SMART REAL ESTATE MANAGEMENT

AR3R010-MBE GRADUATION LAB
ASSIGNMENT: P5 (10TH July-2018)

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FROM DATA TO VALUE

IN REAL-ESTATE INVESTMENT MANAGEMENT

"One of the applications of Big Data is giving people the facts, and getting them to understand that their own decision-making is not perfect. And that in itself causes them to change their behavior"

Laszlo Bock, senior vice president
of people operations, Google

I COLOPHON

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II PREFACE

This thesis is the final product of the master track Management in the Built Environment (MBE) at the Technical university of Delft. It combines a practical and theoretical knowledge of two years master's program in the real estate management and real estate finance disciplines.

During my study at Tu Delft, my passion about finance, real estate investment and portfolio management becomes more significant which drove me to choose my thesis topic within this area. In this thesis, I am willing to leverage big data for making more informed real-estate investment decisions based on predictive analytics and smart analytical methods.

Moreover, given the great opportunity of exposing to a real life cases with a big international and innovative firm like Royal HaskoningDHV with a great real-estate experts broadens my perspective and adds a lot to the conducted experience and knowledge to this report. Using the experts' experiences helped me to test and validate the hypothesis and come up with the required results and further recommendations within this topic. At the end, an integrated real estate investment decision model is developed based on the main findings of the whole research analysis, for improving the decision making process of real estate investment.

Hoda Hassan

10-July- 2018

III WORD OF THANKS

I would like to express my gratefulness and appreciation for many people who contributed directly and indirectly in this master thesis.

First of all, I would like to thank my family who helped and supported me for having the great opportunity of doing my masters at TU Delft university.

I am extremely grateful to my mentors from TU Delft University, Drs. Philip Koppels and Dr.ir. Andrea Mauri, who supported me on both the theoretical and practical level, and were a good motivation through the whole journey. Integrating their different backgrounds and experiences through reflection, meetings and discussions, was really helpful and important for my thesis which aims to bridge two different areas 'real estate investment and innovation'. Moreover, It was great to have Dr.ir. Huib Plomp as an external mentor with his impressive reflection on the methods, presentation and the discussion between me and my main mentors.

I would like to thank my professional mentor ir.Teun van Schijndel for giving me the opportunity to conduct my research in Royal HaskoningDHV as a graduation company. Teun was really helpful with his great ideas and practical knowledge which broadened my thoughts and opened new insights for the whole research.

At the end, I would like to acknowledge that I gained a lot of valuable information and knowledge within my research area through my interviews with all the conducted professionals from the different companies, who were really helpful and open. Thus, I would like to finally thank all the interviewees for their co-operation and openness which expanded my perspective, raises my passion and ambition about the research topic.

IV ABSTRACT

Introduction:

'Real estate is the largest asset class in the world' as stated by Harvard business school Professor Arthur Segel. It is also unbeatable driver of individual wealth and overall economy. But on the other hand, it is one of the most imperfect markets, due to the lack of accessibility to valuable information in the limited time of decision making process. Thus, it is crucial to find out what is brought by the state of art that could tackle this problem in such a complex and competitive context.

Since, the main component of information is data which is also the chief resource in the modern world; (big) data could be a hot phenomenon to be adapted within the real estate investment domain for improving the performance of the real estate market.

Thus, the main goal of this research is to bridge the area between real estate investment domain and big data, by leveraging big data methods, predictive analytics and smart tools for achieving informed real estate investment decisions. Consequently, investors will be able to maximize return, achieve better risk diversification and select the right time to invest.

Methodology:

This research is classified as an empirical research which aims to solve a knowledge-related problem by building up a hypothesis and testing it, and aims to produce knowledge with the goal of understanding the new and innovative techniques related to (big) data for promoting the decision making process in real estate, following the shown structure in fig.IV.1. Besides, It is based mainly on qualitative methods. the main research question is:

- •How to make use of (big) data for achieving more informed real estate investment decisions? and the sub-questions are:
  - •Which acquisition criteria are affecting the real estate investment decisions for institutional investors?; and what type of data is required and available?
  - •How could (big) data tackle the current problems in the real estate industry?
  - •What are the main challenges for applying big data to the real estate industry?
  - •What are the opportunities of using big data and predictive analytics in real-estate investment decisions?

The hypothesis is:

'Big data and smart tools enhance the investment decision making process of office property for institutional real estate investors by reaching more accurate and informed decisions based on data and reliable analysis.'

Many tools will be used for achieving the intended results such as reviewing literature, semi-structured interviews, yearly reports, observations, exhibitions & events and case studies. Moreover, the main conducted research technique for validation is the Delphi Expert Panel.

The selected sample for this research are categorized in three groups: investors & advisors, (big) data in real estate and end-user firms. The total involved companies are 15 with approximately 22 participant, and the expert panel is only from the first category and contains approximately 10 experts (two rounds).
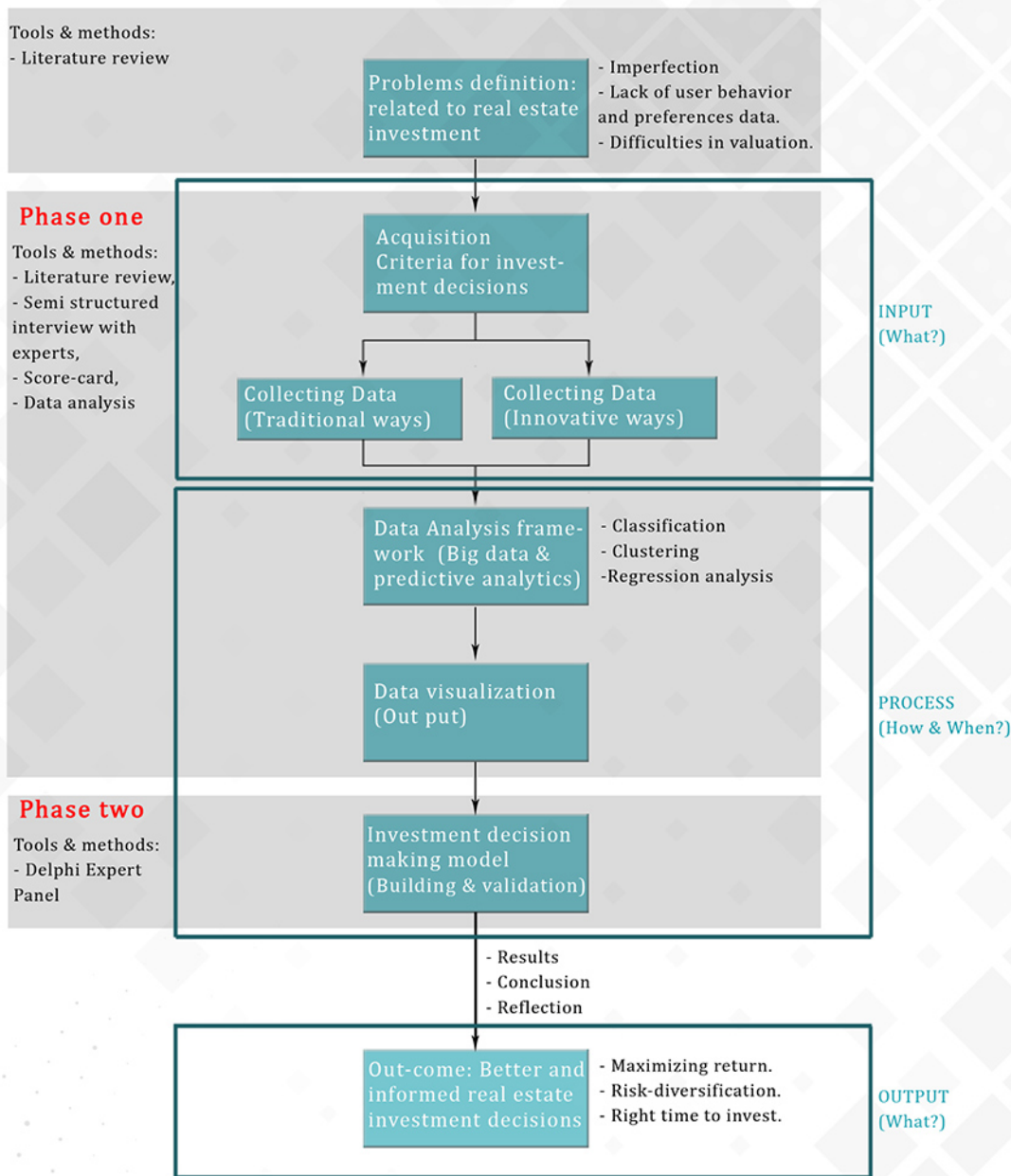
Fig.IV.1. Research scheme (own illustration)

The first chapter contains research problem, research outline, motivation, research questions and hypothesis. The second chapter is the theoretical frame work which reviews literature in both areas real estate investment management and big data & smart tools. The third chapter describes the methodology into more details and related instruments. The fourth chapter illustrates the main results of both phases with different conducted research instruments, followed by discussion for each theme and main conclusion.

The main interview consists of different questions about real estate investment decision making process, acquisition criteria for the office properties and big data and smart tools. After conducting the first phase of interviews, the interviews are analyzed, then an integrated decision making tool and flowchart are developed for validation by the expert panel in the second round as shown in fig.IV.1.

In order to be able to analyze all the collected results (open answers) in a structured and clear way for answering the research questions, a thematic analysis is used. The results are divided into main four themes and each theme contains main keywords as shown in fig.IV.2.
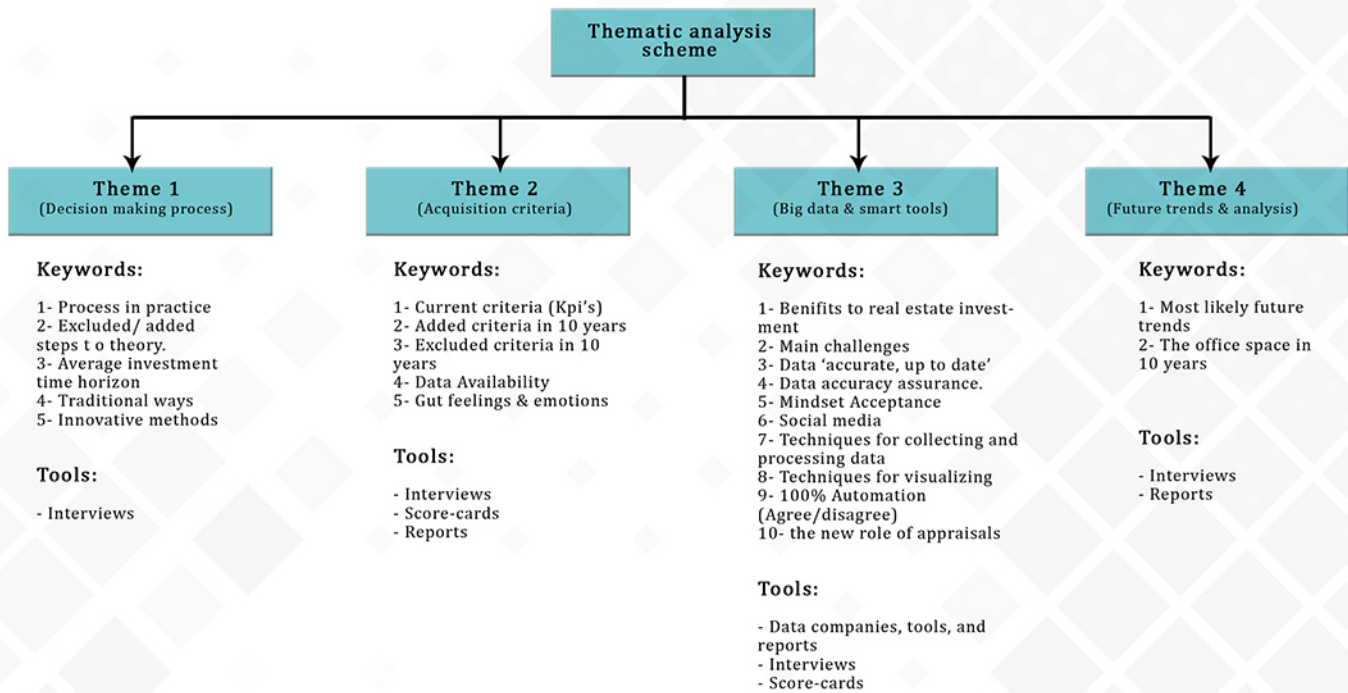
Fig.IV.2. Thematic analysis (own illustration)

Results:

As illustrated above the research is divided into two phases and the first phase has 4 main themes.

Phase 1:

Theme 1: Decision making process:

The professionals validated the shown decision making models from theory with the addition of some extra steps such as: sourcing capital, sourcing product, sourcing dept and business plan on the property level. Furthermore, some excluded socio-political analysis and detailed strategy.

The interviews also showed that the average investment time horizon is based on the type of investor or asset. Core assets is for long-term investments and value add is for shorter terms. Most investors and advisors are still following the traditional ways of valuation.

Theme 2: Acquisition criteria:

Current office building acquisition criteria are financial indicators, location, building quality, sustainability and sustainable location. Furthermore, respondents are expecting the following indicators to be more significant and important in the future: sustainability, health, well-being, social aspects, building service & flexibility, contractual flexibility and political factors. Parking is anticipated to be less important due to mobility.

In general, the required data for valuation and decision making is not available or accessible. Fig.IV.3: fig.IV.4. shows the score cards' results about the significance of different indicators in relation to the rent level.
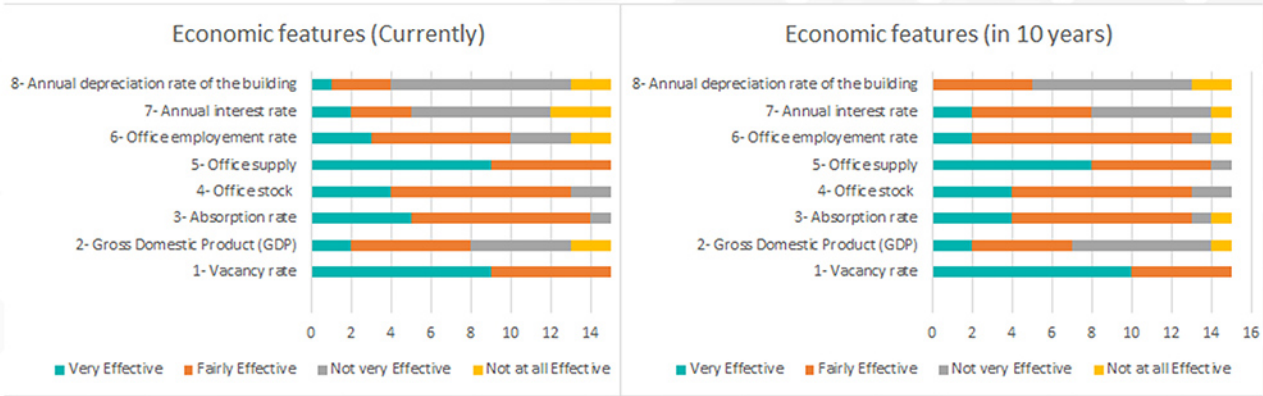
Fig.IV.3. Score-card results- economic features (own illustration)
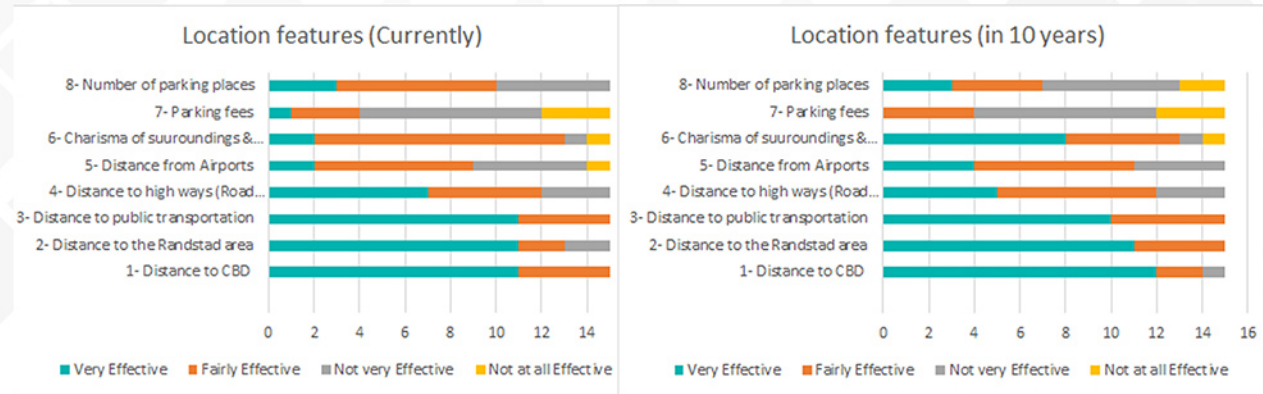

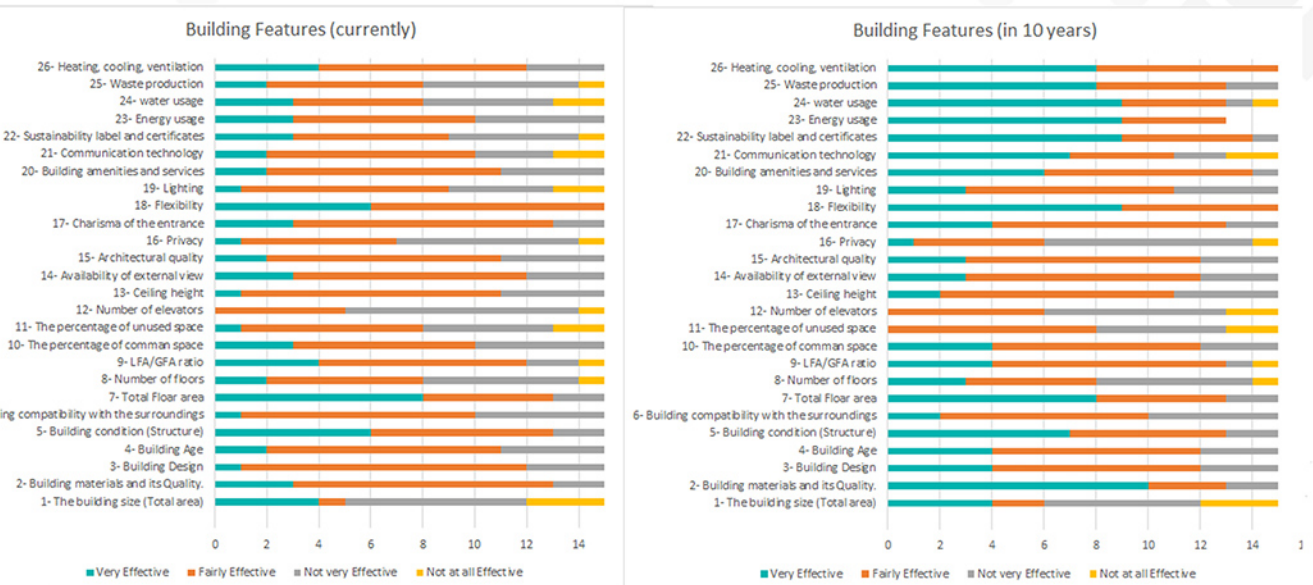Fig.IV.4. Score-card results- location features (own illustration)

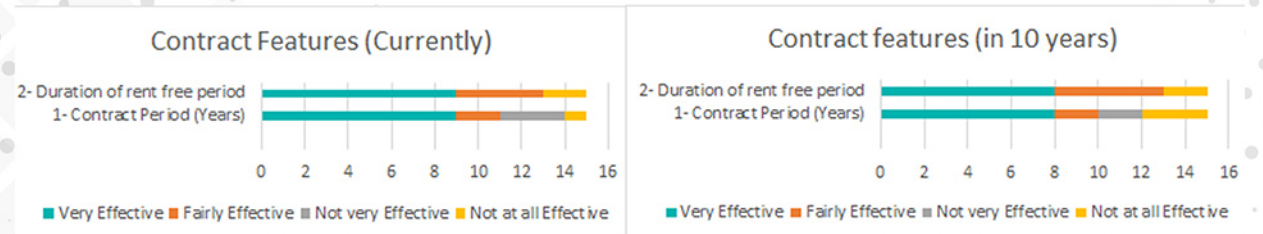Fig.IV.5. Score-card results- building features (own illustration)

Fig.IV.6. Score-card results- contract features (own illustration)

Theme 3: Big data & smart tools:

The growth of data availability, machine learning and advanced analytics can ease the valuation process , lead to faster and better informed decisions and open new investment and business opportunities for different entities within the real estate industry. Fig.IV.7. illustrates the main benefits and challenges for deploying big data in the real estate investment industry.
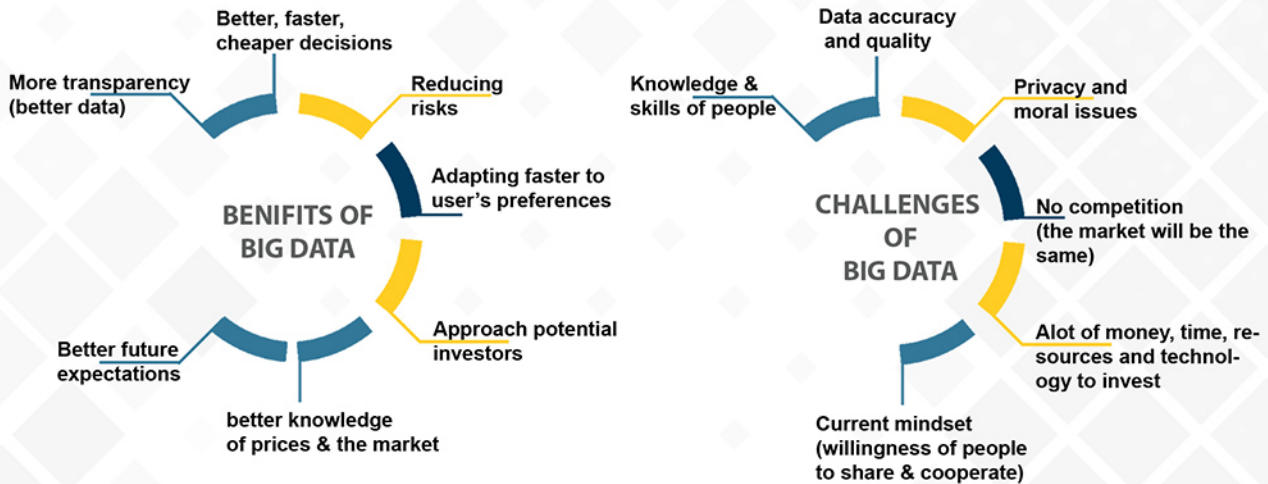
Fig.IV.7. Benifits and challenges of deploying big data to real estate investment (own illustration based on interviews)

The available data is not accurate enough, thus some solutions were proposed by interviewees to tackle this problem such as: manual check, blockchain, comparing different datasets, internal data input, etc.

Finally, the current mind set is ready for big data and some firms already started, but most of them assured the importance of combining data with experience, which means that the decision making process cannot be fully automated, and the human touch is important in validating data and capturing the emotional sides.

based on the interviews and the score-cards, table.IV.1. shows which indicators are available and which could be better available based on smart tools or big data analytics.

