text part is coded when talking about sustainability and whether smart offices contribute to sustainability.
Longevity	• Longevity_Improved • Longevity_Predictivemaintenance • Longevity_Notimproved • Longevity_Stillunsure	Text part is coded when talking about longevity and whether smart offices contribute to longevity.
Making office work easier	• Comfort_Communication • Comfort_Satisfaction • Comfort_Stillunsure • Comfort_Image • Comfort_Thenewnorm • Comfort_Features	Text part is coded when determining whether smart offices contribute to comfort and satisfaction and make office work easier.
Preferences and wishes	• Preferences_Valueformoney • Preferences_Loyalty • Preferences_Qualitybuilding • Preferences_Socialresponsibility • Preferences_Location	Text part is coded when investigating other wishes and preferences of users.
Added Value	• Addedvalue_None • Addedvalue_Thenewnorm • Addedvalue_Positive • Addedvalue_Stillunsure	Text part is coded when talking about whether smart offices add value to the commercial real estate stock.

Risk	• Risk_Easierleasing • Risk_Image • Risk_Socialresponsibility • Risk_Attracttalent • Risk_Nohigherrents	Text part is coded when talking about whether smart offices are expected to deal with less risk than traditional offices.
Rents	• Rents_Nohigherrents • Rents_Higherrents • Rents_Densification	Text part is coded when talking about whether smart offices generate higher rents.
Maintenance costs	• Maintenancecosts_Predictive • Maintenancecosts_Savecosts • Maintenancecosts_Morecosts • Maintenancecosts_Stillunsure	Text part is coded when talking about the maintenance costs of smart offices.
Preferences and wishes	• Preferences_Tenant • Preferences_Contract • Preferences_Location • Preferences_Qualitybuilding	Text part is coded when investigating other wishes and preferences of investors.
Marketing	• Marketing_Thenewnorm • Marketing_Creatingnewmarkets	Text part is coded when investigating whether smart offices are a marketing tool or trend.
Price Premiums	• Pricepremium_Sustainability • Pricepremium_Savecosts • Pricepremium_Comfort • Pricepremium_Qualitybuilding • Nopremium_Investmentpressure • Nopremium_Easierleasing • Nopremium_Otherfactors	Text part is coded when investigating whether parties are willing to pay a price premium for smart offices or not.