	Available indicators	Easier to be collected via big data analytics, smart tools or building and combining different data sets
A- Economic Features	1-GDP 2- Office employment rate 3- Annual interest rate 4- Annual depreciation rate of the building	1- Vacancy rate 2- Absorption rate (Net/Gross) 3- Office stock 4- Office supply (vacant stock)
B- Location Features	1- Distance to CBD 2- Distance to the Randstad area 3- Distance to public transportation 4- Distance to highways (road infrastructure) 5- Distance from airports 6- Parking facilities/fees	1- Charisma of the surroundings & Environmental amenities 2- Number of parking spaces
C- Building Features	1- The building size 2- Building age 3- Building compatibility with the surroundings 4- Total floor area 5- Number of floors 6- Availability of external view 7- Privacy 8- Charisma of the entrance 9- Sustainability labels and certificates	1- Building materials and its quality 2- Building design 3- Building condition (structure) 4- LFA/GFA ratio 5- The percentage of common space 6- The percentage of unused space 7- Number of elevators 8- Ceiling height 9- Architectural quality 10- Flexibility 11- Lighting 12- Building amenities and services 13- Communication technology 14- Energy usage 15- Water usage 16- Waste production 17- Heating, cooling, Ventilation 18- Building layout (Single/ multi-tenants) 19- Renovation date 20- Health
D- Contract Features		1- Contract period 2- incentives

Table.IV.1. Data availability - (Own illustration based on the conducted interviews).

Theme 4: Future trends and scenarios:

The physical work space is expected to sustain within 10 years but it will be more flexible with more amenities and social connections. There is also a shift in demand to building communities, space as a service, mixed use buildings, omni-buildings and all different social aspects that could affect the effectiveness, performance and satisfaction of the employees.

Many trends can affect the future office space like sustainability, mobility, urbanization, densification, changing economy and technology.

Real estate investors and developers should consider the end-user preferences in their journey to sustain in a competitive position within the market, and think of developing new business and valuation models for the mentioned new concepts.

Phase 2:

For achieving the best real estate investment decisions, data, technology and human experience should be combined.

DATA   TECHNOLOGY   EXPERIENCE (HUMAN FACTOR)
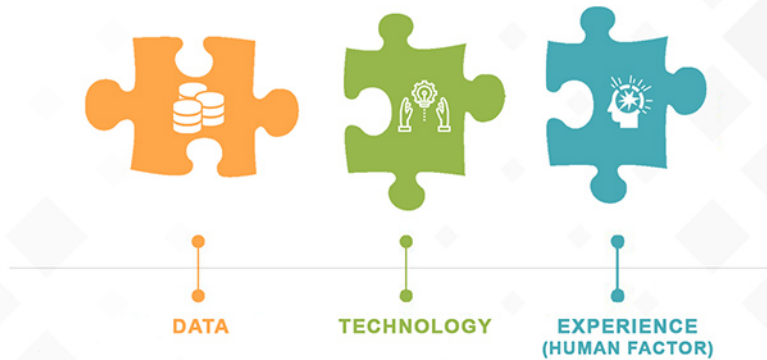
The following data, analysis and methods are required to improve the decision making process (fig.IV.8.):

01

REQUIRED DATA:
(based on form)

A- Quantitative data: transactional data, building data, location, contracts, economic, etc.

B- Qualitative data: location data, user preference, user satisfaction, etc.

02

DATA SOURCES:
(based on the collection method)

A- Internal data sources:
  *Internal data bases (Api's, automatic, etc.)
  *Sensors and machine generated (real-time data)
  *Manual human data

B- External data sources :
  *External data bases by data providers
  *Social media / web.

03

ANALYSIS TYPE:

- Descriptive & Exploratory
- Estimation
- Prediction

04

ANALYSIS METHODS:

- Analytics
- Predictive analytics
- Real time analysis
- Location based analysis
- Statistical & mathematical analysis
- Social networks/web analysis
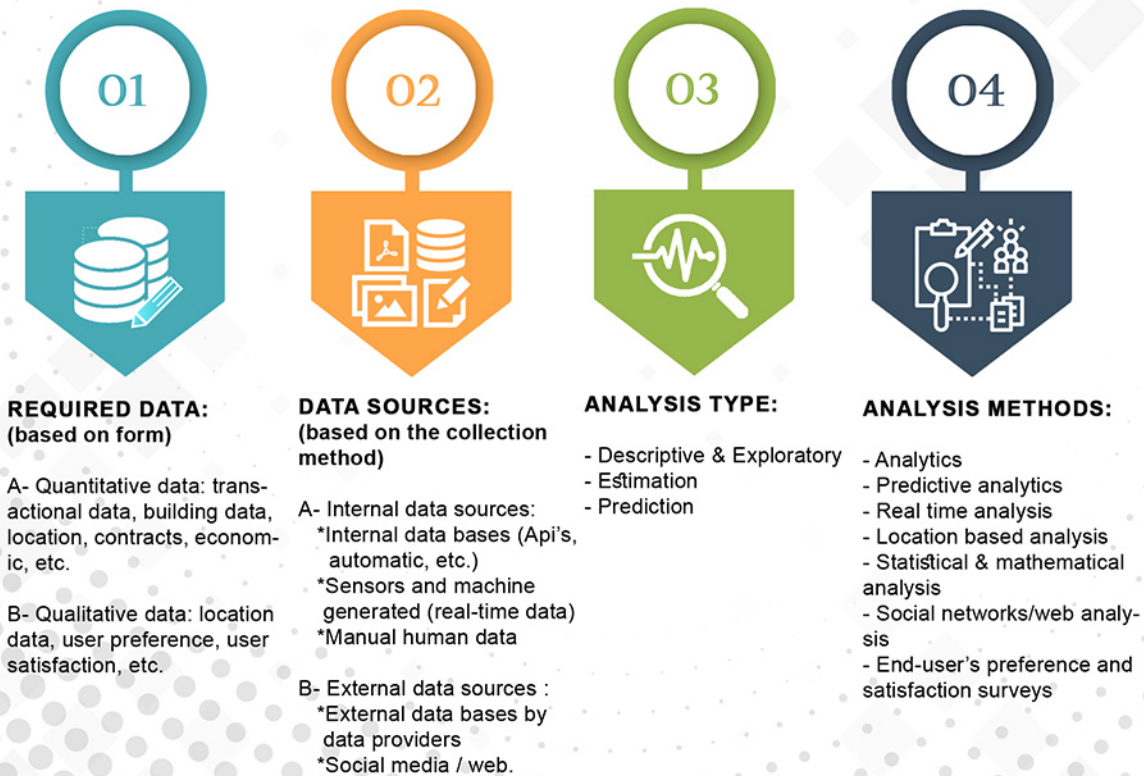- End-user's preference and satisfaction surveys

Fig.IV.8. Required data and analysis (own illustration based on the results' analysis)

Fig.IV.9. illustrates the improved real estate investment decision making model concept, and fig.IV.10. is the decision making flowchart based on adapting big data analytics and smart solutions to the real estate investment decision making process.

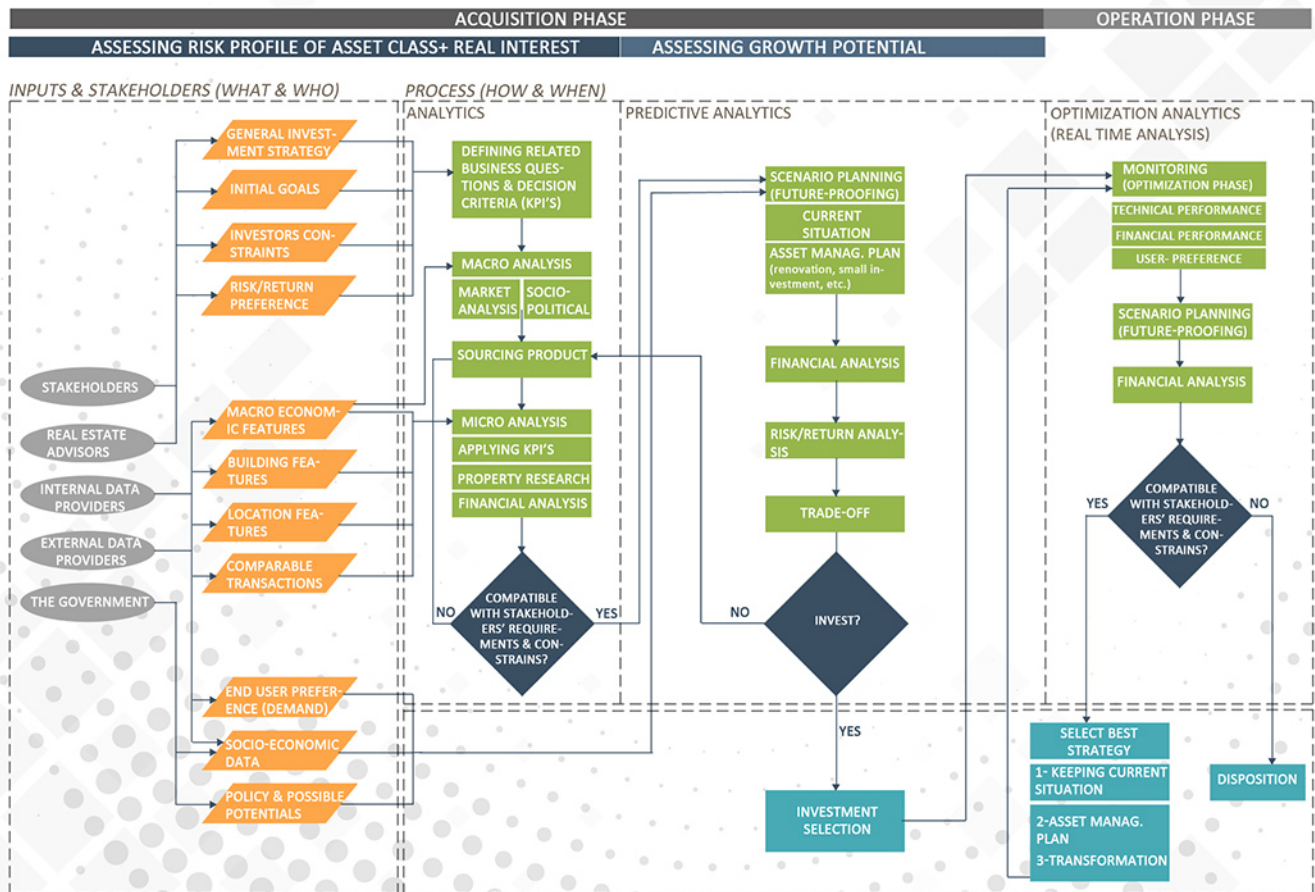Fig.IV.9. Real estate investment decision making model (own illustration)

Fig.IV.10. Real estate investment decision making flow chart (own illustration)

Conclusion:

This research started with addressing the main problem of the real estate market of being imperfect market duo to the lack of information, which results in less informed and accurate investment decisions. The proposed solution to tackle this problem is big data, smart analytics and tools.

looking back into the designed hypothesis, the results of the research approved significant relation between adapting big data and smart analytics to the real estate investment process and achieving more accurate, fast and informed decisions. The research questions were answered through the whole research.

The results show that most investors believe in big data benefits and transparency, but saying is different than doing, as few firms only started already but they are still behind comparing to other industries such as finance, banking, aviation, etc. On the other hand, experts claimed that the whole decision making process cannot be fully automated due to the importance of the human touch in validating the data, asking the right questions and capturing the emotional side.

Adapting big data and smart analytics results in better, faster and cheaper decisions, reducing risks, adapting faster to user's preferences, approaching potential investors, better knowledge of prices and future expectations and more transparency. But after investigating the Dutch market, an integrated trusted investment decision making model could not be found yet, despite the fact that many smart tools, data sets and algorithms are found in the Netherlands. Thus, further efforts are required to develop and integrate adequate algorithms and innovative tool in order to promote the decision making process.

On the other hand, there are some challenges to adapt them such as: data availability and accuracy, knowledge & skills of people, privacy and moral issues, the need of a lot of money, time and sources to invest and the willingness of people to share.

Moreover, investors started to realize the importance of looking to the end-user preference, social aspects and future demand, but they should consider them more in their strategies and investment decisions and plans. Additionally, a big shift towards sustainability, quality, health and well-being is getting further and further. Moreover, 'Space as a service' concept is growing by time. This concept might change the whole industry especially for investors in terms of contracts, cash flows, financing, etc. Thus, investors should study different scenarios and possibilities to be ready for the future of the office market.

Finally, the integrated developed investment decision making process model and flowchart are considered good illustrations to conclude the main findings of this study and answer the main research question of this research. Deploying this integrated decision making model in the real estate investment industry will help investors to maximize their returns, choose the right time to invest and reach better risk diversification.

To sum up, three factors are important to be integrated for improving the real estate investment decision making process: data, technology and human experience. In short, it is about humanizing technology and technifying man!

Recommendations:

Further researches are needed to study more in depth how to capture the added value of the soft aspects such as: innovation, circularity, health, well-being, quality, sustainability, flexibility, user satisfaction, etc. and how to reflect them into the financial analysis.

Further technical research should follow this study, in order to improve the concluded decision making model and flowchart through developing and integrating adequate platforms, algorithms, analytics, etc.

This study should also be done in different markets for generalizing its findings.

V TABLE OF CONTENT

1. INTRODUCTION:

The real estate market is a vital component of wealth which is estimated to represent about one-half of the world's economic wealth, and considerably forms big part of shaping the economic conditions of individuals and firms (Ling & Archer, 2013). Consequently, better and informed real estate investment decisions lead to higher productivity, greater wealth and better life quality (Ling & Archer, 2013). Nowadays, real estate becomes more valuable for firms and has a great impact on their overall financial performance, it also helps firms to be more competitive in the global economy, as it turned from being only about managing physical properties for the business into being part of the business itself, by adding value to organizations in a such globalized complex context (CoreNet Global, 2015). In short, real estate becomes a critical financial instrument for investment around the world. And since the desire in investing in the real estate market is increased, the need for more informed investment decisions is increased as well.

During the international economic crisis in 2008, the vacancy rate of office space in the Netherlands rose significantly, as a result of the bad economic circumstances of many firms. But during the previous years, the economy of the Netherlands was recovering and taking-up upturn, which is shown in an increase of the GDP by 2.2% in 2016 (Danneaux, 2017). The demand of office space is increasing intensely as investors are directing their interest more to the office market especially to the top segment at the Randstad area (Colliers int., 2017). In 2016, approximately 1.16 million sq.m. were sold on the open market (Bak, 2017). Moreover, the office take-up in the Dutch capital rose by 70% '383,000 sq.m.. Supply levels and vacancy rates dropped especially that many old offices in the Randstad area has been transformed into residential spaces (Danneaux, 2017; Bak, 2017). 4 billion euros were spent last year on office buildings and approximately 60% of total investment volume was invested in commercial property 'office buildings in 2016 (Bak, 2017). The high demand of office spaces resulted in climbing prices and rents in 2016. Prices in the Randstad's best locations increased by approximately 25% as the initial yields dropped (Bak, 2017).

Consequently, the positive position of the office market in the Netherlands turns it to be more attractive for institutional investors, and more informed decisions are highly required.

1.1. Problem definition and proposed solution:

Despite all the benefits and potentials of investing in the real estate market, the real estate market is considered as a complex and an imperfect market, and thus could be explained through various reasons. The main reason is due to the lack of transparency and information about the determination mechanisms of prices and different transactions (Geltner & miller, 2007; Manganelli, 2015). Additionally, prices are not only dependent on the demand but also on different characteristics due to the heterogeneity of the properties (Age, location, design, etc,), which are negotiable between the involved parties based on asymmetrical information (Geltner & miller, 2007; Ling & Archer, 2013; Manganelli, 2015). Moreover, decision making could be also affected by sociological and psychological aspects which are hard to be measured or predicted.

Generally speaking, the poor availability and low quality of information besides the limited available time drive the decision maker to assume a lot of issues which could influence the reliability of the decision. In such a complex context, data plays a fundamental role in solving a lot of clues. As data is the basis for information as stated by Daniel Keys Moran *'You can have data without information, but you cannot have information without data'* (NT, 2015). To illustrate, having access to sufficient data base can ease and secure the investment decision making process by basing it on data instead of guesswork. The main argument as triggered by Manganelli (2015) in his book 'Real estate investment' is that if the decision-maker has enough data and information about the characteristics of supply and demand and the costs of different alternatives, maximizing profit and capturing value will be so simple.

In an era of IoT 'internet of things' and 'Big Data', investment managers should leverage the vast availability of data and its infrastructure in the different required analysis through the whole process, for achieving higher accuracy, less human errors and saving time and money, due to the fact that most organizations are aiming now to achieve many goals like being agile, being smart, creating value and including their customers within the business journey. In this digital age, traditional ways of valuation, collecting and analysing data are not compatible anymore with the recent business demand and current firms' vision in order to sustain competitive within this complex context. In such a perspective, Data-intensive computing is an emerging trend that will transform the decision making process and the business performance, depending on data as a raw material (Bessis & Dobre, 2014). Thus, Big Data could be the solution to build a platform as a base for our future predictions.

1.2. Relevance:

The lack of transparency and information are not the only drawback of the real estate market, but there are still a lot of uncertainties and risks associated to investing in the real estate market, which prevent investors to invest in this asset class. For instance, illiquidity, segmentations and high transaction cost are considered other drawbacks for investing in the real estate market as stated by many authors (Geltner & miller, 2007; Ling & Archer, 2013; Manganelli, 2015).

Furthermore, Big Data is not only beneficial for investors but could be also leveraged for different actors within the real estate market. For instance, big data helps realtors to predict human behaviour and estimating the right time for their advertisement by using smart tools Such as SmartZip (Veips, 2014). For banks and buyers, Big Data is even more crucial to their industry. For instance, knowing the market value of a property beforehand is giving them the chance to wait for the right buyer instead of selling it below its value. Big Data helps in collecting different physical and non-physical features about any property for building better overview about the portfolio which is a driver for better decisions on the right time.

1.3. Research questions:

Main question:

The following question is the main question of this research, and answering it should solve the research problem and cover all relevant research topics.

• How to make use of (big) data for achieving more informed real estate investment decisions?

Sub- Questions:

In order to answer the main question of this research, the following sub questions are drawn to cover both areas real-estate investment and Big data, and bridging them to achieve the required results:

• Which acquisition criteria are affecting the real estate investment decisions for institutional investors?; and what type of data is required and available?

• How could big data tackle the current problems in the real estate industry?

• What are the main challenges for applying big data to the real estate industry?

• What are the opportunities of using big data and predictive analytics in real-estate investment decisions?

1.4. Hypothesis:

Big data and smart tools enhance the investment decision making process of office property for institutional real estate investors by reaching more accurate and informed decisions based on data and reliable analysis.

1.5. Research outline:

This part describes the main outline of this research. Generally speaking, This thesis will start by investigating the real estate market, which acquisition criteria and KPI's are currently important, how the real estate investment decisions are made and what factors affect this decision through literature review, market research and interviews. The market analysis review will be done by exploring big data, predictive analytics and smart tools for better results and less time. The analysis procedures will be explained step by step through a framework in addition to illustrating the benefits and challenges of adapting big data and smart tools in order to show the impact of big data and its tools in real estate investment management domain based on this research and interviews with professionals.

Chapter one 'the introduction' describes the motivation to choose the main research topic, research location, the research problem and research questions, to identify the research area and scope.

Chapter two contains the literature review of both areas real estate investment management and Big data. This chapter is important to give a background information which is used as a base for the whole research by providing required information and some input for the operation part.

Chapter three illustrates the methodology where all required research methods and instruments are defined. A description of both quantitative and qualitative approach is well defined, in addition to several ways of collecting the required data.

Chapter four clarifies the important findings and results of statistical and mathematical analysis, qualitative analysis and the designed decision making model.

Chapter five discusses and reflect on the main findings and in a critical way, in order to find out if the main question is well answered and if there are any shortage or limitations. This part compares as well the main findings of the operation part to the theoretical framework.

Chapter six gives the conclusion which illustrates the main concrete findings and results of this research in a relation to the research questions.

1.6. Research outcome:

The expected final product of this research is a developed integrated decision making model and flow chart that involves big data methods and techniques for making more informed real estate investment decisions 'Dutch office market'.

1.7. Research timeline:

According to Delft university system, the time span for the master thesis of the MBE track is 10 months from September 2017 till July 2018. The thesis process consists of 5 main stages where P5 is the final submission as shown in the research time line (fig.1.1).

Activity

- Choosing topic
- writting a proposal

- P1 Report 24-Oct
- Final P1 presentation 31-Oct

- Finalizing the research proposal
- Starting Literature review 'Theoritical frame work'

- P2 Report 12-jan
- Final P2 presentation 19-jan

- Collecting data
- Starting the operation phase

-P3 Report 1- April
- Final P3 presentation 6-April

- P4 Report 23-may
- Final P4 presentation 30-May

- Final P5 Report 3- July
- Final P5 presentation 10-July

Month | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | March | April | May | June | July

2017 | 2018

Fig.1.1. Research timeline (own illustration).

1.8. Graduation company:

This research is conducted with a cooperation of Royal HaskoningDHV. The main driver to do this internship is to be given the great opportunity for exposing to practical life in order to validate the theoretical framework and the developed real estate investment decision making model. Additionally, the company has multiple expertise and better access to different required experts and data.

Royal HaskoningDHV is an independent international engineering and project management consultancy leading the way in sustainable development and innovation, with around 6000 employees from 100 fixed offices in around 30 countries.

The main striking reason to have Royal HaskoningDHV as a graduation company is their passion about innovation to create value for better society, and thus through connecting innovation and smart solutions to their business for achieving better, faster, safer and more sustainable results.

2. Theoretical framework :

2.1. Real estate investment management:

This part gives a brief background about the real estate investment management. It starts with general information about investing in real estate with defining the main opportunities and drawbacks and brief explanation for the real estate and economic cycles. Then, it describes more specifically the office market in the Netherlands, most important acquisition criteria and followed strategies and methods in real estate investment. Those information and criteria are considered input to the following operation phase of this research (input parameters).

2.1.1. Investing in real estate :

It is obvious that buildings fulfil fundamental services and needs in individual's daily life such as: home, shelter, work place, culture place, social place, etc. In this research we consider real estate property as an asset. In that sense, people are willing to obtain real estate properties as an investment for preserving capital and making profit (Manganelli, 2015).

The main objective of investors is to define and develop an investment opportunity which could result in higher profit than the expected normal rate of return for generating profit, investment portfolio diversification, hedging against inflation or increasing their income by generating regular cash flow (Geltner & Miller, 2007; Manganelli, 2015). This could be also explained through comparing the opportunity's return to the opportunity cost of capital (OCC) as the return of a potential investment should be higher than the OCC. Thus, the main objectives are maximizing the potential positive outcomes and mitigating associated negatives and risks.

Since many institutional investors - e.g. banks, insurance companies, pensions, hedge funds, REITs, mutual funds, etc.- assigned the management of their savings to investment funds & business funds, the managers of those institutional investors became significant players in the global finance (van Loon & Aalbers, 2017). The increase of this institutional money was main driver to transform a lot of economic activities and firms into financial assets. Especially after the crisis in 2008, the financial actors paid more attention to illiquid assets like real estate, seeking to magnify the financial sphere (van Loon & Aalbers, 2017).

Generally speaking, Manganelli (2015) stated that '*The investment involves the sacrifices of something in the present (not only economic resources) with the prospect of obtaining benefits in the future*' (Manganelli, 2015). This income could be income stream or capital gain.

Fig.2.1 shows the two different forms of profit: Income stream and Capital gain. The first one is almost stable over time but the second one has much more influence as it is related to the economic and market circumstances, which shapes the riskiness within the real estate market (Manganelli, 2015).
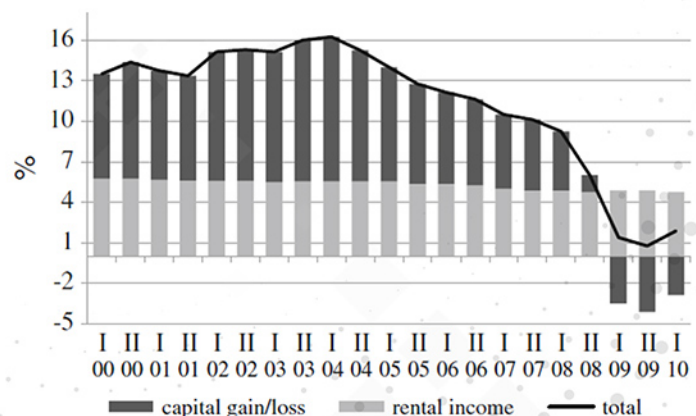

Fig.2.1. Returns on investment (Manganelli, 2015).

Additionally, The real estate as an asset class could be classified into:

A. Direct real estate:

Direct real estate is made by direct acquisition of a physical asset (building, land, etc.) and operating that asset by leasing, rent collection and maintenance without involving third party (Ali, 2006; Delfim & Hoesli, 2016; Morawski et al., 2008). Returns in this case are mainly: income cashflow and return on capital or exit value (Manganelli, 2015).

Generally speaking, Private real estate markets are always associated to high transaction costs and illiquid due to the lack of efficient information (Morawski et al., 2008). Those problems were main drivers to evolving indirect real estate investment 'securitized real estate' with the aim of improving the risk/return structure and tackling the mentioned problems (Morawski et al., 2008).

B. Indirect real estate:

Indirect real estate can be done by obtaining share in a company that holds real estate assets, instead of directly buying and owning them (Morawski et al., 2008).

There are many structures and forms of indirect real estate entities. For instance, indirect real estate companies include: closed-end funds, open-end funds, REITS, private real estate funds and listed property companies (Morawski et al., 2008; Baum, 2009).

In the 1990s, institutional investors directed their efforts to the securitization of real estate ownership through emerging Real Estate Investment Trusts and converting significant stock of global investment property into listed and non-listed shares (Van Loon & Aalbers, 2017). Indirect real estate enabled investors to expand globally as direct real estate requires local expertise and many legal challenges (Van Loon & Aalbers, 2017).

This research focuses on non-listed (private) real estate funds and both categories are elaborated in this part:

1. Listed real estate (Public):

Listed real estate is traded on public bases in a relation to given stock market (Baum, 2009). Starting from the nineties, listed real estate companies experienced a significant growth from small capitalized and unremarkable stocks to a highly attractive asset class (Morawski et al., 2008). Additionally, Real estate investors preferred listed real estate for the potential of accessing long historical data, transparency, time prices, high liquidity and the ability to enter or exit anytime (Van Loon & Aalbers, 2017). On the other hand, the explosion of listed real estate to the stock market resulted in more volatile accumulation cycles and less security for investors as daily fluctuated stock prices might estimate a market value above or below the fundamental share value (Van Loon & Aalbers, 2017; Morawski et al., 2008).

2. Non-listed real estate (Private):

Non-listed real estate is an alternative investment vehicle for portfolio diversification with low correlation with stock market on private bases (Fuerst et al., 2014; Delfim & Hoesli, 2016). On the other hand, it is less transparent due to the heterogeneity of fund characteristics the lack of available public data and information(Delfim & Hoesli, 2016).

Furthermore, non-listed fund performance is positively linked to real GDP growth, inflation rate, gearing, leveraging, fund size and stock market returns (Fuerst et al., 2014; Delfim & Hoesli, 2016).

According to Fuerst and Matysiak (2013), non-listed real estate returns are also linked to sectoral and geographical boundaries, thus institutional investors should also consider the geographical boundaries of any investment opportunity (Delfim & Hoesli, 2016).

In the Netherlands, the institutional investors are mostly pension funds, and they have the highest pension fund assets to GDP ratio about 159.3% (OECD, 2015). Furthermore, many institutional investor within the Netherlands transformed their investment into listed and non-listed shares in real estate funds as shown in fig.2.2. (Van Loon & Aalbers, 2017).
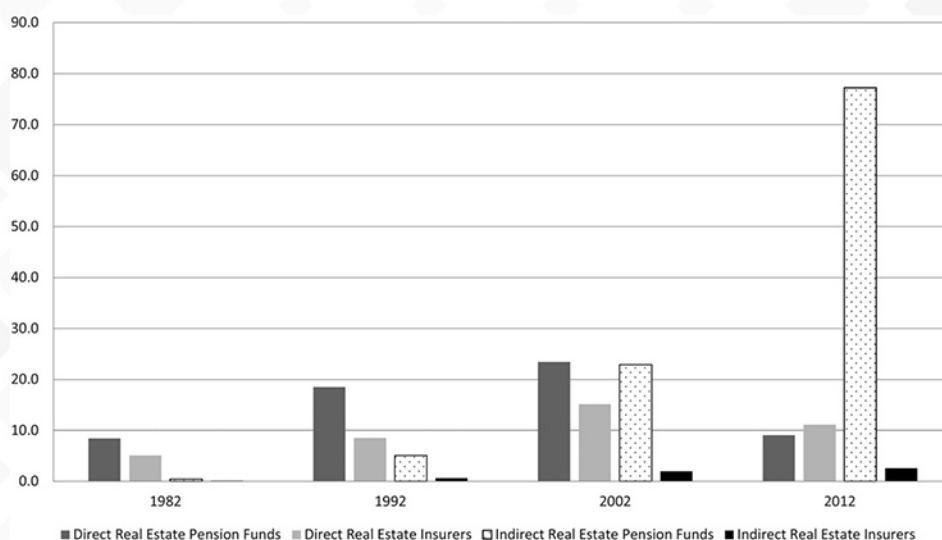
Fig.2.2. Real estate investments of Dutch institutional investors (in billion euro).
Source: (Van Loon & Aalbers (2017) based on CBS (2014)).

Thus, it is important to analyse real estate market as part of capital assets based on the financial economics, which focuses on the capital markets, to be able to translate the potential future flows into monetary terms (Geltner & Miller, 2007).

Finally, there are many reasons for institutional investors to include real estate within the financial and investment sphere. The next part contains the main advantages and disadvantages for investing in real estate market for depicting a holistic overview on the real estate market.

2.1.2. Advantages of investing in the real estate market:

Employing equity in real estate has many advantages and benefits that attract many investors. Acquiring real estate provides:

1. High returns:

Real estate unlike any other assets can retain its value and have a greater resale value than the initial price (Weatherhead, 1997). Moreover, Vijverberg et al. (2012) showed that real estate can provide higher return comparing to stocks and bonds (Li, 2015). It is also observed that the real estate value mostly increases on the long run, despite the fact that its value fluctuates according to the local market cycles (Manganelli, 2015).

2. Hedging against inflation:

Different properties have hedging capabilities against inflation that come from the capital return not from the income return (Baum, 2009). To illustrate, the increasing margin of the property

and the rent indexation can compensate inflation which results in high profit margin (Li, 2015; Mei-jners, 2012). The low correlation between property performance (preserved capital) and inflation is due to the fact that real estate is tangible asset which has relatively stable return and cashflow (Geltner & miller, 2007; Manganelli, 2015).

3. Security:

Security in real estate investment can be seen in the following:

A. Real estate as a collateral:

Real estate is also a crucial financial instrument for providing security for debt finance which is highly demanded in operating any business (Weatherhead, 1997). Acquiring real estate enables investors to easily attract debt with high LTV and low interest rate. Collateral gives more security and mitigates associated risk as it could be seized to repay back the loan in case of losses (Fleisig, 1996).

B. Stable and predictable cash flows:

In a normal economic circumstances, real estate has stable and predictable cashflows due to the long life-investment cycle and conducted lease-contracts (Geltner & miller, 2007).

C. Portfolio diversification:

Adding real estate assets to the investment portfolio provides some security and mitigates associated risks to investing only in stocks and bonds. The risk reduction is due to the low correlation between real estate and stock market, because the real estate investment market is not in a direct relation with the bonds and stock market as can be shown in fig.2.3. and fig.2.4. at the period of the crisis (Manganelli, 2015; Li, 2015; Meijners, 2012). The two Figures (2.3 & 2.4) show that during the crisis period, real estate was more stable and not as much fluctuated as stock market in Amsterdam.

Fig.2.3. Stock market price index of Amsterdam
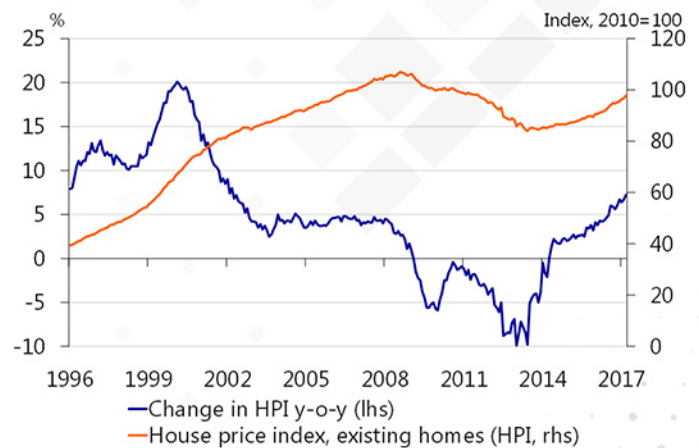Source:https://markets.ft.com/data/world/countries/netherlands

Fig.2.4. House price index of Amsterdam (Lennartz, 2017)

Thus, real estate market is potential market for many investors as the main objectives of investors are making higher profit, hedging against inflation, more security (mitigating risk) and generating income as illustrated before.

2.1.3. Disadvantages of investing in the real estate market:

Although real estate is different than other asset markets and considered more profitable and stable, it has some drawbacks which turns it to be unfavorable for some investors such as:

1. Imperfect Market:

The lack of information and transparency about prices and transactions are main reasons for making real estate market an imperfect market (Manganelli, 2015; Geltner & miller, 2007; Li, 2015; Meijners, 2012). Prices are also dependent on other factors and characteristics rather than demand due to the heterogeneity nature of the property (Manganelli, 2015; Geltner & miller, 2007; Ling & Archer, 2013). Those information are important for valuation and giving some security and stability to investing in real estate. This imperfection resulted in the following:

A. High acquisition cost 'transaction cost':
Real estate requires a considerable amount of money 'cost' for acquisition. This significant monetary commitment consists of purchase costs, transaction costs and market analysis costs (Manganelli, 2015). It also requires maintenance costs to maintain the capital value over time and additional cost for hiring required experts and managers (Manganelli, 2015; Meijners, 2012). The high involved capital in real estate shapes a significant risk for investors.

B. High segmentation:
Real estate market is highly segmented market because of the heterogeneity nature of real estate properties. Supply and demand are for specific location and type which leads the real estate market to be local and specialized in specific usage (Geltner & miller, 2007).

2. Intensive management role:

Real estate requires an active intensive management role, as it involves high personal control and demands a lot of information through the whole investment life cycle (Manganelli, 2015). For instance, real estate investment process contains buying, maintaining and selling which take many years, and acquiring required information and management skills are important for each stage (Li, 2015).

3. Fixed asset:

Real estate is fixed asset which has a finite useful economic life and will be replaced after specific period.
Many elements should be considered for the value of fixed assets (Weatherhead, 1997):

A. Obsolescence:
Obsolescence charges are calculated each year against the profit and loss account in order to make sure that an acceptable proportion of asset cost and value is allocated in an asset which is still beneficial (Weatherhead, 1997). In other words, it is about being prepared for the obsolescence that occurs to many buildings and has affected many companies. Shortly, obsolescence is mainly about conserving the capital which is based on cost of the asset and its residual value.

B. The value of fixed operational assets
Real estate values change over time. Consequently, considering historic cost and value in current valuation can be very misleading (Weatherhead, 1997). Those changes can be for example: changing in inflation rate or local market conditions like building a new road, etc (Weatherhead, 1997).

4. Illiquidity:

Real estate has the lowest degree of liquidity due to the non-transferable and indivisible characteristics of the property, which results in high segmentations and diminishes the size of the market (Manganelli, 2015; Geltner & miller, 2007). The illiquidity concept reflects the non-immediate ability of converting real-estate assets into cash, as real estate process is a long process which requires a lot of time between buying and selling. In other words, . It could shape a stiff investment by locking the investment capital in long term leases, especially in the commercial sector (Geltner & miller, 2007; Manganelli, 2015).

The current efforts in real estate domain try to increase the transparency of the real estate market for solving the mentioned drawbacks, in order to attract more investors, which is also the main topic of this research. It is also important to have an intelligent way of determining the future behaviour of rents.

Table.2.1. summarizes the main advantages and disadvantages of the real estate market.

ADVANTAGES	DIS-ADVANTAGES

1 - High returns.
2 - Hedging against inflation.
3 - Security:
    a- Real estate as a Collateral.
    b - Stable and predictable
        cash flows.
    c - Portfolio diversification.
	1 - Imperfect Market.
	    a - High acquisition cost
	        'transaction cost' &
	        maintanance cost.
	    b - High Segmentation.
	2 - Requires intensive & Active
	    management role.
	3 - Fixed asset.
	4 - Illiquidity.

Table.2.1. Advantages and disadvantages of the real estate market (Own illustration)

2.1.4. Real estate markets:

Since the market is the basic mechanism for trading goods and transactions, real estate has three main markets as shown in fig.2.5.:

1- **Real estate Space market** reflects the rental market that contains the right to use any property ' land and built space' . Individuals, households and firms represent the demand side and owners represent the supply side. The rent price which is the price of using specific space for a certain period, gives an indication of the current market value of this specific space. The profit in this market is from the gross income (Geltner & Miller, 2007; Manganelli, 2015).

2- **Real estate Asset market** is the market of ownership and one of the main four components of the capital market, like: bonds and stocks. Real property market is part of the private markets which is based on less liquid assets and private transactions. private asset markets are not informationally efficient like public markets which makes it hard to determine the right price for any asset. Investors represent both the demand and supply side in this market (Geltner & Miller, 2007; Manganelli, 2015).

3- **Real estate development market** is the market of developing new spaces either by transformation or expansion according to demand and supply (stock) (Koppels, 2016a).

The relation between the three markets is shown in fig.2.5.
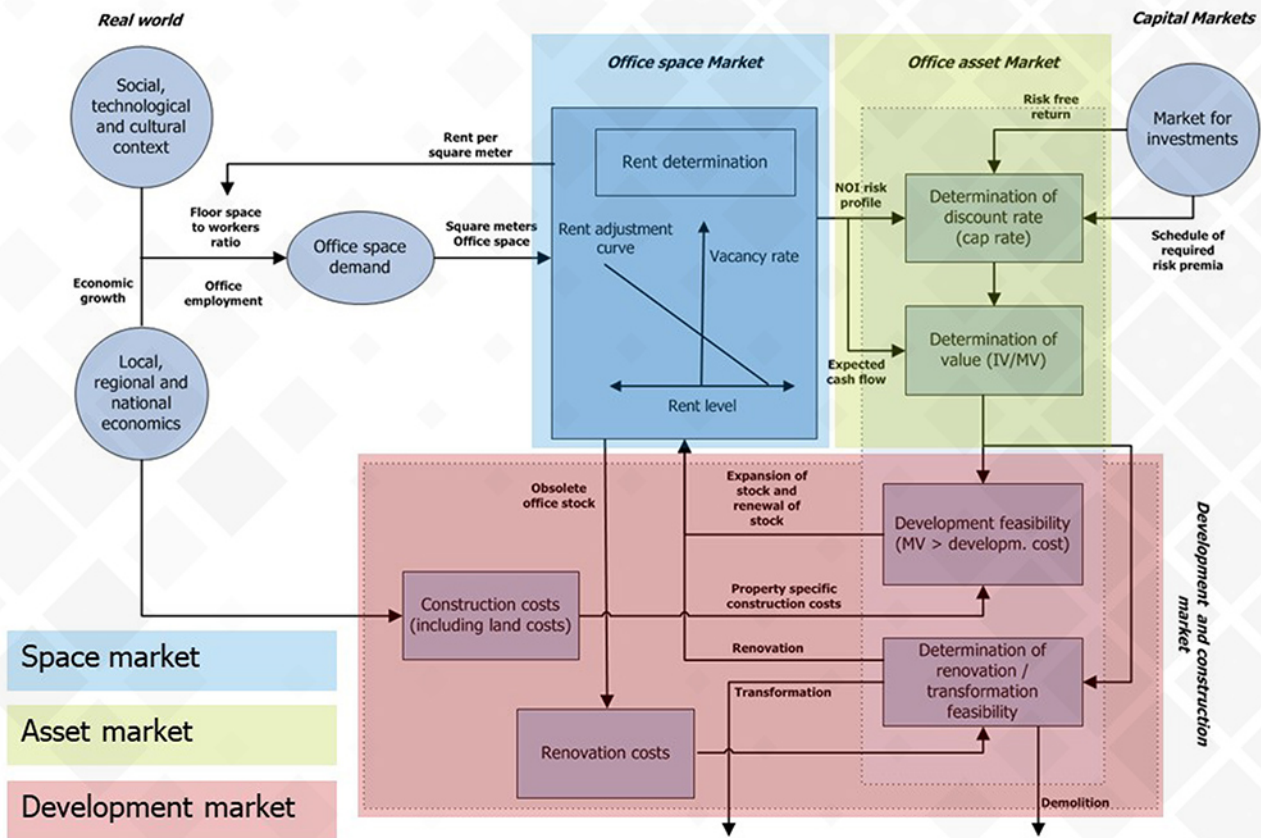
Fig.2.5. Commercial real estate markets (Koppels, 2016a).

2.1.5. Real estate cycles & bubbles:

Real estate is sensitive to economic fluctuation and emergent bubbles like other investment markets. The economy has up-turns and down-turns which form a cycle. Each cycle consists of set of events that reiterates periodically (Geltner & Miller, 2007). Usually, the economic cycle experience different stages: depression, recession, recovery, expansion and peaks (Galbraith & Darity, 2005). After the credit crunch 2008, many countries faced a huge recession period which ended up into depression, that affected as well the real estate market and specially the office market as many firms has been shrunk or could not be able to survive. Nowadays, the world economy is recovering and expanding. Thus, it is crucial to identify and cope the economic cycle with any real estate investment strategy for better outcome. Accordingly, Born (1994) defined four main phases for each real estate cycle: Peak, declining, through and rising as shown in fig.2.6. (Koppels, 2016a).
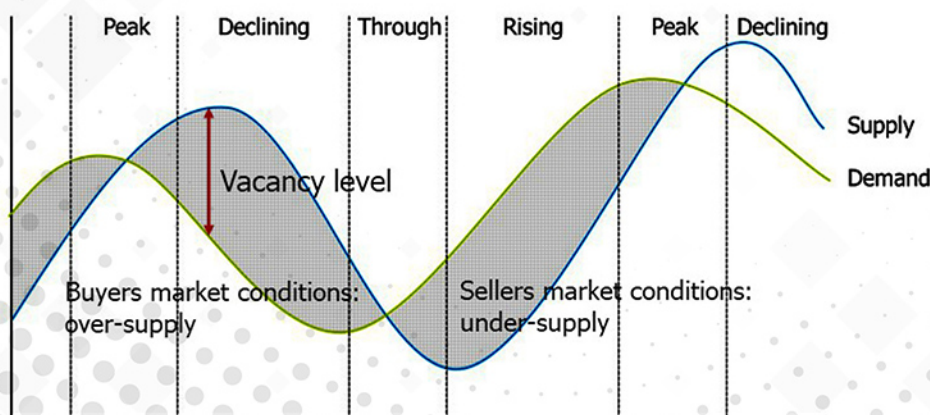
Fig.2.6. Real estate cycles (Koppels, 2016a based on (born, 1994)).

Normally, there would be under supply at the rising phase and over-supply at the declining phase (down turn) which leads to less new developments. At the peak phase (stabilizing), new developments are gradually added to the market. At the through phase (stabilizing), developers start thinking about expansion of the stock by adding new developments (Koppels, 2016a).

Cycles are originated by two main aspects: exogeneous like demographics, employment growth and productivity, and endogenous by the industry characteristics (Winters, 2016).

Moreover, Winters (2016) in his lecture at TU Delft University stated that the major reasons for financial instability in economies are the interaction and relation between:

- Infinite capacity of banks to create credit (mortgages).
- Inelastic scarce supply of desirable real estate assets (static supply & dynamic demand): supply takes long time which makes real estate market late responder.

Fig.2.7. shows the relation between economic cycle and property cycle (Barras, 1994).
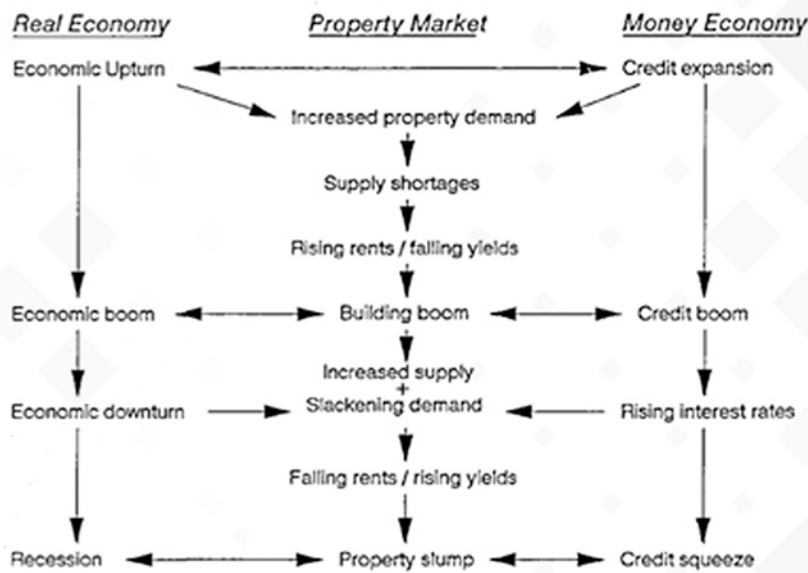
Fig.2.7. How the building cycle works (Barras, 1994).

Real estate or property bubble:

Is a type of economic bubbles which happens from time to time in the local or the global market that reflects a sudden high growth with no clear fundamentals (Winters, 2016). This increased value is mostly related to opportunism and enthusiasm, and followed by a crash (Winters, 2016).

The main reason of emerging those bubbles is the imperfection of real estate market and economics knowledge, which reflects risks for investors. Additionally, those bubbles could be resulted from an unsustainable risk premium property or unsustainable credit expansion (Winters, 2016).

Commercial real estate market system:

Real estate market consists mainly of two markets Asset Market and Property Market (Space Market) as mentioned above. Dipasquale & Wheaton (1992) developed a four-quadrant model describes the relationship between both markets within the real estate cycle.

The real estate cycle affects four main factors: construction, rent, demand and supply, in a continuous manner, trying to reach equilibrium between demand and supply (unreachable in reality due to the long time needed for supply) (Dipasquale & Wheaton, 1992). The property market determines the rent level at equilibrium when demand equal supply, which is important for investors to determine current and future cash flow (Dipasquale & Wheaton, 1992). The increase in rent level in the property markets affects the demand of assets in the asset market. Additionally, the increase in construction at the Asset market affects the stock and leads to decreasing rents in the Property market as shown in fig.2.8. (Dipasquale & Wheaton, 1992).
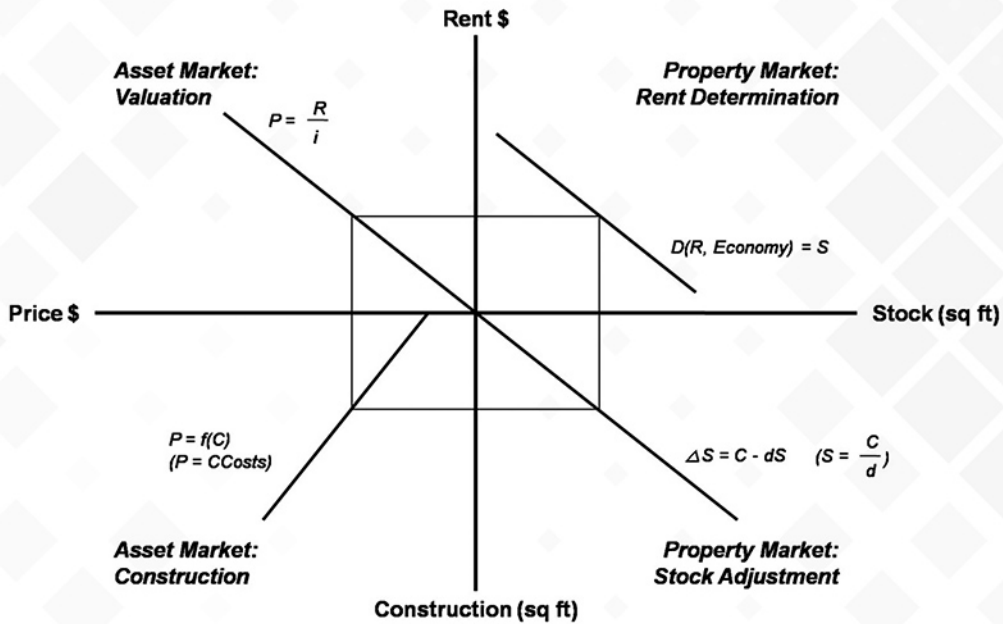
Fig.2.8. The four-quadrant model (Dipasquale & Wheaton, 1992).

2.1.6. Office real estate market in the Netherlands :

The Dutch market is recovering from the credit crunch and performing significantly strong during the last years, and is predicted to experience an annual growth of approximately 2.0 to 2.4 for the coming period, increase about 2.0 % of employment growth, decline to 4.9% in the unemployment rate as shown in table.2.2. and fig.2.9. (Bak, 2017; Colliers int., 2017).
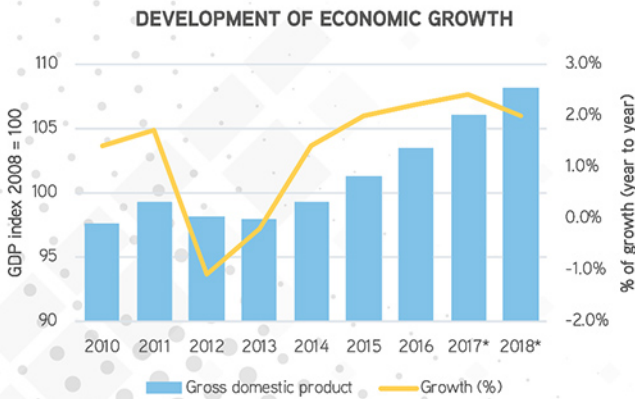
Fig.2.9. GDP in the Netherlands (Colliers int., 2017).

	2014	2015	2016	2017	2018 F
GDP	1.40%	2.00%	2.20%	2.40%	2.00%
Inflation	0.30%	0.20%	0.10%	1.40%	1.40%
Unemployment x 1.000	660	614	538	444	427
Unemployment %	7.40%	6.90%	6.00%	4.90%	4.70%
Purchasing power	1.20%	1.10%	2.60%	0.30%	0.20%
Household consumption	0.30%	1.80%	1.70%	1.80%	2.00%

Table.2.2. Economic development in the Netherlands (Colliers int., 2017).

INVESTMENT VOLUME BY ORIGIN (EUR) Q1 + Q2 2017

Based on the mentioned statistics of the Dutch economy, the current market is considered potential for investors especially that the Netherlands has a very stable market., but, the new supply of assets is relatively low. Fig.2.10. shows the investment volume by origin at 2017 (Colliers int., 2017)

2%
10%
18%
38%
32%

- Netherlands
- Europe
- United States
- Asia
- Other
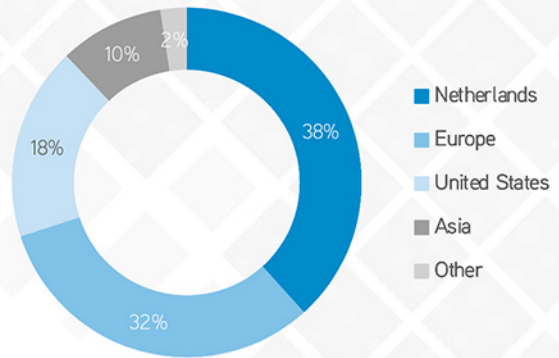
Fig.2.10. Dutch international investment volume (Colliers int., 2017).

The office market:

Looking specifically into the Dutch office market, there are an increase in the take-up rates since 2015 as shown in fig.2.11. The Randstad area contains 80% of the total transaction volume (Bak, 2017). Demand is growing and supply is falling since 2014 (available for rent and sale dropped from 17.1% in 2015 till 15.9% in 2016), which is still high but it drops relatively fast as well, and there are falling in vacancy rates, and increasing in new development. Prices are increasing (fig.2.13.) and the highest demand is for high-quality offices at major cities (Bak, 2017; Colliers int., 2017). Investors are showing significant interest in the Dutch office market which increased the volume of investment sharply last couple of years as shown in fig.2.12.

INVESTMENT VOLUME (EUR) OFFICE SPACE

(in billions)

€ 8
€ 6
€ 4
€ 2
€ 0

2010 2011 2012 2013 2014 2015 2016 2017

- Full year
- Q1 + Q2
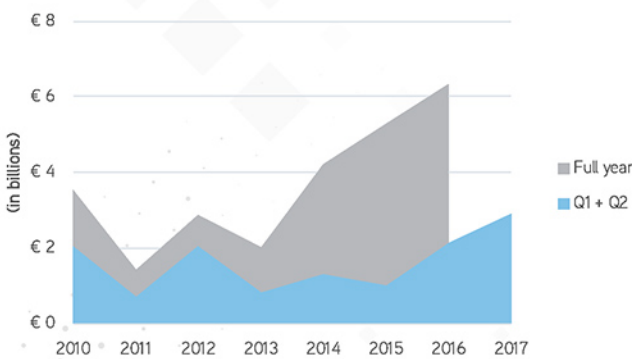
Fig.2.11. Dutch investment volume (office space in EUR) (Colliers int., 2017).

TAKE-UP OF OFFICE SPACE (QUARTERLY)

Sqm (in billions)

1.5
1.0
0.5
0.0

2010 2011 2012 2013 2014 2015 2016 2017

- Q4
- Q3
- Q2
- Q1
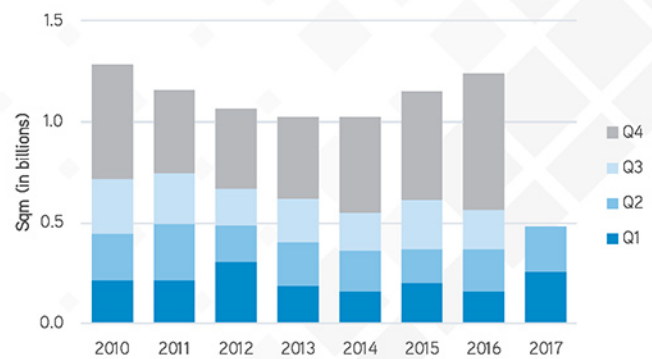
Fig.2.12. Dutch Take-up office space (EUR) (Colliers int., 2017).

On the other hand, rents is hardly growing as shown in fig.2.13. (Bak, 2017). The gross initial yields are dropped last couple of years as shown in fig.2.14. (Bak, 2017).

AVERAGE RENTS OF OFFICE SPACE   Source: NVM

€/m²

220
200
180
160
140
120
100

2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

- Amsterdam
- The Hague
- Rotterdam
- Utrecht
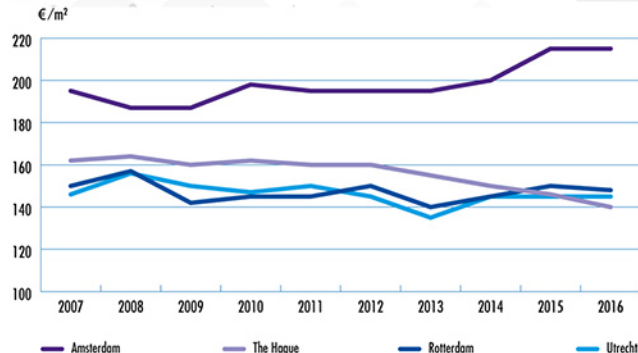
Fig.2.13. Average rent of office space (Bak, 2017).

AVERAGE GROSS INITIAL YIELDS OF OFFICES   Bron: NVM

%

11
10
9
8
7
6
5

2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

- Randstad - best locations
- Randstad - other locations
- The Netherlands other - best locations
- The Netherlands other - other locations

Fig.2.14. Average GIY of office space (Bak, 2017).

NVM Business and Colliers are expecting further drop in vacancy rate in 2017, and increase of rent in major cities like Amsterdam between 5% and 10% in major locations.

In short, the office market research in the Netherlands is attractive for investment, and the need for making better decision is significantly rising for gaining more return.

2.1.7. Acquisition criteria:

For making an investment decision, certain criteria are needed to judge the financial performance of the buildings. From a microeconomic perspective, the building itself, its location and characteristics are fundamental determination factors (Koppels, 2016a; Kuyper,2014). From a macroeconomic perspective, the global and local market mechanisms and adjustments have major impact on the financial performance aswell (Koppels, 2016a).Those criteria could be also be sorted into physical and non-physical features (Kuyper, 2014; Li, 2015). This chapter aims to give an overview of the most relevant factors that influence the financial performance of the office buildings which will be devided into 4 main categories; economic factors, location, building and contract features.

The following criteria are based mainy on literature study in addition to two former studies by (Geijselaar, 2010) & (Kuyper, 2014). Gijselaar identified the acqusition criteria based on literture review, interviews with experts and analysing quartly collected data. Kuyper started by Geijselaar findings and added new factors and examined all collected data.

2.1.7.1. Economic factors:

Vacancy rate:

Vacancy rate is a key factor that has a significant effect on the rent of office buildings (Frew & Jud, 1988; kuyper, 2014). The demand has direct effect on the vacancy rate and subsequently the rent. To illustrate, a high demand leads to fall in vacancy rates, and prices will increase if the actual vacancy rate falls below the natural estimated vacancy rate as a result of tighter market conditions and viceversa (Orr & jones, 2003).

Gross Domestic Product (GDP):
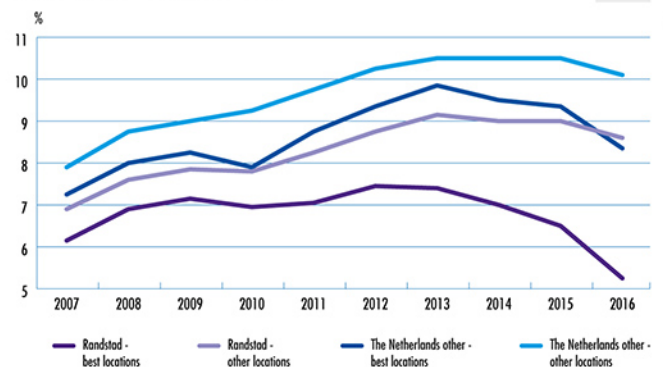
GDP is the most common indicator of economic activity. *'GDP is the market value of goods and services produced within a selected geographic area (usually a country) in a selected interval in time (often a year)'* (Leamer, 2010). The down size of GDP is considering all the monetary transactions whether it is good or bad and doesnot count any deals without money, which makes it an imperfect indicator for the health of nations (Leamer, 2010).

In the real estate domain, Aizenman & Jinjarak (2013) found out that current account/GDP is one of the most economically variables that influences real estate and important for real estate valuation through examining different variables in 36 different countries before and after the crisis of 2008 (Aizenman & Jinjarak, 2013).

Many authors (Hoskins et al., 2004; Chen & Hoobs, 2003; Van Doorn, 2003) showed a strong correlation between GDP growth & inflation and property returns (Lieser & Groh, 2013). To illustrate, increasing the size of a country's economy attracts more investments and capital as larger economy is more stable and less risky for investors (Lieser & Groh, 2013). Thus, GDP is important variable for strategic and investment real estate decisions.

Absorption rate:

Absorption rate is critical indicator for investor-income-growth or decline at the capital market (Sivitanidou & Sivitanides, 1999). It reflects the average sold vacancy offices in a specific period of time within specific market (Region) (Investopedia, 2017). Thus, it is more easy to lease vacant office space in markets with higher absorption rate, in addition, higher vacancy rate comparing to absorption rate, leads to higher future risk in rents' decline (Sivitanidou & Sivitanides, 1999).

Although Wheaton and Torto found out that absorption rate is more significant than vacancy rate, Sivitanides stated that vacancy rate is more related to rents than absorption rate (Gijselaar, 2010).

Office stock & Supply:

Although Dipasquale & Wheaton (1992) showed through their framework that the increase in construction at the Asset market affects the stock and leads to decreasing rents in the property market, other authors like Öven and Pekdemir (2006) stated that the stock variable is not pertinent to rent level (Gijselaar, 2010). Therefore, offices stock and supply have low effect on the rent level.

Additionally, the total volume of new construction (supply) is shown to be only significant in growing cities (Sivitanides, 1997)

Office Employment rate:

The employment (unemployment) rate is significantly related to investment activities (Lieser & Groh, 2013). Tsolacos et al (1998) stated that Sector employment is an indicator of demand side which contains the number of employees in the banking, finance and insurance (BFI) sector (Gijselaar, 2010). Due to the fact that availability of skilled stuff is important and highly considered by office buildings occupiers (Demand side) (Weatherhead, 1997).

In short, it could be drawn that vacancy rate has the most significant influence on rent estimation, followed by GDP and absorption rate. The office stock size and supply have relatively low impact on estimating the rent Level.

2.1.7.2. Location:

Location is the first factor to affect the property value especially the commercial property value. Hurd (1903) linked the value to accessibility as could be shown in the following (Lusht, 2001):

Land value ⟶ Rent ⟶ Location ⟶ accessibility (Distance)

According to the Bid- Rent theory Fig.2.15., the rent changes according to the distance from the Central Business District (CBD) and the relation between rent and value is shown in fig.2.15. for different functions (Mcdonald & Mcmillen, 2011).

Cost of accessibility (Transportation) is the major factor that affects location. The distance from the CBD increases if the cost of accessibility increases as shown in fig.2.16. (Lusht, 2001).
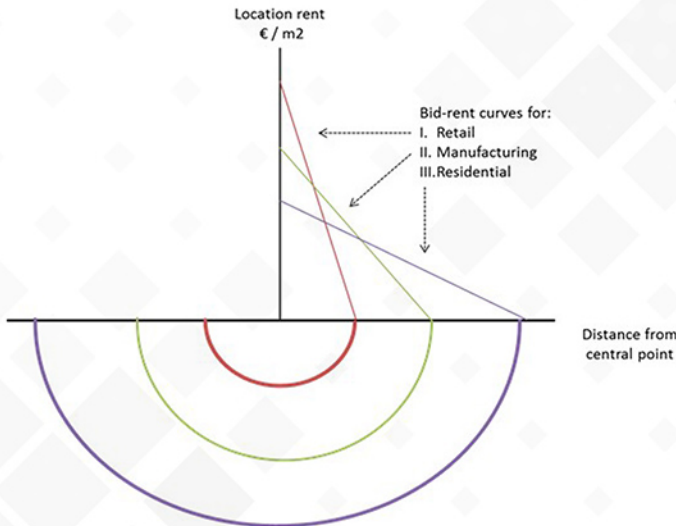
Fig.2.15. Bid- Rent theory (Mcdonald & Mc-millen, 2011)
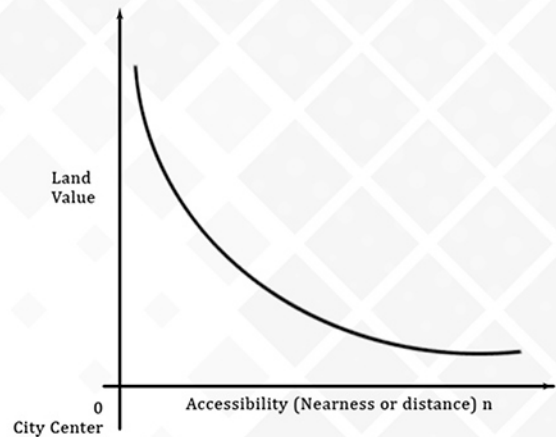
Fig.2.16. Landvalue depends on accessibility (Lusht, 2011)

The office market needs to decrease the cost of accessibility as it requires face-to-face interaction. But retail accessibility depends on its target market and could be found on the suburbs (Lusht, 2001). On the other hand, the transportation system is highly advanced and fast nowadays, which made it difficult to consider accessibility cost in many locations due to the extreme low value of premium accessibility cost to location consideration for specific target group (Lusht, 2001). Thus, it could be seen that location becomes relatively less significant as have been also concluded by the study of Kuyper (2014).

Moreover, research by King Sturge & Co. (1995) and another one by Harris research centre came to the conclusion that the following elements are considered by office buildings occupiers (Weatherhead, 1997):

- Distance to the central business district (CBD) and target market.
- Good motorway accessibility (Road infrastructure)
- Total occupancy costs

The following table.2.3. shows the relevant features to location for office buildings as approved in different studies by different authors :

LOCATION FEATURES	
FEATURES	STUDIES & LITERATURE
1- Distance to CBD and important places	Bollinger et al., 1998; Clapp, 1980; Frew and Jud, 1988; Gat, 1998; Kuper, 2014; Mcdonald and Mcmillen, 2011; Sivitanidou, 1996; Sivitanidou, 1995; Weatherhead, 1997; Öven and Pekdemir, 2006.
2- Distance to public transportation and railways	Clapp, 1980; De Graaff et al., 2007; Gijselaar, 2010; Kuyper, 2014; Lusht, 2001; Debrezion et al., 2007; Wheaton, 1984.
3- Distance to High ways (Road infrastructure)	Clapp, 1980; Gijselaar, 2010; Kuyper, 2014; Öven and Pekdemir, 2006; Weatherhead, 1997; Wheaton, 1984.
4- Parking	Bollinger et al., 1998; Clapp, 1980; Gijselaar, 2010; Glasscock et al., 1990; Kempf, 2015; Kim et al., 1999; Kuyper, 2014; Mills, 1992; Sivitanidou, 1996.
5- Charisma of surroundings & Environmental amenities	Clapp, 1980; Gijselaar, 2010; Kim et al., 1999; Kuyper, 2014; Sivitanidou, 1995; Sivitanidou, 1996.

Table.2.3. Location features (Own illustration).

2.1.7.3. Building features:

Many studies (Bollinger et al., 1998; Clapp, 1980; Gijselaar, 2010; Frew and Jud, 1988; Gat, 1998; Kempf, 2015; Kuyper, 2014; Li, 2015; Lusht, 2001; Mills, 1992; Sivitanidou, 1996; Sivitanidou, 1995; Öven and Pekdemir, 2006; Weatherhead, 1997; Wheaton, 1984) revealed a strong relation between the physical features of office buildings (Demand side) and their financial performance. Hedonic regression analysis is the common method to evaluate and check the impact of building features on their financial performance (Kempf, 2015).

Due to the obsolesce process of real estate, age represents a crucial factor when it comes to office rent determination and valuation (Kempf, 2015). Many authors found strong link between age and rent level, as rent is higher when the building is newer or with a lower age (Bollinger et al., 1998; Clapp, 1980; Gat, 1998; Kim et al., 1999; Li, 2015; Lusht, 2001; Sivitanidou, 1995; Sivitanidou, 1996; Weatherhead, 1997; Wheaton, 1984). Other authors concluded that there are no significant relation between age and rent level of office buildings (Brennan et al., 1984; Frew and Jud, 1988; Mills, 1992).

According to Ball (2003), although many new buildings can commit higher rent due to better quality and innovations, old buildings also can commit high rent due to status and prestige (Kempf, 2015).

Kim et al. (1999) studied the office market in Seoul area in Korea, and found out that building age, owner type, the number of elevators, and the building size are statistically significant, while parking space size and the amenity variable are not statistically significant.

Furthermore, Öven and Pekdemir (2006) investigated the office market in Istanbul and concluded that the following factors affect the level of rent; building age, percentage of unused space in the office, total floor area, number of floors and the percentage of common space in the building.

The building and architectural design qualities of office spaces represent fundamental aspect in acquisition consideration (Geltner et al., 2007; Kempf, 2015; Lusht, 2001). According to a previous study of Boston's and Cambridge's office market made by Vandell, et al. (1989), based on a survey with 80 Architects, building age, percentage of unused space in the office, total floor area, number of floors and the percentage of common space in the building are found important factors for reflecting the building and architecture quality, which has an effect on the rent level. However, many other aspects that could reflect the appearance quality and aesthetics of the building are subjective and hard to measure which makes it difficult to relate them to specific increase in value.

Although many studies ignored the energy efficiency factor, recently it becomes more important especially after the climate change disaster. The impact shouldn't be directly to value of the building but to promoting its image and decreasing the energy cost (Popescu et al., 2012).

Finally, the main building characteristics of the building which influence its value as described by (Lusht, 2001; Weatherhead, 1997) are:

- The size of the building: the relationship between the size of the building and its size is nonlinear, which means that the greater the size, the lower the value.
- Building materials and its quality: the attractive, functional and long lasting materials are more likely to increase the building value.
- Building design
- Building Condition: age and structure.
- Building compatibility and formity with its surroundings (mostly for residential)
- Energy efficiency
- communication technology
- Parking

2.1.7.4. Contract features:

The length of rental contracts has a positive impact due to the fact that longer lease contracts offer more security in terms of more stable and predictable cashflows and less vacancy risk (risk-averse tenant) for investors, although it might result in lower rental value (Öven, & Pekdemir, 2006; Wheaton & Torto, 1994). The long rental contracts can also affect the office rental pricing as this type of contract doesn't take into consideration the change in the market price but only CPI within the contract period (Englund et al., 2005).

Moreover, the free rent period is also regarded as a strong variable with significant influence which is also highly related to the physical attributes of the building (Brennan et al., 1984; Öven, & Pekdemir, 2006)

In addition, the impact of contract variables can be considerably susceptible on office rent as they are significantly interrelated (Öven, & Pekdemir, 2006).

In the current dynamic, fast and global context, contracts become shorter for more flexibility as a result of the difficulty of future prediction, which might form a significant risk for investors.

Based on the interview held by PWC and the Urban Land Institute about emerging trends in real estate: reshaping the future in Europe, occupiers are willing to pay for shorter lease contracts and increased flexibility (PWC & ULI, 2017).

Occupiers are willing to pay for shorter leases and increased flexibility

21% Strongly agree 52% Agree 17% Neither agree nor disagree 10% Disagree 1% Strongly disagree

To summarize, many factors has been studied in a relation to rent and acquisition. Table.2.4. Summarizes the main findings based on the reviewed literature and studies.

ECONOMIC FEATURES	LOCATION FEATURES	BUILDING FEATURES		CONTRACT FEATURES
1- Vacancy Rate. 2- Gross Domestic Product (GDP). 3- Absorption Rate. 4- Office stock & supply. 5- Office Employement Rate.	1- Distance to CBD and important places. 2- Distance to public transportation and railways. 3- Distance to High ways (Road infrastructure). 4- Parking. 5- Charisma of surroundings & Environmental amenities	1-The building size. 2- Building materials and its quality. 3- Building design. 4-Building Condition: age and structure 5- Building compatibility and formity with its surroundings. 6- Energy efficiency. 7- Parking. 8- Communication technology 9- Total floor area. 10- Number of floors.	11- The percentage of common space. 12- The percentage of unused space . 13- The number of elevators. 14- Building amenities and services. 15- LFA/GFA ratio. 16- Architectural quality. 17- Lighting. 18- Privacy. 19- Ceiling height. 20- Availability of external view.	1- Contract period (years). 2- Duration of rent free.

Table.2.4. Acquisition criteria for office space (Own illustration).

2.1.8. Fundamentals of investment & acquisition:

This part shows the basis of the relation between different types of investors and their investment choices, based on their attitude towards risk which affects their decision making strategy and their path in the analysis activities.

2.1.8.1. Types of investors:

The investor is the entity or the person who is involved in real estate industry with the purpose of making profit (Manganelli, 2015; Li, 2015). Investors can be classified into Active investors or Passive investors depending on their level of intervention. Active investors own real estate directly, make investment decision, concluding contracts, supervise and manage, and operate their assets (Manganelli, 2015). On the other hand, Passive investors assign all activities to others and mostly portfolio managers (Manganelli, 2015; Li, 2015). Investors have normally different goals depending on their nature but they are all aiming for financial returns.

In terms of risk, the behavior of investors is different which influence their choices. Some investors are willing to confront risks and sometimes looking for it, with the aim of making more profit (Manganelli, 2015). Others avoid it and accept less return with higher level of warranty, which limits their investment opportunities and financial returns (Manganelli, 2015). Most investors are at the middle of those two extremes. Fig.2.17. shows that the expected return is higher in case of higher associated risks.

Fig.2.17. Indifference curve risk-return (Manganelli, 2015).

In most cases, investors are willing to accept additional risks that bring a significant proportion of extra return till a certain limit of risk, based on "common sense and economic rationality" (Manganelli, 2015). Thus 4 main steps should be followed; identifying objectives, main sources of risks and quantifying them, removing unnecessary risks and making the final decision (Manganelli, 2015).

2.1.8.2. Decision making process:

The decision making process in real estate investment is mostly based on some statistical and mathematical models for the pricing and allocation of assets, besides current expectations and business constrains, however, decision makers tend to use some outside parameters according to their expertise, which can be more explained through the Decision Theory (French & French, 1997).

"Decision theory is the study of models of judgements involved in and leading to deliberate, and usually rational choice " (French & French, 1997). This theory arises from different disciplines such as: philosophy, mathematics, economics and social sciences, including psychology and sociology (French & French, 1997; Ricciardi and Simon, 2000). Thus, it is important to figure out how to make the decision and on which model should we base our decisions is specific discipline, especially that some models could be in conflict which each other's. For example, according to French (1996), in case of real estate, the portfolio maximization model which aims to maximize the allocation of a property considering its performance, might conflict with business risk considerations about the competitors for example (French & French, 1997). Accordingly, decision models can take three forms (French & French, 1997):

1- Descriptive analysis: 'how we do decide'.
2- Normative analysis: 'how we should decide'.
3- Perspective analysis: 'normative models which are using other limiting conative parameters as well'.

Although normative theory assumes that rational decision making is transitive, decision makers tent to use intransitive preference models due to the external factors that could affect the organization strategy (French & French, 1997).

It has been also described by Ahlers (1975) that is it important to perform first a behavioural analysis of decision process before defining any tools, as much of the benefits are gained from the early phase of the analysis instead of the later introduction phase of complicated models. As a result, a Structured Decision making model (SDM) has been developed based on the concept of bridging past business management systems to the ones of the future, tackling the problem of organizational change and its operations through a period of time by comparing them to other alternatives (Ahler, 1975). Fig.2.18. shows a flowchart of the SDM which was regarded as a crucial step in terms of new tools, reports and responsibilities.
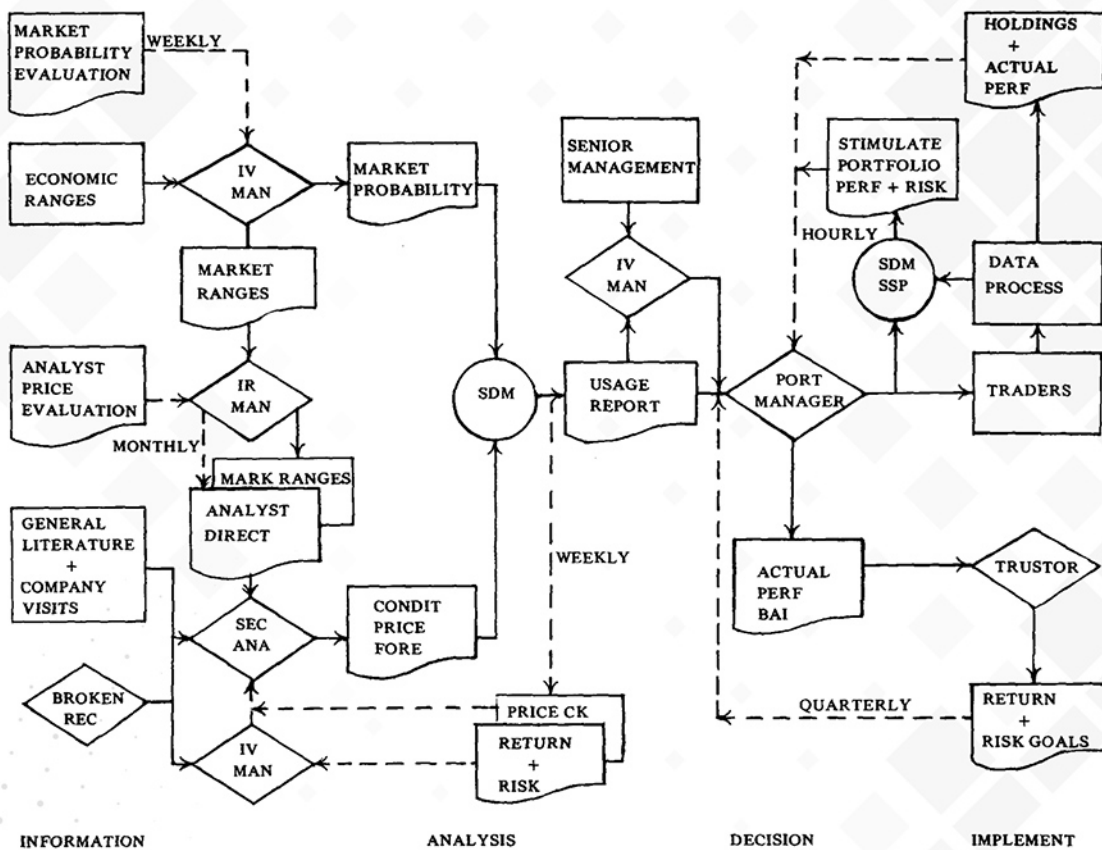
Fig.2.18. Structured Decision making model (SDM) flowchart (Ahler, 1975).

Furthermore, Hartigay and Yu (1993) identified main 6 steps for investment decision process in a circular structure through their last step of revising goals despite many other models which followed a sequential structure:

    1- Definition of the purpose and objectives of the real estate portfolio.
    2- Formulation of a specified strategy and their selection/assessment criteria.
    3- Assessment of individual projects against the predefined criteria and strategy.
    4- Closer examination of projects that meet return and risk profile.
    5- Closing the investment decision and implementation of actions.
    6- Post auditing and optimising (link to step 1)

In that sense, parker (2010) described a process approach based on Pagliari (1995) and Brown and Matysiak (2000), which is sequential and linear in nature and circular in extent, as shown in fig.2.19.

Source: Parker (2010)
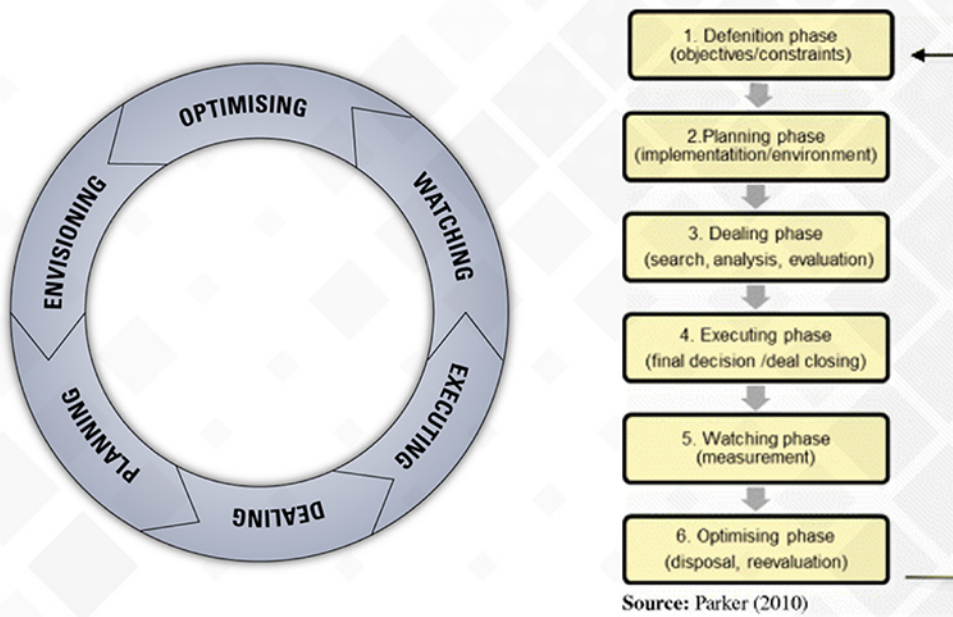
Fig.2.19. Mapping the Real Estate Portfolio Management Process (Parker, 2010).

Moreover, Roberts & Henneberry (2007) studied the office investment decision- making process in different European countries. Based on many literature (Eilon, 1969; Farragher and Kleinman, 1996; Feeney et al., 2000; Gallimore et al., 2000; Hargitay and Yu, 1993; Jaffe and Sirmans, 1995; Phyrr et al.,1989; Tyebjee and Bruno, 1984), They built up a composite model of the property investment decision-making process of investment and tested it in many European countries (Roberts & Henneberry, 2007). Finally, They concluded that the original model based on theory consists of 10 main stages which were decreased to be 5 in case of France and Germany, and 6 in case of UK as shown in fig.2.20. This proved that comparing to the normative model of decision-making, in practice, the decision making process is simpler.
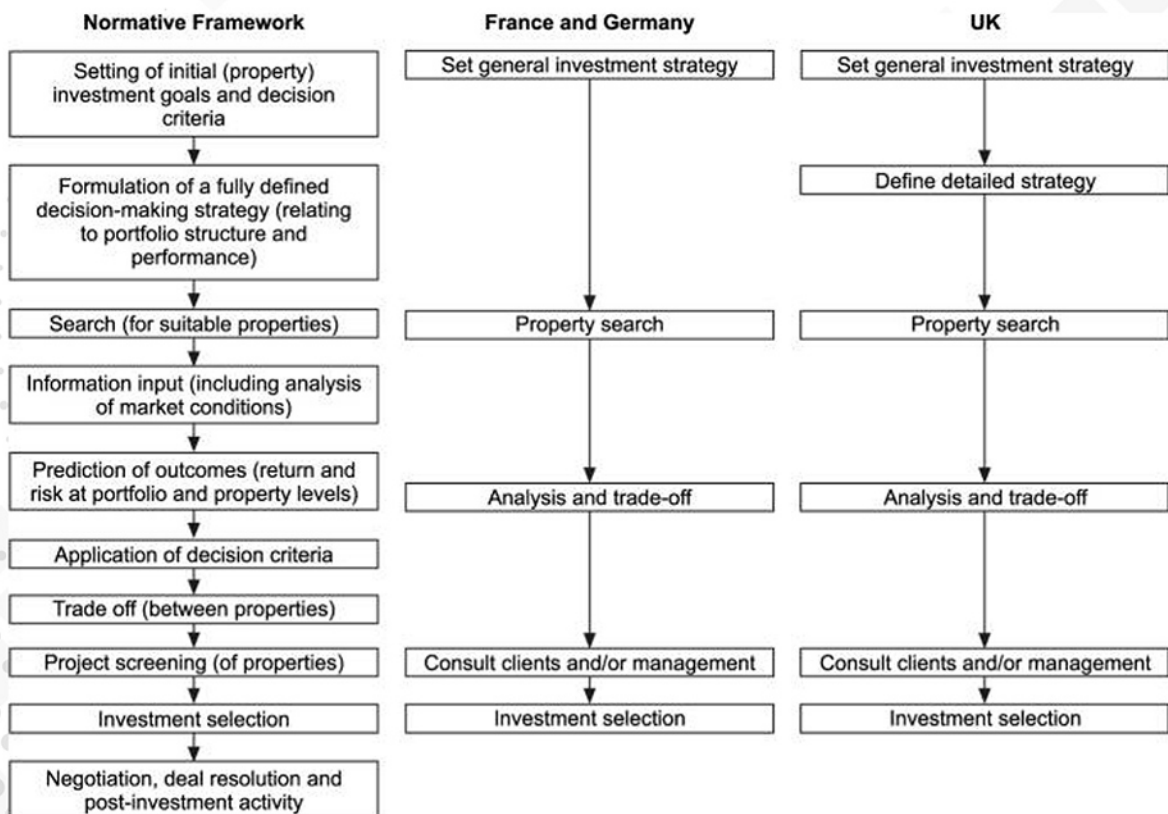
Fig.2.20. Comparison of stylised national investment decision-making heuristics with normative model (Roberts & Henneberry, 2007).

According to Manganelli (2015), the decision making process of real estate investment can be defined in five main steps which is not different than any other investment procedures as shown in fig.2.21. The first step concerns the definition of the specific investor's objectives and constrains which is crucial in determining the best opportunities, for example: an investor might have sustainable and green objectives besides maximizing the profit (Manganelli, 2015). The second step is to collect data and information about certain market (market analysis) and different possible opportunities at the market as much and accurate as possible for better predicting future benefits and mitigating associated risk (Manganelli, 2015; Geltner & miller, 2007). The third step is analyzing the collected data from a financial perspective. The fourth step is building valuation models for assessing different investment opportunities and feasibility (highest and best use), based on identifying the critical parameters for maximizing the outcome and most effective decision criteria, which will be discussed further in the coming sections (Manganelli, 2015). Finally, the final decision will be made.
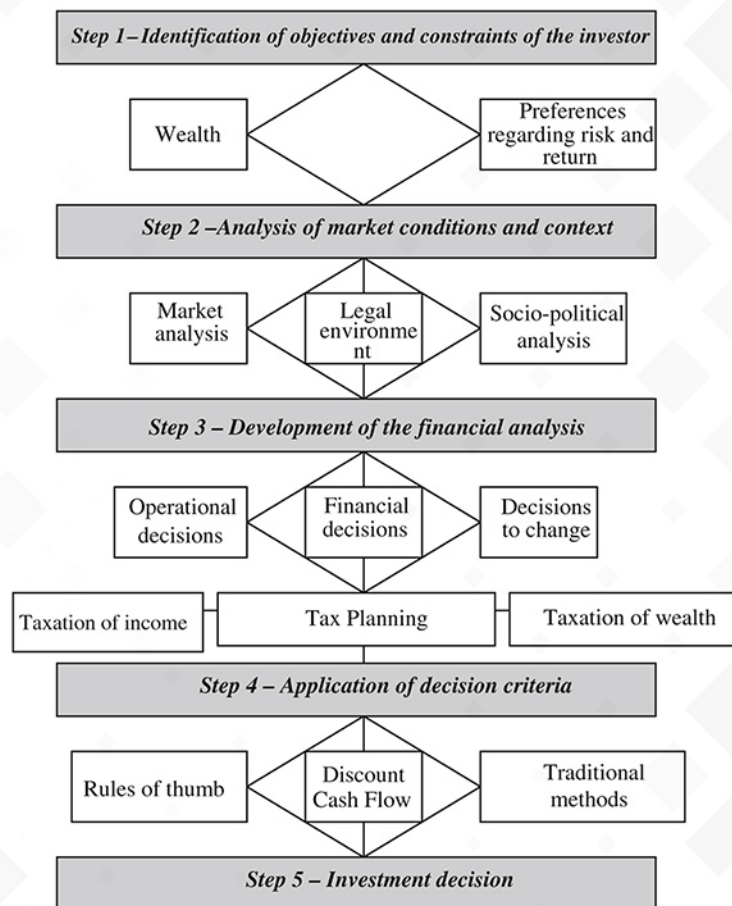
Fig.2.21. A model of decision-making process relating to the generic investment (Manganelli, 2015).

In short, the previous studies showed the difference between decision making process in theory and practice as it is much simpler in practice. on the other hand, many studies and models ignored the external factors, risks, and corporate strategy, thus risk analysis, external information and factors should be incorporated to work with those decision models by considering also available innovations and technologies. It has been also shown that some models followed a linear or sequential structure and others considered a circular structure based on feed-back loops for better performance.

2.1.9. Investment value & Returns:

When the real estate is kept by company not for operational purpose but for its investment potential, it will be considered as an investment property and included in the balance sheet at open market value (Weatherhead,1997). In that case, annual depreciation charges are not included in the profit and loss account except for short term leases which means that higher profit will be declared each year (Weatherhead,1997).

Thus, The investment value is the value of an asset to a specific investor based on his own assumptions (Lusht, 2001; Manganelli, 2015). In other terms, it is the highest price an investor is willing to pay (Koppels, 2016b; Manganelli, 2015). It could be equal to the market value or higher if the investor has the ability to put it to best use (Lusht, 2001), but investors are willing to buy if the investment value is higher than the market value of the property (Manganelli, 2015). Determining this value requires predicting the future cash flow and comparing that with associated risks (level of uncertainty) and time (chronological alignment of cashflow) to be able to compare between different opportunities as shown in fig.2.22. (Koppels, 2016b; Manganelli, 2015).
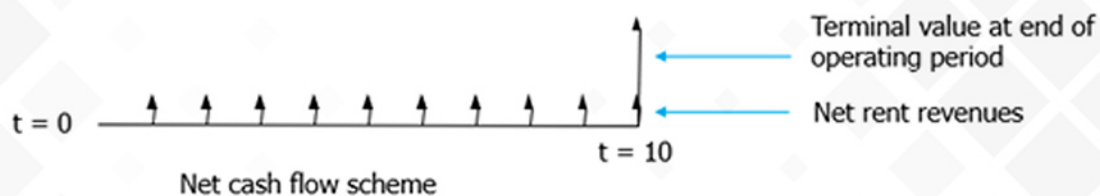
Fig.2.22. Cashflow diagram (Koppels, 2016b).

Return is the proper way to quantify the investment performance over time and the involved amount of risk (Geltner & miller, 2007). Simply, investment return is measuring the profit by subtracting all what we spent from all what we gained from the investment. There are two main types of returns: Real returns and Nominal returns. Real return is measured in constant-purchasing-power dollar and include inflation (Geltner & miller, 2007; Koppels, 2016c). Nominal returns is adjusted for inflation which reflect the actual purchasing power (Geltner & miller, 2007; Koppels, 2016c).

Additionally Returns could be measured by two different ways: periodic (period by period) and multiperiod (Geltner & miller, 2007). The periodic return is measured regularly in a specific holding period (daily, monthly, quarterly, or yearly), which is more related to the macro-economic level and crucial to compare the performance of the portfolio over time, measuring risk in investments, assessing managers performance and determining the time-weighted multiperiod return (Geltner & miller, 2007). The multiperiod return measures a single number for a comparatively long term period which is more related to the micro-economic level of individual projects and opportunities (Geltner & miller, 2007). The most common used multiperiod return is the internal rate of return (IRR) which is more convenient to be used in real estate valuation as it doesn't require knowing the capital value of investment in intermediate points of time unlike periodic returns (Geltner & miller, 2007).

Finally, real estate values change over time as it is fixed assets which has a finite useful economic life and will be replaced after specific period (Weatherhead,1997). Consequently, considering historic cost and value in current valuation can be very misleading. Those changes can be for example: changing in inflation rate or local market conditions like building a new road, etc. Thus, companies should reevaluate their assets regularly and include the new figures within their annual accounts (Weatherhead,1997).

2.1.10. Investment decision making strategies and methods:

The previous part described the main topics of investment, investors and the concept of returns. This part stresses more on the real estate investment at the micro-level. Thus, it introduces briefly some used methods and techniques in real estate investment valuation for assessing the best investment choice, and the strategic thinking and procedures for real estate investment management from a holistic perspective.

2.1.10.1. Real estate valuation techniques:

The real estate investment valuation calls for appraisal and comparison of both cost and revenues (cost-benefit confrontation) for the property itself and its management. Consequently, The financial efficiency of any proposal could be defined by the ratio between final value of goods and the cost of the used factor (Geltner & miller, 2007; Manganelli, 2015). The main problem with this concept is the uncertainty of estimated benefits which considers future values and cashflows (Manganelli, 2015). As this cashflow requires analysts to predict a lot of factors based on the historical performance of the building, which could be also better to base it on statistical-econometric techniques for more reliability (Manganelli, 2015). Many parameters should be defined and calculated first like: Net Operating Income (NOI), Construction cost, The Potential Income, etc.

Traditionally, the following financial and profitability measures are used examples to measure the profitability (Manganelli, 2015):

1. Annual Debt Service Cover Ratio (ADSCR): the ratio between net operating income and debt service in the same year.
2. Life Loan Debt Service Cover Ratio (LLDSCR): the sum of discounted cash flows for debt coverage.
3. Return on investment (ROI): the ratio between net operating income and net invested capital.
4. Return on Equity (ROE): the ratio between cash flow before tax and the equity (available capital by investor).
5. Payback Period (PP): the ratio between Equity and annual cash flow when the expected cash flow stays constant.

The main limitation for the traditional analysis is ignoring the effects of timing of cashflows which is highly important for any investor, in terms of commitment of capital, expected future cash flows and investor's attitude towards risk (Manganelli, 2015). As a result, modern technique and measures were developed for profitability analysis that are "time-adjusted" (Geltner & miller, 2007; Manganelli, 2015):

1. The Discounted Cash-Flow Analysis (DCF): depends on the modern financial analysis that accepts a proposal when its return rate exceeds the marginal cost of involved capital that considers time as a substantial factor " (Manganelli, 2015). DCF involves three main steps; forecasting the expected cashflows, estimating the required total of return and then discount the cashflows into present value using the required rate of return " (Geltner & miller, 2007). Three related measures are important:

A. The Net Present Value (NPV): the sum of the outgoing and coming individual cashflows" (Geltner & miller, 2007; Manganelli, 2015). The general formula is:

$$NPV = \sum_{t=0}^{N} \frac{CF_t}{(1+r)^t}$$

where
N number of periods, investment time horizon or period of analysis;
CF_t expected cash flows;
r discount rate (minimum acceptable rate of return).

b.   The Discount Rate: It gives the possibility to convert future dollars into present equivalent value, and is an important effective factor, as any slight change in it , changes the hierarchy of investment alternatives " (Geltner & miller, 2007; Manganelli, 2015). Thus, it is important to estimate it so carefully by considering both factors; time value of money and associated risk to the expected future cashflows (Geltner & miller, 2007). Those risks could be for example: risk tolerance, wavier of immediate consumption, lack of liquidity and portfolio management risks (Manganelli, 2015).

c. The Internal Rate of Return (IRR): is the discount rate that equalize the positive and negative cashflows of an investment and can be obtained by putting NPV=0. It is important measure to compare between alternatives by addressing the minimum expected return from particular transaction (Manganelli, 2015).

Moreover, real estate consists of two components: the land and the buildings. Although most firms are paying more attention to the buildings, the land itself should be also considered as a main aspect of valuation, as for example, changing in the local economy or the planning decisions can certainly influence the land value as shown in fig.2.23. (Weatherhead,1997; Manganelli, 2015). Thus, in order to fight obsolescence and other factors that might affect the increase value of the property, real estate investors should be aware of the importance of monitoring comparable properties which might increase in value much faster, and not only relying on the notion that inflation can cover the building obsolescence (Weatherhead,1997).
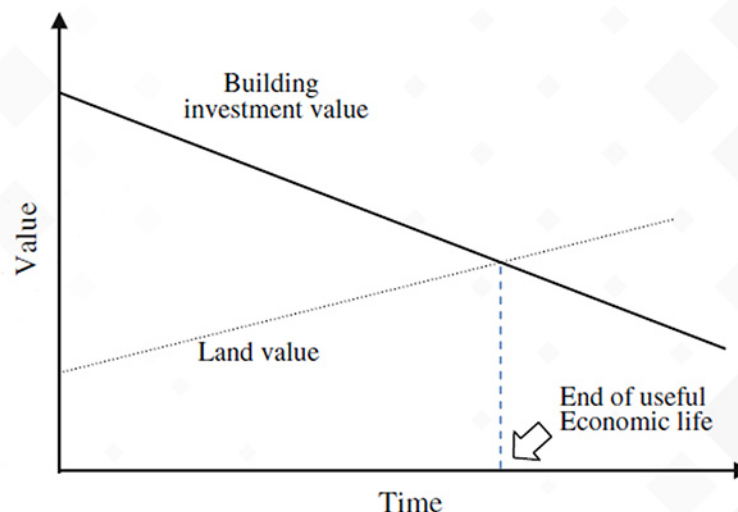
Fig.2.23. End of the useful economic life of a building (Manganelli, 2015).

In general, all these measures depend mostly on future prediction and assumptions. The more they are based on data and information, the more reliable and the least risk.

2.1.10.2. The theory of options and investment management:

The discounted cash flow method is regarded static and limited in terms of considering the interaction between current investment alternatives and future decisions (strategic thinking), especially concerning probabilistic approach in risk- analysis (Manganelli, 2015). The theory of options tries to tackle this limitation by managing the uncertainty of possible future changes and scenarios (Manganelli, 2015). For illustration, it takes into account the strategic goal for specific investor in determining the future value such as: expansion, contraction, abandonment or postponement (Manganelli, 2015).

Therefore, decision makers should adapt models that assign specific value to the property based on future threats and opportunities (adaptability/flexibility management), which gives them more flexibility in considering additional value based on the strategic future goal (Manganelli, 2015). Consequently, the concept of NPV is adapted to be extended NPV (ENPV) according to the following formula (Manganelli, 2015):

$$ENPV = NPV_b + OP$$

Where:

NPV_b net present value related to base investment , the evaluation is deterministic in this case, and the result does not consider future opportunities;

OP   the value of future options

To conclude, incorporating the real options approach to evaluation methods could overcome the complexity nature of many projects by addressing and evaluating different future scenarios which also requires the availability of a lot of data and information.

2.1.11. Technology and real estate investment management:

Recently, business managers are aiming to manage and improve their use of recourses. Accordingly, human resource, technology, financial management, data science and information management are crucial for achieving higher productivity, higher efficiency and being smart and agile.

The new technology in an age of digitalization brought new insights into business practice as any other discipline. Thus, understanding and benefiting from the new communication and technological systems will open new possibilities in investment management related to the real estate industry . The key factor of leveraging technology is building up knowledge of new systems in such a fast-changing environment. The core element is data and how to control its flow.

Furthermore, in the current investment world, real estate occupies a significant position and has the ability of changing the world of business by making financial improvement (Weatherhead,1997).

In this context, information management are significant and highly needed in real estate, which is about managing any form of data within the computer environment. Especially that the current explosion of massive data, computer technologies and internet of things drove the business world to focus on big data (Du et al., 2014).

2.1.12. Conclusion:

This part of that chapter discussed the main principles of real estate investment management and most related topics. It also addressed the main characteristics of the Dutch office real estate market.
After addressing the main characteristics of the real estate market in general and the available techniques, methods and tools for assessing the decision making process for different investors, it could be concluded that the availability of information plays a fundamental role in the different stages of the investment development process. As data is the row material of information, the next part of this chapter will review and study the current hot topic of big data and its analytical methods, with the aim of finding how to benefit them in favor of achieving better real estate investment decisions and mitigating associated risks.

2.2. Big Data:

Recently, big data and predictive analytics become hot topics of attention for different disciplines. The vast explosion of big data concept and the acceptance of public and firms affected the required time for academic domain to cover and develop sufficient analysis of this hot topic. Thus, the literature review of this part will combine both academic review and practical review for coherent understanding.
This part aims to define the main concepts, tools and methods of big data and current technologies in general and in a relation to real estate valuation and decision making process, from both academic studies and practice.

2.2.1. Background:

The rapid evolution of technology in the current digital era, was main driver to shoot up data volume in different types in different industries, especially with the recent high technological capabilities of storing, processing and turning these data into real value. But, the origin of big data was in natural science such as astronomy and in our social life as well (Du et al., 2014). Although, the origin of the term big data itself is debatable but it might be originated in a lunch conversation at Silicon Graphics in. (SGI) in mid 1990s by John Mashey then it became widespread term (Gandomi & Haider, 2015).

Additionally, the highly competitive market in a globalized world drives firms to find new paths for enhancing their products/service, client satisfaction, efficiency and effectiveness (Portela et al., 2016).

Looking at our daily practicee, there are more than one billion accounts on Facebook, those accounts upload around 10 million photos daily besides billions of comments and likes by others. Furthermore, banks, financial industry and telecommunication industries generate every day big amount of data of personal information (Du et al., 2014). This massive amount of data could be potential for improving the decision making capabilities that results in benefits for different enterprises and the whole economy as well, especially today as the real estate is considered a pillar industry within the national economy (Du et al., 2014). Thus, leveraging big data in the right way will present an essential guiding role in the national economy, especially in property bubbles. As described by Andrew McAfee and Eric Brynjolfsson *"Exploiting vast new flows of information can radically improve your company's performance. But first you 'll have to change your decision-making culture."* (McAfee & Brynjolfsson, 2014). In short, big data can be considered the new petroleum that will shoot the future information economy (Jin et al., 2015).

Additionally, Viktor Mayer-Schonberger who is known as the prophet of big data claimed that prediction is the core of big data and mainly the era of big data requires the transformation from samples to overall data, from aiming for exactness to accept uncertainty, and from causality to correlativity (Mayer-Schonberger & Cukier, 2014).

This part describes the essential concepts and characteristics of big data and which data and level are exactly needed for enhancing the performance, due to the fact that data should be considered by looking at its value and how can we leverage it to our domain, instead of analyzing it from philosophical perspective.

2.2.1.1. Definition of Data and Big Data:

First of all, data is about converting the world into categories, measures and other forms, and normally represented in nature (e.g. Height, weight, color, opinion, habit ,location, etc.) (Kitchen, 2014). Rosenberg (2013) described good quality data as distinct, aggregative, have associated metadata and can be integrated to other data sets to produce new insights in a specific domain (Kitchen, 2014).

Data is significant and valuable as it is an essential input for different required analysis for individuals, institutions, businesses and science, in order to create knowledge, value, innovations, products and policies that form our communities (Kitchen, 2014). In short, it is the key resource in our modern world.

Big data still vague and confusing term for most people. In order to define big data, we should think in terms of some characteristics. The first attribute to define big data is definitely volume, additionally many authors added two more dimensions to describe big data: variety and velocity (Chen et al., 2012; Gandomi & Haider, 2015; Kwon et al, 2014; Laney, 2001; Jin et al., 2015; McAfee & Brynjolfsson, 2014; Mccarthy, 2016; Portela et al., 2016).

Volume: (the magnitude of data) the size of big data is in terabytes and petabytes, and what exceeds one terabyte is considered big data as reported by IBM in 2012 (Gandomi & Haider, 2015; Jin et al., 2015; Mccarthy, 2016; Portela et al., 2016).

Variety: (the structure of the data sets) text, images, audio and videos from social media, GPS signals from cell phones which are considered as unstructured data and almost 95% of big data, or structured data like companies data bases (McAfee & Brynjolfsson, 2014; Gandomi & Haider, 2015; Jin et al., 2015; Portela et al., 2016).

Velocity: (the speed rate of generated data) high-frequency data is generated every day (around 2.5 exabytes in 2012) due to the escalation of smart devices like smartphones and sensors (Gandomi & Haider, 2015; Jin et al., 2015; McAfee & Brynjolfsson, 2014; Mccarthy, 2016; Portela et al., 2016).

For instance, Gartner, Inc. defined it as follow *"Big data is high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insights and decision making"* (Gandomi & Haider, 2015; Mccarthy, 2016).

In addition to the main 3 V's of big data, other attributes are defined by different firms for example: Veracity is defined by IBM which reflects uncertainty of some sources, Variability and complexity by SAS due to the variation in the data flow rates and the different sources, and Value is introduced by Oracle which could be higher by further analysis (Gandomi & Haider, 2015; Jin et al., 2015).

It could also be defined simply as *"set whose size and complexity is beyond the ability of conventional tools of manage, store and analyze data"* (Portela et al., 2016).

Finally, fig.2.24. shows the results of an online survey for 154 C-suit global executives by Harris Interactive on behalf of SAS in 2012 about how executives defined big data in terms of it is meaning or its application (Gandomi & Haider, 2015).
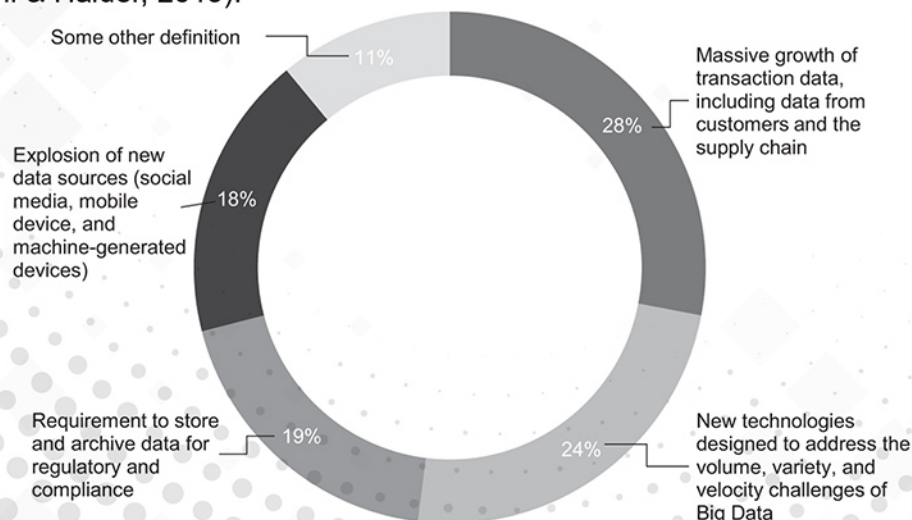

Fig.2.24. Definitions of big data based on an online survey of 154 global executives in April 2012 (Gandomi & Haider, 2015).

In short, big data can be seen as data with huge or infinite volume, dynamic changing, fast responding time requirements, high transfer rate, different certain and uncertain sources, unstructured format and value (Miloslavskaya & Tolstoy, 2016).

2.2.1.2. Related innovations and methods:

After the evolution of analytics, data and big data, many related concepts came into existence. This part discusses some related concepts to big data.

Big Data IT:

 is known as data science which is part of computing and includes different process such as: designing a methodology for processing data and defining what can be added to the stream developing certain algorithms for fast arriving data and analzsing and mining the structure of these vast data (Miloslavskaya & Tolstoy, 2016).

Methods & Applications:

1- Predictive analytics:

Set of tools and techniques which predict the future outcome and trends depending on historical and current data and can be applied in any domain or industry especially in decision making process (Abualzolof, 2016; Gandomi & Haider, 2015; Akbar et al., 2017). This type of analysis conduct mostly statistical models. In the real estate domain, it could be used for example to predict vacancy rate or future prices based on current and previous behavior of people and their demographics.

According to Gandomi & Haider (2015), predictive analytics techniques could be classified into:

a. Moving averages techniques which aim to investigate the historical behavior and data of the outcome variable and forecast the future based on the results.

b. Linear regression techniques which seek to capture the relationship between outcome variables and explanatory variables to predict the future outcome.

2- Fast Data:

Fast data is an application of data analytics for identifying which data is time-sensitive and can be stored within the data base and creating smaller data sets in near-time or real-time for solving a specific problem, due to the rapid growth of data each day (Miloslavskaya & Tolstoy, 2016). Its main aim is to quickly gather and mine structured and unstructured data for taking actions, which requires two main items: fast streaming system and adequate data store (Miloslavskaya & Tolstoy, 2016).

3- Business Intelligence (BI):

set of technologies, methods, smart tools, and applications which develop required knowledge for the decision making process, based on improving the quality of information and providing useful knowledge through acquiring, processing and analyzing different data sets (Portela et al., 2016).

4- Blockchain:

"A blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by consensus of a majority of the participants in the system" (Crosby et al., 2015).

To illustrate, for any transaction in anywhere, a secured block is built within this network between the two entities of the transaction only and there is no need for third party to validate or register this transaction which will save the involved transaction cost and time in a more secured way.

Although this concept is highly related to transaction costs which is an important factor and highly related to real estate investment, it is not studied in this research and further research should focus on this aspect from an investment perspective.

Infrastructure:

1- Data Lakes or Data Hubs:

Data lakes or hubs are huge scalable storage for large volumes of raw data (unstructured data) in its original format till it is required, besides engines which are processing systems such as: Hadoop (Laskowski, 2016: Mcclure, 2016). Data within the data lakes uses flat architecture as each data has its own identifier and tag (Miloslavskaya & Tolstoy, 2016).

2- Cloud computing:

According to the National Institute of Standards and Technology, *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"* (Mell & Grance, 2011). Simply, it could be defined as the application of storing, managing and processing your data through an internet network of remote servers rather than local service (Gale, 2015).

It also indicates to the application whether it is delivered through the internet or hardware and software systems in the data centres (Armbrust et al., 2010). These clouds could be private (e.g. for specific organization), community (e.g. for specific country), public, or hybrid and in that case a specific technology is involved to secure the success of some parts to specific individuals or departments (Mell & Grance, 2011).

2.2.1.3. Types of Data:

According to Kitchin (2014), Data is different in characteristics that forms its way of handling and use. In terms of:

1. **Form:** qualitative and quantitative. Quantitative data is numeric records (height, length, distance, weight, area, volume, ranking, etc.) , and qualitative data is non-numeric data like, pictures, videos, text, music, etc.

2. **Structure:** structured, semi-structured and unstructured. Structured data is data which can be simply and easy organized, stored and used directly, semi-structured data has categories and tags but loosely and irregularly structured, and unstructured data has no identified structure or format which requires classification and categorization.

3. **Source:** captured, derived, exhausted and transient. The data can be captured from observations, surveys, experiments, camera, scanners, sensors, etc. it can be also derived by processing and analysing the captured data, exhausted by a system or a devise based on its function, or transient in nature as it is discarded due to its complexity and irrelativity.

4. Producer: Primary, Secondary and tertiary. Primary data is generated by the researcher himself, secondary data is generated by someone else to be used, and tertiary data is derived data which can be produced by statistics.

5. Type: indexical and attribute and metadata. Indexical data reflects identification and linking such as passports, credit cards, IP address, etc. Metadata can describe either the data content which includes the names and fields of certain domains or the whole data base.

Additionally, big data could be classified into two categories based on its source: data from the physical world which collected by experiments, sensors and observations, and data from the human society which is acquired via social media, internet, health, finance, economics, and transportation (Jin et al., 2015).

2.2.1.4. The Knowledge Management Pyramid:

In order to understand the different between data, information, knowledge and wisdom, it is crucial to understand the knowledge pyramid that has been adapted by Alder 1986 (Kitchen, 2014). This knowledge pyramid consists of different layers and each layer is differentiated based on a process of percolation (reducing, abstracting, processing, organizing, analysing, interpreting, applying) in order to add value to the organization as shown in fig.2.25.& 2.26. (Kitchen, 2014).
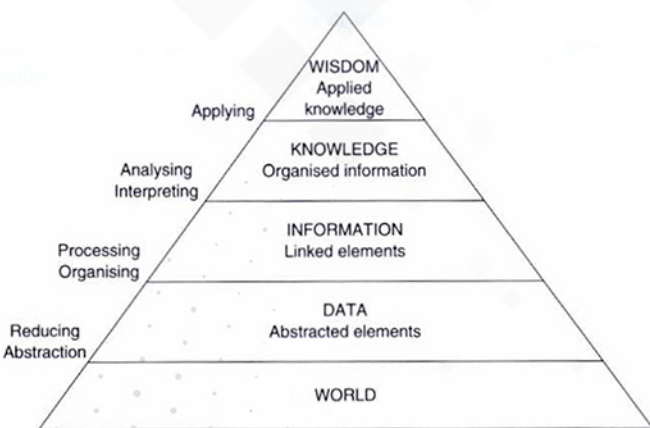
Fig.2.25. Knowledge Management Pyramid (Kitchen, 2014).
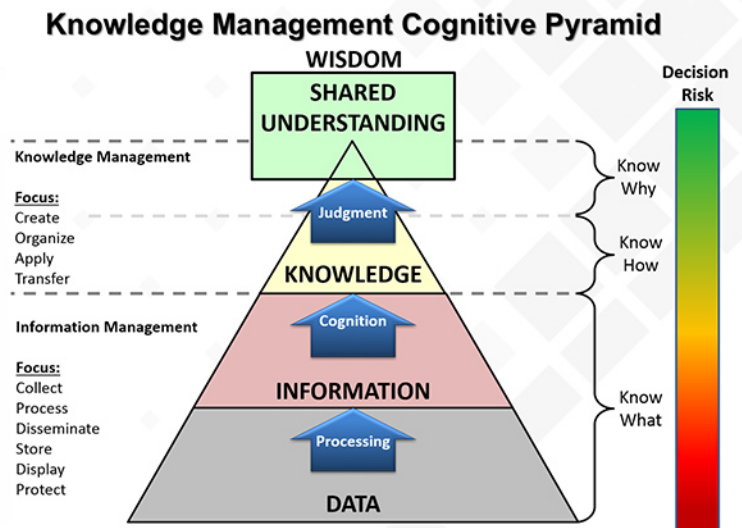
Fig.2.26. Knowledge Management Cognitive Pyramid Source: https://commons.wikimedia.org/wiki/File:KM_Pyramid_Adaptation.png

To illustrate, data is various abstracted elements that can be collected by different means. Data could be turned into information by creating and capturing value from this data through sorting, classifying, linking, visualizing. So, information could be considered as an organized meaningful data (Kitchen, 2014). Knowledge is basically the 'Know how' which transforms information into instructions and actions. Wisdom is the peak of the knowledge pyramids, which represents the ability of wisely applying knowledge in practice (Kitchen, 2014). Consequently, going through the different layers of the pyramid mitigates the decision risk and leads to more informed and accurate decisions.

2.2.2.5. Challenges of adapting big data:

As the whole world has totally accessed the era of information age, it becomes very important to investigate how to adapt this phenomenon which will change our way of living, working and thinking. Thus, looking at the challenges and associated problems of big data is the first step to be prepared for this era. These challenges can be related to the characteristics of big data, its methods and tools and its limitation as will be discussed in this part:

1- Complexity:

Big data is a very complex and unstructured. Collecting, processing, analyzing, classifying and storing all this massive data requires very advanced technology (Du et al., 2014).
According to Jin et al., (2015) this complexity can be defined through three terms:

Data complexity: the unstructured format, different types and patterns, and extreme size of data are main reasons for complexity. Understanding and representing this massive data requires new computational techniques as the traditional techniques ,such as, semantic analysis, topic discovery and retrieval analysis, are turned to be extremely difficult in case of dealing with big data. Thus, new mechanisms and models are required (Jin et al., 2015).

Computational complexity: as big data has multi-sources, huge volume and changes fast, traditional computational approaches became not adequate anymore. New highly-efficient computing approaches are required which integrate and optimize communication, storage and computing by focusing on the whole life cycle of big data application (Jin et al., 2015).

System complexity: Big data requires very complex computing algorithms ,thus designing hardware and software system architectures as the shown example in fig.2.27. by Deloitte company in the Netherlands, processing modes, and benchmarks for highly energy efficient operational platforms are highly required for tackling the complexity nature of processing and analyzing this massive data (Jin et al., 2015).
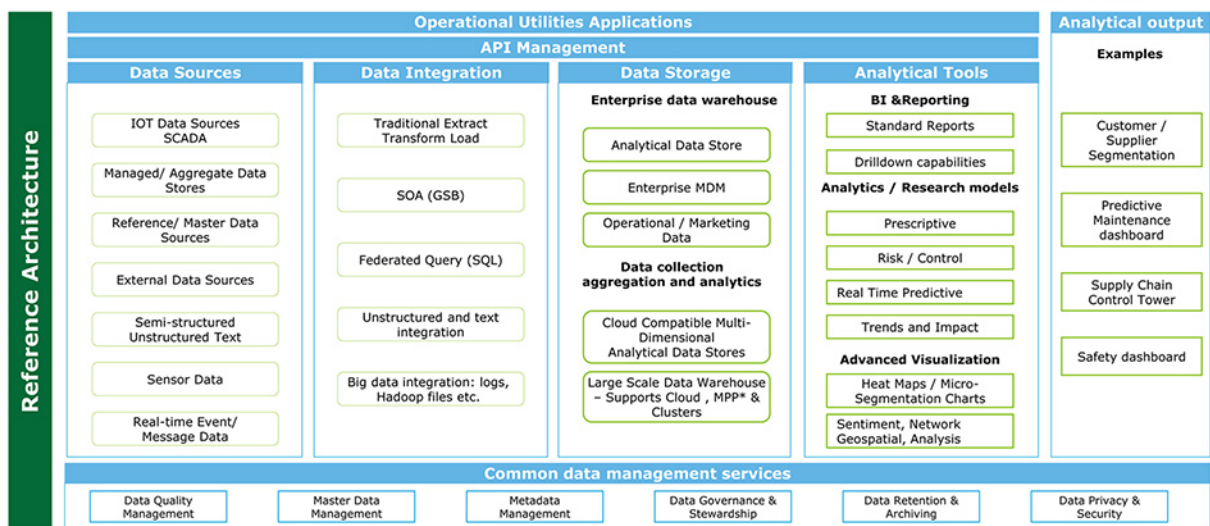
Fig.2.27. Example of System Architecture (Schalekamp, 2017).

This challenge should be the mission of any estate corporation by making national big data strategies and fostering and encouraging more universities' research and conduct those researches to real life application. Additionally, big data exchange and cooperation between nations (internationalization of big data business) should be also considered to figure out the foreign impact which could influence the domestic business (Du et al., 2014).

2- Privacy and Security:

In the information age, The critical, ethical and moral debate is about the private personal information within this big data (Acquisti et al., 2015; Du et al., 2014; UN Global Pulse, 2012). Our daily routine and actions through internet and social media depict our personal information and share it in many streams through the internet, which could be abused for economic and social discrimination (Acquisti et al., 2015). Individuals should navigate privacy and manage the boundaries between private and public spheres based on their culture, context and believes by knowing exactly what to share and what to keep invisible and private (Acquisti et al., 2015). For instance, the facebook profile update from 2005 to 2014 resulted in sharing more personal data by adding more gaps to be filled (home town, current city, status, concentration, life events, images, etc.,), unless the user himself controls the privacy terms as shown in fig.2.28. (Acquisti et al., 2015).
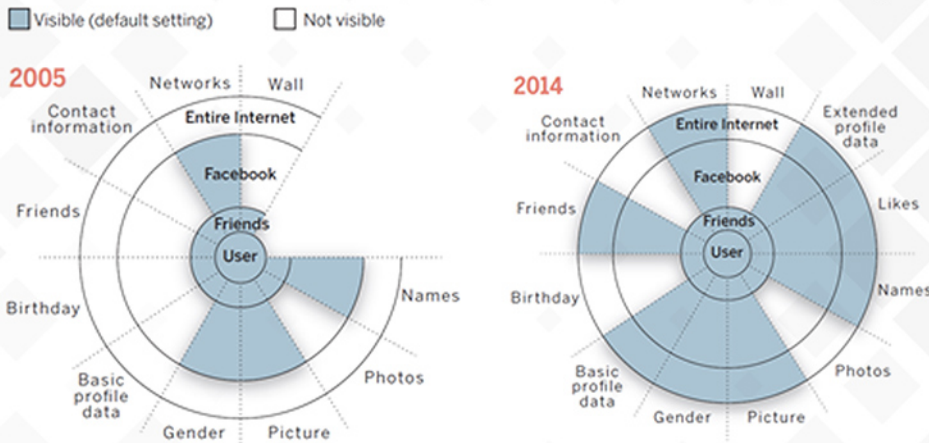
Fig.2.28. Defult visibility settings in social media over time (Acquisti et al., 2015).

Accordingly, It is proposed that data users rather than possessors should take the responsibility of protecting this personal information by making it purposely inconspicuous (Du et al., 2014). Additionally, privacy policies are required to protect people's privacy by designing a baseline frame work of protection and to be sufficiently flexible in order to cope with the high complex context of the information age (Acquisti et al., 2015).

3- Culture and mindset:

One of the main problems is to change the way people think about data and their culture. To illustrate, if the organization wants to be transformed into a data driven organization, people within the organization should first understand and believe that data is value and change the 'Can't do' mentality (Schalekamp, 2017). Fig.2.29., shows the difference between business intelligence services and analytical services.
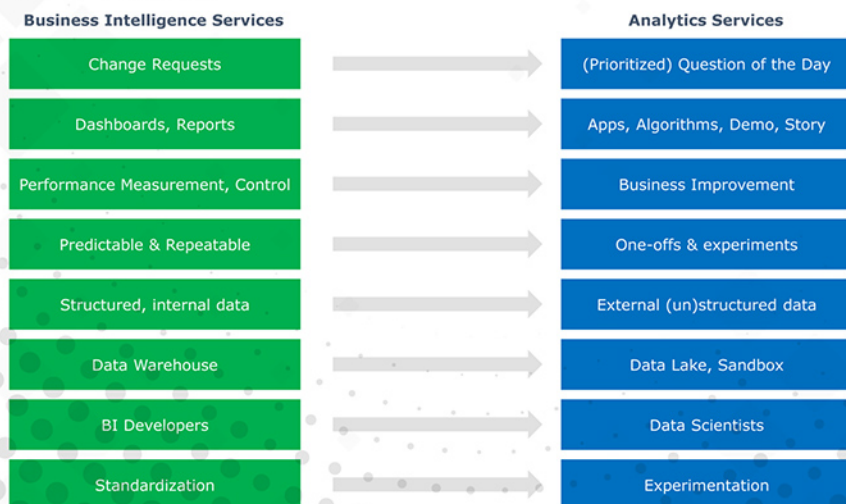
Fig.2.29. BI vs Analytical services (Schalekamp, 2017).

Each organization which is willing to be a data-driven organization should start by investigating its current knowledge and culture about data, then moving towards becoming a real data-driven organization instead of pretending, as some executives are mentioning big data while preparing their reports using traditional approaches (McAfee & Brynjolfsson, 2014). Thus, it is essential to understand and believe in big data and its value to change our culture and behavior from traditional approaches to current innovative approaches, which also require a lot of learning and experimenting.

2.2.1.6. Collecting, processing and analyzing data:

Storing data is vital for some analysis and firms. Thus, relational data base such as MySQL propose a flexible way to store, manipulate and retrieve medium-sized datasets based on Structured Query Language (SQL) (Varian, 2014). For bigger datasets (several gigabytes), NoSQL is more compatible which is more primitive and can handle bigger data sets. Nowadays, storing platforms can be only rented instead of being bought which turned the big fixed initial value into variable cost to attract more firms to use big data (Varian, 2014). Accordingly, many tools has been developed to manipulate those vast amount of data as shown in Table.2.5. (Varian, 2014).

Google name	Analog	Description
Google File System	Hadoop File System	This system supports files so large that they must be distributed across hundreds or even thousands of computers.
Bigtable	Cassandra	This is a table of data that lives in the Google File System. It too can stretch over many computers.
MapReduce	Hadoop	This is a system for accessing manipulating data in large data structures such as Bigtables. MapReduce allows you to access the data in parallel, using hundreds or thousands of machines to extract the data you are interested in. The query is "mapped" to the machines and is then applied in parallel to different shards of the data. The partial calculations are then combined ("reduced") to create the summary table you are interested in.
Sawzall	Pig	This is a language for creating MapReduce jobs.
Dremel, BigQuery	Hive, Drill, Impala	This is a tool that allows data queries to be written in a simplified form of SQL. With Dremel it is possible to run an SQL query on a petabtye of data (1000 terabytes) in a few seconds.

Table.2.5. Tools for Manipulating big data (Varian, 2014).

The outcome of the previous stage should be small table of data and directly readable by human, and if it is not clear enough, some data cleaning techniques such as: openRefine and DataWrangler can be used (Varian, 2014).

According to statistics and econometrics, data analysis could be divided into four types (Varian, 2014):

1- Prediction: Machine learning concerns designing high-performance computer system which gives better useful prediction.
2- Summarization: data mining aims to classify data and finding interesting outcome e.g. (linear) regression analysis.
3- Estimation.
4- Hypothesis testing.

Although most economists and evaluators use linear regression analysis, the vast availability of data resulted in more options based on non-linear methods such as (Hastie et al., 2009):

1- Classification and regression trees (Cart)
2- Random forests
3- Penalized regression e.g. LASSO, LARS and elastic nets.

Furthermore, traditional ways of colleting, analyzing and processing data are not compatible any more, due to the massive volume of available data and its rapid change(Miloslavskaya et al., 2014). According to Hornbeck (2013) there are three main types of processing data (Miloslavskaya & Tolstoy, 2016):

1- Batch processing in pseudo real or soft real-time:
Processing the stored data only in the non-volatile memory with determining the applied time and probability by the applied problems. This model has the potential of using more data and performing better prediction comparing to traditional ways.

2- Stream processing in hard real-time :
Collected data will be processed directly without storing the data itself but rather storing the operation results only. The related time and probability are determined by new data rate. This model is only compatible to very fast decisions (low response time) due to the risk of losing data.

3- Hybrid processing (Lambada Architecture):
This approach is based on three main principles: robustness, data immutability and re-computation. It also has four-layers architecture:

A- Batch layer: includes the stored fixed raw data on a distributed file system.
B- Serving layer: exposing the batch views in a data store for further investigation and exploration.
C- Speed layer: deals only with new data and computes real-time analysis.
D- Combination layer: for data synchronization, results composition, etc.

The main way to leverage big data is to turn all these data into meaningful insights through the shown five stages in fig.2.30. based on Jagadish (2012) (Gandomi & Haider, 2015).
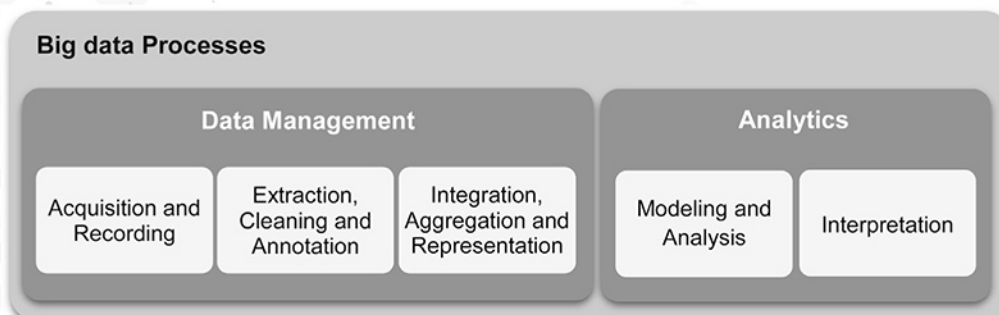

Fig.2.30. Process for extracting insights from big dara (Gandomi & Haider, 2015).

Analytics in that sense reflects innovative ways to extract intelligence from big data (Gandomi & Haider, 2015). As described before the unstructured data takes many forms such as: text, audio, video or social media. This part aims to figure out methods and tools to analyse those different types which is related to real estate investment.

1- Text analytics:

Extracting important information through analysis of any textual data such as: emails, blogs, social media comments, news, online forums, etc., which involves statistical analysis, computational linguistics and machine learning data (Gandomi & Haider, 2015). The current methods are used for this type of analytics: 1) Information extraction (IE) which consists of Entity Recognition (ER) and Relation Extraction (RE) and relies on advanced Natural Language Processing (NLP), 2) Text summarization techniques which has two approaches: extractive and abstractive, 3) Question Answering (QA) techniques such as Apple's Siri and IBM's Watson and relies on Complex NLP techniques, and 4) Sentiment analysis (Opinion mining) techniques which include people opinions (reviews) against entities such as products, organizations, services, etc. (Gandomi & Haider, 2015).

2- Social media analytics:

It applies to the analysis of social media structured and unstructured data by using different online platforms, and could be divided into social networks, blogs, microblogs, social news, social bookmarking, media sharing, wikis, review sites and different mobile applications . (Gandomi & Haider, 2015).

Social media analytics categories:

- **Content-based analytics**: analysis of the unstructured and noisy data (content of social media) which is posted by users on social media that can contain: feedback, reviews, images, comments, etc . (Gandomi & Haider, 2015).
- **Structure-based analytics**: deals with social media as a network and focuses on synthesizing the structural attributes of a social network which is depicted into edges and nodes. The main concern is finding out interesting outcome based on the relationship between different entities (Gandomi & Haider, 2015). According to Heidemann et al. (2012) there are two types: social graphs and activity graphs (Gandomi & Haider, 2015). Furthermore, many techniques have been recently developed in order to extract information from social media such as: Community detection, Social influence analysis and link prediction.

3- Time series analysis:

Nowadays, time series data processing and real time data analysis become a big phenomenon and hot topic. The concept refers to set of observations of the behavior of any single variable over time which can be used to predict the future values of this specific variable, for example: the daily price of gold or stock over the last six month (Anderson & Semmelroth, n.d.) . The concept itself is not new but the current enormous availability of data in the IoT era turns this analysis to be easier and achievable, due to the existence of sensors everywhere which emit and report thousands of numbers every second (Whipple , 2014).

Currently, there are many time series databases (TSDB) and methods which allows you to efficiently analyse the data. One of its methods that has been described by Varian (2014), is Byesian Structural Time Series (BSTS). The main challenge with time series and predictive analysis is to find the most predictive queries for a specific purpose. This method was designed to tackle this challenge as normally there are billions of queries, and this is based on 'local linear trend' where the level and time trend in the model can vary through time for optimizing the desired result (Varian, 2014).

This part described and elaborated some techniques and methods to process and analyse different types of data. After analysing the collected data, the outcome should be visualized in a clear and smart way. Thus, next part discusses the further step which is data visualization.

2.2.1.7. Big Data visualization:

Data and information visualization is crucial for easier, faster and better understanding by executives (Tam & song, 2016; Hudson, 2013). Due to the huge available amount of data and information, information visualization becomes a big challenge and not an easy task. The main purpose of visualizing information is to provide *'the right information to the right person at the right time in the right way '* (Hudson, 2013). Thus, information visualization can be defined as *"an operation where data, information and knowledge were transformed into visual forms so that the innate visual ability of people's could be made use of."* (Gershon et al., 1998).

Additionally, Tam and Song (2016) stated main 5 benefits for information visualization:

1. Understanding of large data,
2. Unexpectedly interesting ways of perceiving information,
3. Quick recognition of errors and outliers in data set,
4. Identification of patterns in data, and
5. Ease at hypotheses formation out of the data.

One of the chief findings of a conducted survey by MIT Sloan Management Review partnered with the IBM of around 3,000 executives, managers and analysts working across more than 30 industries and 100 countries, is *'Visualizing data differently will become increasingly valuable'* (LaValle et al., 2011). The respondents were asked to define the most three analytical techniques creating value for the organization at that time and anticipate which three would be the most valuable in the 24 months. The results are shown in fig.2.31.
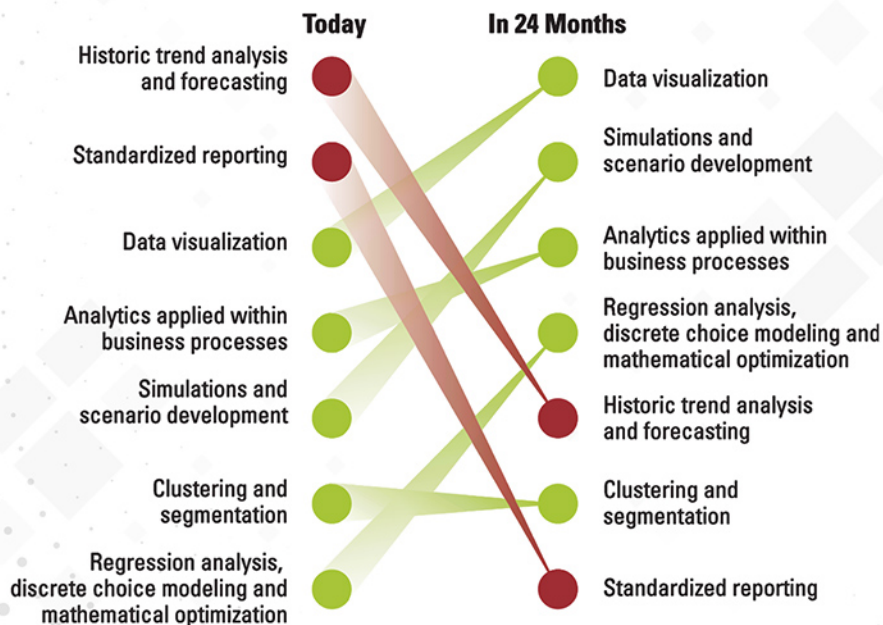
Fig.2.31. the most analytical techniques creating value for the organization (LaValle et al., 2011).

The results shows that Data visualization such as dashboards and scorecards, simulations, scenario development and progressive statistical techniques, like regression analysis, discrete choice modelling and mathematical optimization, are emerging techniques for boosting values for data-driven organizations valuable' (LaValle et al., 2011).

Data visualization tools:

Many tools and techniques emerge every day for improving the outcome of data insights and making value of the data analytics for executives and decision makers, some of them are presented in the following figure (2.32):

GEPHI THE OPEN GRAPH VIZ PLATFORM :
Gephi is an open source software for graphs and network analysis which employs 3d render engine in real-time for accelerating the exploration, and gives the ability of spatializing, filtering, navigating, manipulating and clustering

RAPIDMINER DATA MINING System:
is an open-source system for data mining and stand- alone applictaion for data analysis.

SENCHA EXT JS:
is an "Enterprise grade JavaScript Framework" which offers a progressive and attractive charting and graphing potentials for data analytics

D3.JS DATA-DRIVEN DOCUMENTS:
is a JavaScript library for maniputing documents based on data. And thus through using HTML, SVG and CSS.

DATA VISUALIZATION TOOLS

HIGHCHARTS:
is a charting library which is written in pure JavaScript, and proposes intuitive, interactive charts.

RAPHAËL:
is a small JavaScript library which aims to simplify your work with vector graphics based on using the SVG W3C Recommendation and VML for developing graphics.

VISUAL.LY :
uses data visualization and infographics for visual storytelling which can enhance communicationa and overall performance.

TABLEAU:
is a data visualizing software which allows you to analyze data virtually in order to produce highly interactive graphs and dashboards in minutes.

Fig.2.32. Data visualization tools (Own illustration based on Bastian et al, 2009; Hudson, 2013; Heymann, 2014; Beimer, 2017).

2.2.2. From Big Data into Decisions:

In the business world today, organizations rely on the so called HIPPOs –the highest paid person's opinion- in their important decisions, due to their expertise and track records (McAfee & Brynjolfsson, 2014). Accordingly, it is obvious that people still rely much more on experiences, opinions and intuitions rather than data, despite the vast available amount of data (McAfee & Brynjolfsson, 2014). It can be logic if data are scarce, too expensive, or not digitally available, but big data addressed new managerial revolution for companies to rely on data in their decisions, especially in the current turbulent environment. Actually, it doesn't mean to completely erase human insights as they are also important to be combined for validating the outcome of the big data analysis and drawing some future scenarios. In other words, their role is different in the big data era. Computers can give you answers but cannot formulate the question which is the new role of HIPPOs. In that sense, executives should change their culture to ask and address the most important questions to assess the analysis of data, such as, *"what do the data say?; what kind of analysis were conducted?; how confident are we in the results?, etc."* (McAfee & Brynjolfsson, 2014).

2.2.2.1. Five rules to transform big data into decisions:

The principle idea is to transform our way from prediction to experiments (we learn things by running experiments) which turns our firms into data driven mind-set.

Andreas Weigend - Former chief at amazon, author of data for people and founder of the social data lab- described five rules to transform big data into decisions during his KEYNOTE session in the Big Data Expo in Utrecht (2017):

1. Start with the question, and never start with the data
2. Write down your fitness function To make the implicit explicit and help people to understand what they are doing and evaluate them ,such as, recommendations.
3. Experiment: Launch and learn
One of the advantages of the internet is that we can do experiments in minutes instead of the traditional ways which take months, and we don't have to deal with samples, but we can know who the individuals are by having their personal information.
4. Respect and empower your customers:
For instance, Companies are making money now by reducing the data barriers.
Respecting customers in terms of making data easily accessible, enabling people to judge the product (reviews) and giving the retailors the feasibility on the shelves
5. Embrace transparency by allowing customer to review on their purchases as a lot of people now decide on reviews (data) and building tools allowing people to access these data.

Moreover, he added a bonus principle:

6. Collaboration between people and machines (Artificial intelligence):
"Let people do what people are good at .. let machines do what machines are good at and don't confuse the two"
"what we are in the game we are in, is not a race against the machine but we are in a race with the Machine"

Thus, in order to be transformed into data driven organization we need main four sets (Weigend, 2017):

1. Data-set: gathering and collecting possible data as will be discussed in the following part.
2. Tool-set: systems, engines, soft-wares, etc.
3. Skill-set: the ability of individuals to use those tools.
4. Mind-set: believing in data and its value.

2.2.2.2. Stages of supporting the decision making process:

The competitive, fast and turbulent environment requires firms to take faster and more accurate and efficient decisions which could be done through an automation process via analyzing big data using smart systems. Due to the fact that the quality of any decision making process is based on the rule of 4F; Focus, Fast, First satisfy the need and Flexibility (Kościelniak & Puto, 2015). Thus, the current big challenge of managers is to find a lot of information for their decisions, and as illustrated before data is the row material of information and following a data integrated management approach. After acquiring this big amount of data, the following stage is to know how to use them efficiently for better decisions. According to Kościelniak & Puto, (2015) there are four stages to support the decision making process based on their research and conducted interviews as shown in fig.2.33.:

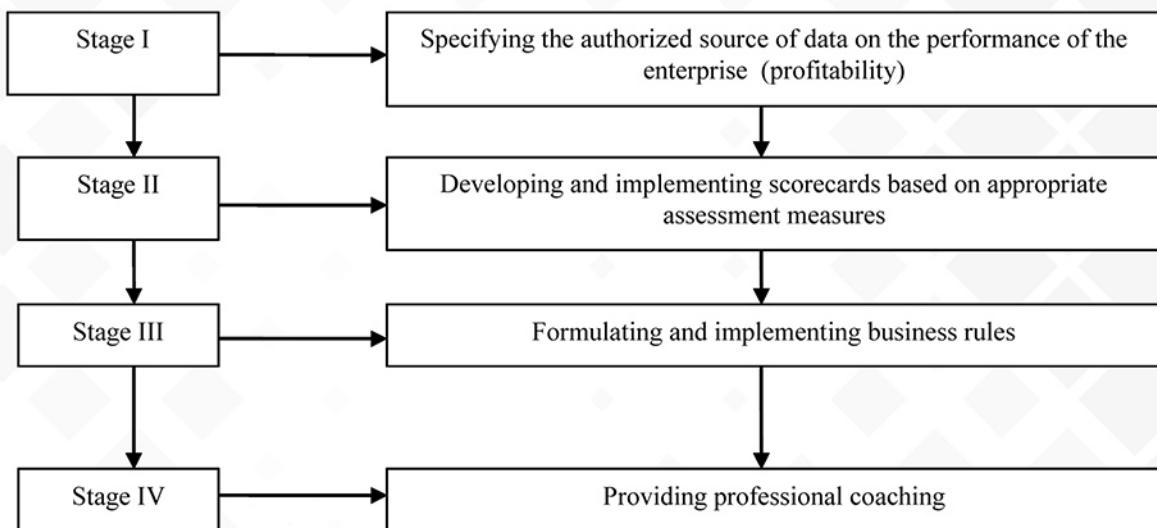| Stage I | Specifying the authorized source of data on the performance of the enterprise (profitability) |
Stage II	Developing and implementing scorecards based on appropriate assessment measures
Stage III	Formulating and implementing business rules
Stage IV	Providing professional coaching

Fig.2.33. Stages of the decision-making process based on the market data set (Kościelniak & Puto, 2015).

The first stage requires building one data engine that can be used in preference of any project. In the second stage, a scorecards should be developed and updated for individuals in order to assess the scope of control for each employee and feedback from managers. The third stage is conducted to formulating business rules about how to operate in specific situations which is a main driver for getting cheaper decisions as there is no need for a lot of expertise. The final stage concerns providing professional coaching for supplying data on the performance, measures and score cards, for increasing the efficiency of each employee.

2.2.2.3. How to adapt big data strategy:

Creating a Data driven business model (Analytical model) requires 5 major dimensions (Schalekamp, 2017):

Strategy   People   Process   Data   Technology

1- Strategy: creating an analytics strategy. The organization should have clear vision about what it means to be insight driven organization for the business, what should be achieved, what exactly their ambition level is (Fig.2.34.), which analytical services they want to deliver and how much they are willing to pay. As, it is always a trade-off between ambition versus return, besides considering the most optimal organizational structure that best fits their vision.
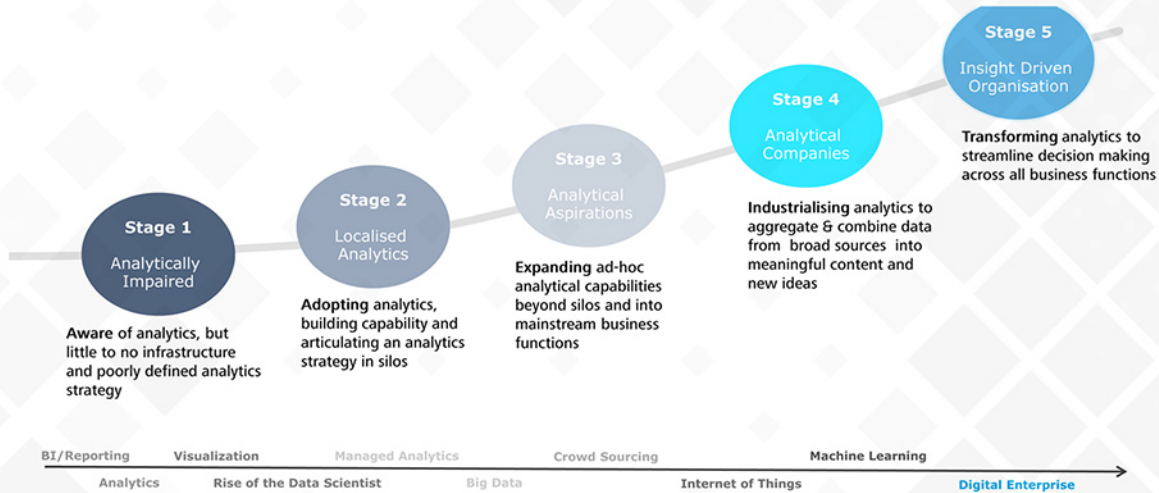

Fig.2.34. The ambition levels of adapting big data (Schalekamp, 2017).

2- People: the organization should acquire the right people at the right time in the right place to take the right actions, and combining both technical analytical specialist and business specialist. Bridging those two areas are the key of making the model works. Fig.2.35. describes the different skills and tasks of technical and business people besides the purple people who combine both knowledge and are essential for the big data era.
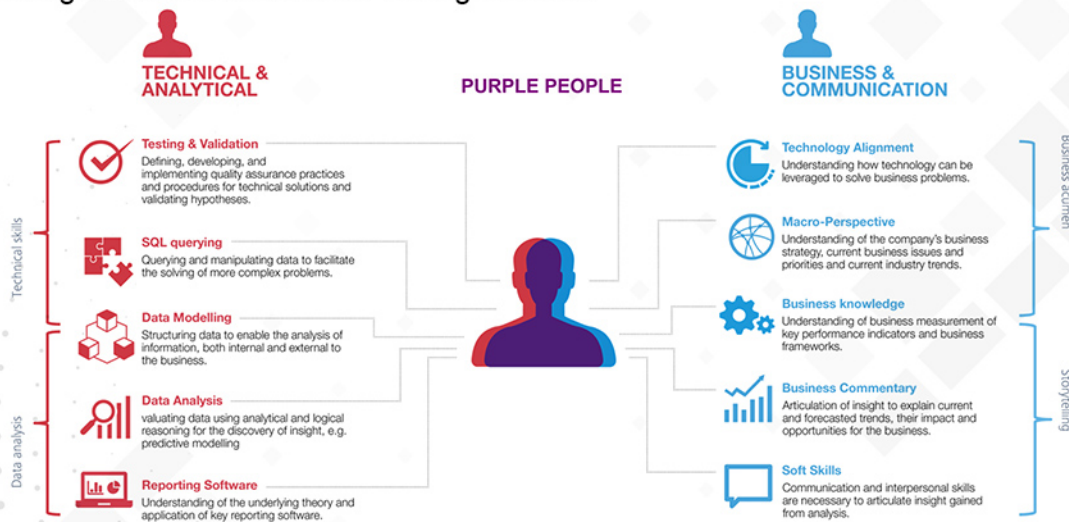

Fig.2.35. Skills and tasks of different type of people within the organization (Schalekamp, 2017).

3- Process: should be designed accurately to provide agility, priority and flexibility. fig.2.36. shows prioritization based on complexity and impact.

Fig.2.36. Complexity- Impact matrix (Schalekamp, 2017).

4- **Data**: is an asset and raw material for data driven business.

5- **Technology:** developing integrated technology infrastructure and architecture that support the long term vision of becoming insight driven organization. many technologies are available but the key issue is to find what best suits the organization as shown in fig.2.37.
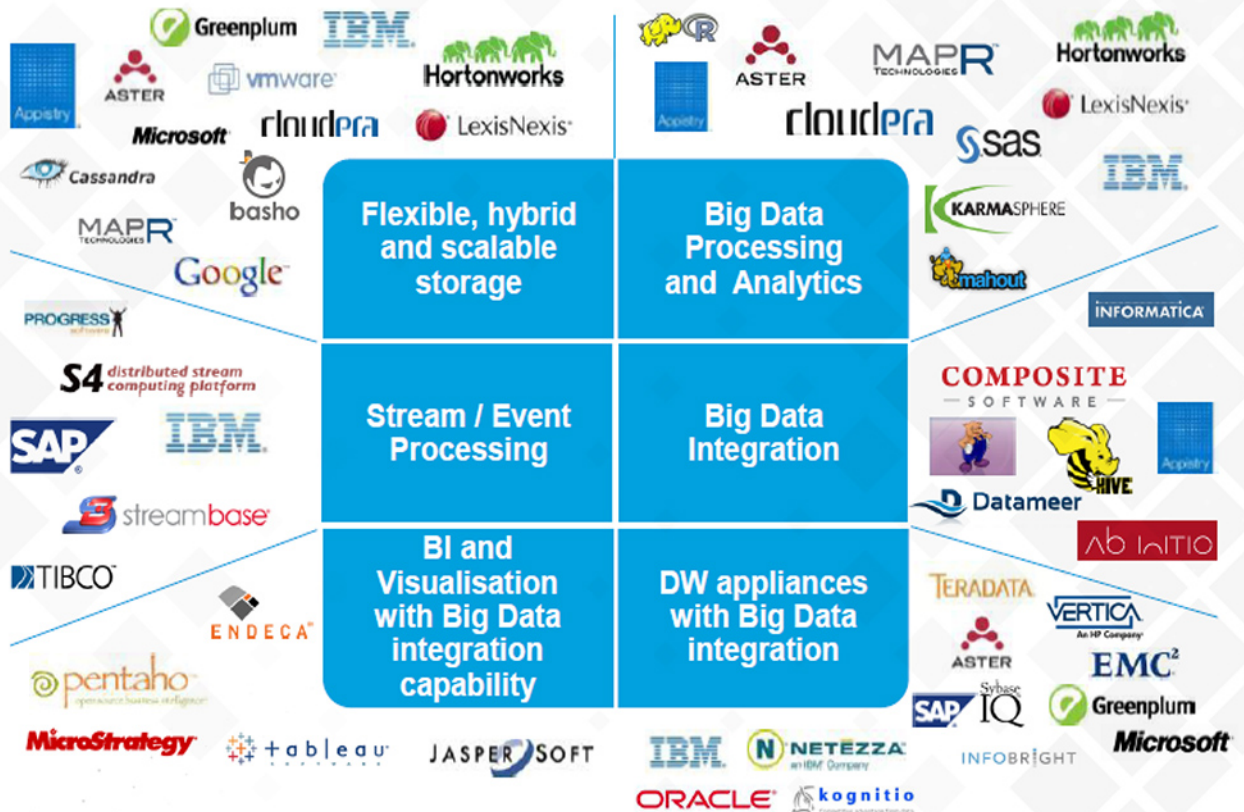

Fig.2.37. Some available technologies and tools for big data (Schalekamp, 2017).

According to Miloslavskaya & Tolstoy (2016), there are some characteristics to deal with big data:

1- Be accurate: by getting data from reliable and trusted resource.
2- Be Timely: by being up to date in reflecting.
3- Be comprehensive: by using a flexible, integrated and clear model.
4- Be tailored: selecting the related data to the business.
5- Be relevant: data should be applicable and useful to the organization and their business.

2.2.3. Benefits of big data in real estate:

"*Nobody really wants big data, ... what they really want is big impact and big results*" Micheal dell, Dell corporation (T.V.G., 2012).

This statement shows that we shouldn't really focus on the size of data but how can we turn this data into value for our organization, it is about what we can do with this data. This part addresses the main benefits of big data in decision and real estate domain.

2.2.3.1. In real estate in general:

Real estate in general can benefit from big data in different areas such as:

1- Property management:

The ongoing maintenance of rental properties counts large portion of any business operation. With big data, monitoring the performance of any building , such as air pressure, room temperature, home appliance malfunction and internal environment, becomes easier through mining the extracted data from sensors which ease the property management as well. This can optimize utilization of resources, reduce the energy waste, prevent maintenance and save money (Chemitiganti, 2017).

2- Portfolio management:

The vast availability of data could be added to the existing portfolio management and predictive models to perform more efficient such as: demographic data, macroeconomic factors, etc. (Chemitiganti, 2017). Having all this data allows manager to have a holistic overview on their portfolio and determine the consequences of any change of the interest rate for example on the exposure of their portfolio, default rate, cost picture, optimal times to buy and sell, etc., which could result also on hedging against any inflation or downside (Chemitiganti, 2017).

3- Smart Marketing:

Smart marketing is a hot trend related to Google-like searches which has the ability of connecting potential buyers to products and sellers around the world in minutes (Tobin, 2015; Piletic, 2017).

Every activity using smart tool (such as smart phone or computer) provides retailors with vast amount of data (Tobin, 2015). This activity can simply be a credit card swipe or a mouse click (Tobin, 2015). By mining this data, real estate companies can find out new buyers, tenants or investors (Tobin, 2015).

E- commerce or smart marketing should rely on accurate and perfect source of data for raising competitiveness for precise marketing models (Du et al., 2014). Table.2.6. Shows the application of big data in Reality marketing by different enterprises.

Enterprise	The big data resources	Marketing patterns
Xinfeng	property information, buyers' demand	create five big data application system to recommend certain houses and evaluate the housing price
CICC	transaction data in different places	CNFS real estate big data system
Realty Mogul	realty information, investor' ability	bridge opportunities of small investments between estate enterprises and investor
E-house China	historical transaction information	lead a diverse scope of services and introduce the CRIC
Haowu	buyers' personal information	establish the big data warehouse, then match the buyers' demand with the house available
Ifeng	page views of users	get their customers' demand better and market more precisely by analyzing big data effectively.
Tencent qqfangshi &Country Garden	data on social network software	the big data on Internet platform provide realty enterprises with precise marketing pattern based on habits data of users

Table.2.6. The application of big data in Reality marketing by different enterprises (Du et al., 2014).

4- Risk analysis and management:

Big data analytics is considered as an outstanding platform for calculating and determining different kinds of risks and future scenarios based on the available data (Chemitiganti, 2017).

5- Preventing money laundering:

Due to globalization and the global nature of investment funds, many illegal problems like money laundering could happen in real estate. Thus, suspicious Activity Reports (SAR) are always needed (Chemitiganti, 2017). Big data provides this type of analysis and alerts owners or institutional investors at the right time (Piletic, 2017). Accordingly, the real estate owners of either Limited Liability Companies (LLCs) or any other partnerships or entities who purchased high end real estate using cash money should be defined and tracked in the United States with advanced data analysis (Piletic, 2017; Chemitiganti, 2017). The initial analysis in the US showed that 50% of the high end homes for $5 million and above are purchased by shell companies (Piletic, 2017).

6- Future smart cities:

In the coming years, smart cities will offer a potential and attractive investment opportunities which can offer a return of 10-20% according to RBC Capital markets (Chemitiganti, 2017). The idea of Smart Cities is developing a city that provides mobility, green technology, personalized medicine, safe services, clean water, traffic management, etc, which targets new type of client (Chemitiganti, 2017). In that sense, those cities will generate a massive amount of data that can be analyzed by landlords. The below fig.2.38. by Cisco shows what can be extracted and analyzed in a smart city.

Fig.2.38. Daily extracted data from a smart city (Chemitiganti, 2017).

2.2.3.2. In real estate investment:

In addition, different massive data is needed in real estate investment domain such as geographic location, economic development situation, urban planning and policy orientation, new developments, user preferences, sustainability measures, etc. Acquiring and analyzing this data drive investors to predict supply and demand, value the investment and make informed wise decision (Du et al., 2014). The main benefits of big data in real estate investment are:

1- Data helps organizations to be more agile, create value, efficient and flexible, grow business by allowing decision-makers to (Schalekamp, 2017):

a. Make the same decision faster
b. Make better decisions
c. Make the same decision cheaper
d. Make innovations in products and services

Make the same decisions faster **Make better decisions** **Make the same decisions cheaper** **Make innovations in products and services**

Structured interviews executives of 330 public North American companies in different industries have been conducted by collaboration between MIT center for digital business, Harvard business and Mckinsey's business technology office, in order to investigate the following hypothesis *"data-driven companies would be better performance"* (McAfee & Brynjolfsson, 2014).the results validated the hypothesis on financial and operational level, and showed that data-driven decision making resulted in increasing productivity by 5% and profit by 6% (McAfee & Brynjolfsson, 2014).

2- Big data and cloud computing improves the decision making process by finding out some hidden risks or correlations (eg. Credit/interest rate), as managing investment is about how to manage the potential risk (Kubina et al., 2015; Frank, 2017; Abuolzolof, 2016; Chemitiganti, 2017).

3- Better and informed future prediction could be achieved by integrating adequate and precise analysis on multi-source heterogenous big data for determining the probably impacts of their capital expenditures or investments (Jin et al., 2015; Kubina et al., 2015; MacMillan, 2016). Big data-based predictive analytics has been also applied in the economic development domain in order to promote the local and global economy. For example: the United Nations initiated a Global Pulse project for improving the global economy. Under this project, an emotional analysis will be held to analyze text massages by using natural-language-processing software, for predicting some economic-societal factors, such as, unemployment rate, spending cuts, disease outbreaks, etc. (UN Global Pulse, 2012). Those factors are part of the acquisition criteria as discussed before.

4- Big data gives the opportunity to access land market information that is crucial in valuation to deal with the rising land price (Du et al., 2014).

5- Collecting data about diversified investments opens new opportunities for business expansion and subsequently enormous profit through enabling new business models, products and services or developing the current products and services (Du et al., 2014; Kubina et al., 2015).

6- After the internet of things and the data revolution, much personal information becomes accessible. That personal information about people, their income, family structure, habits, customs and preferences are important nowadays to predict their purchasing intention by mining all these unstructured data 'network mapped to society' (Du et al., 2014; Jin et al., 2015). Predicting the target tenants by collecting and analyzing data about the flow of people to a specific neighborhood, their composition and movability, which is important for the investors to figure out if those groups will afford the potential rent for maintaining a positive and desirable cashflow (Abuolzolof, 2016).

7- Big data enables investors to determine the right time to invest in a property by defining all the previous economic, social and individual aspects, in addition to acting early and fast for leveraging the opportunity (Frank, 2017).

Furthermore, real-time data analysis based on monitoring technologies are essential in estimating and forecasting real maintenance cost and time by measuring the facility conditions regularly, such as, HVAC and energy performance (MacMillan, 2016).

8- Occupancy rate is an important factor that affects the return on investment. Predictive analytics enables investors to monitor it , identify its main drivers and what could be done to increase it at the future which will also boost the future cashflow (Abuolzolof, 2016).

To summarize, big data and predictive analytics enable investors to identify the financial burden of a potential investment based on modelling property appreciation, maintenance costs, capital outlay, potential tenants, demographical prime growth areas and marketing expenses, which are essential to estimate the total expenses and income for a specific investment opportunity in a certain duration (Frank, 2017).

2.2.4. Applications of big data and innovative methods in Real estate:

In terms of real estate investment, acquiring data about previous transactions, building features, personal information about buyers, economic state, etc. are important for prediction. The vast availability of data and high technologies eased this process. But on the other hand, finding useful insights and making prediction from this massive and complex data remains challenging. This part discusses some applications and methods for prediction based on data mining and innovative models.

One of the main pioneers in big data is Google. Google could analyze the stored data, mathematical methods and comparison between different factors and buildings (Du et al., 2014). By doing that, Google could estimate the supply-demand equilibrium and price index many times more efficient comparing to the government and with a fraction of their cost (Du et al., 2014). Table.2.7. shows more applications of big data in investment.

Enterprise	The big data resources	Realty development and investment
Google	key words	estimate the demand-supply equilibrium and predict the price index in realty market by analyzing the relationship between searching key words and the data of housing price, providing strong support for rational developments
Vanke	land resources	analysis big data of land resources to deal with the rising land price
Wanda, Greenland	realty development	reveal potential value of big data for diversified investment
Fantasia Group	buyers' requirement	build community e-commerce creatively and expands its big data business to financial sector, hotel services, culture and tourism
Vanke	owners' personal information	put forward the concept of building city supporting services
Shimao Group	owners' health conditions	introduce the "health clouds" business management to its property owners for the health monitoring and advisory opinion
Goldland, Greenland	owners' personal information	open up new operations such as Intelligent City and Cloud Service
Windermere	information from drivers' GPS	plan for the potential buyer with their commute routes and the cost of time

Table.2.7. The application of big data in Reality investment (Du et al., 2014).

Based on data mining techniques, an innovative software has been illustrated by Hromada (2015) which used for real estate valuation in the Czech Republic. This software has the ability of systematically collecting, analyzing, evaluating and assessing data regarding the real estate market (Hromada, 2015). The main concept of this software is collecting as mush advertisements as possible about sales and rental transactions, store them each six months (approximately more than 650,000 new entries) in the database, and analyze them (Hromada, 2015).

The software is based on Borland Delphi for Microsoft Windows programming, and is a combination of various partial modules as shown in fig.2.39. (Hromada, 2015).
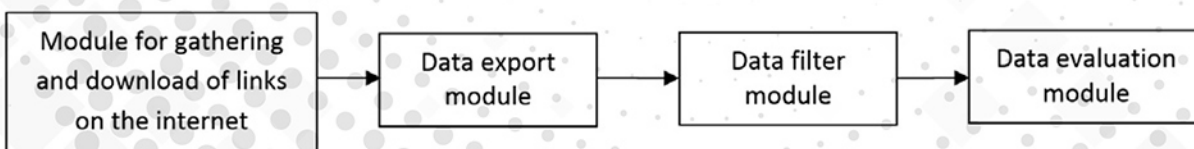

Fig.2.39. The basic structure of the software (Hromada, 2015).

For data acquisition, this software has 6 categories: Flats for sale, flats for rent, allotments for sale, houses for sale, commercial objects for sale, commercial objects for rent (Hromada, 2015).

Another tool for real estate valuation used past comparable sales transaction on the basis of data mining, is the adaptive neuro-fuzzy inference system (ANFIS) for mass appraisal (Guan et al., 2014). This method has been proved to be superior in different scenarios and more efficient alternative than the multiple-regression analysis (MRA) techniques which has many negatives such as: nonlinearity, multicollinearity and heteroscedasticity (Guan et al., 2014).

Basically, the ANFIS model for mass appraisal is one application of the Neuro-fuzzy interference system based on artificial neural networks and fuzzy interference systems, which has been applied to many disciplines for modelling real world problems (Guan et al., 2014). The designed ANFIS model for mass appraisal is shown in fig.2.40. with its five interference layers, X_I is the new entry form the data set with n membership functions.
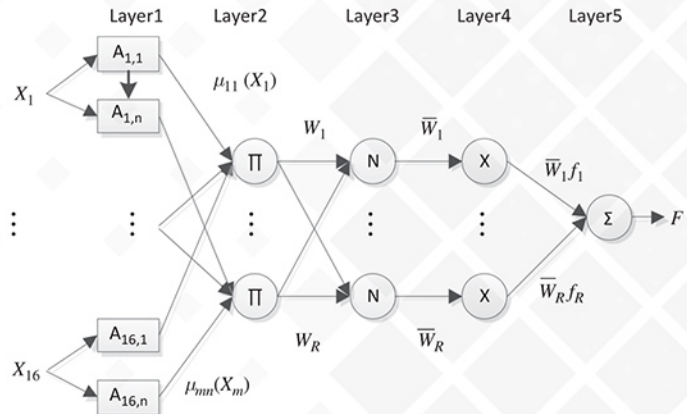

Fig.2.40. An ANFIS model of mass appraisal (Guan et al., 2014).

Guan et al. (2014) tested this model in three different scenarios and compared the results of ANFIS model to MRA models. Their study concluded that ANFIS- based approach is an innovative alternative for tackling appraisal problems by dealing with complex data and interpreting its results through fuzzy rules (Guan et al., 2014).

Additionally, predictive analytics and smart tools are also used to predict some factors that highly affected the investment decision making such as: property vacancy. A system of systems framework has been introduced by Appel et al. (2011) for addressing the housing vacancy problems by combining different systems for mainly organizations, people and technologies, based on predictive analytics and data. This system employs a specific information technology architecture as shown in fig.2.41. (Appel et al., 2011).
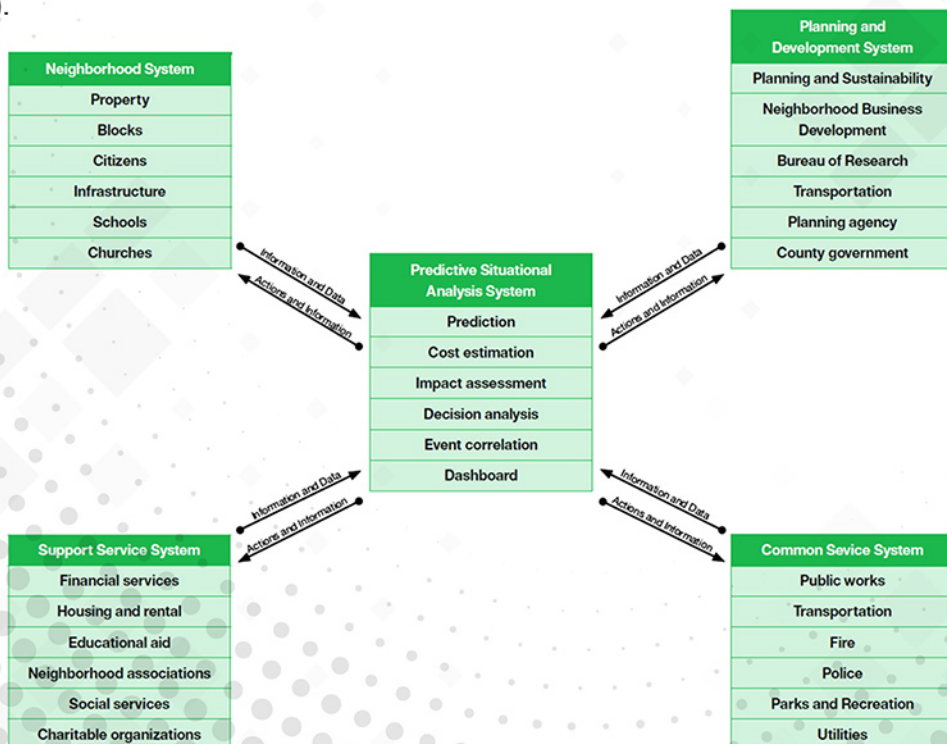

Fig.2.41. Vacant property predictive system of systems (Appel et al., 2011).

In order to simplify and automate the process for efficiency and accuracy, a predictive situational analysis has been developed (Fig.2.42.) (Appel et al., 2014). Data clearinghouse aims to normalize and automate either structured or non-structured data into clear standard forms for better analysis (Appel et al., 2014). Prediction is based on historical data for addressing the main features that causes vacancy or future vacancy risks (Appel et al., 2014). The cost estimation components estimates possible direct and indirect costs and quality of life impact as a result of expected vacancy or occupancy in a specific property (Appel et al., 2014). Decision analysis component is to come up with a decision based on combining vacancy risk scores, vacancy states, and cost and impacts of quality of life by using the impact assessment with stakeholders values and constrains (Appel et al., 2014). Event correlation is developed to supply information to the prediction components. Finally, Dashboards enables different stakeholders to see the outcome of the decision analysis, impact assessment and event correlation beforehand (Appel et al., 2014).
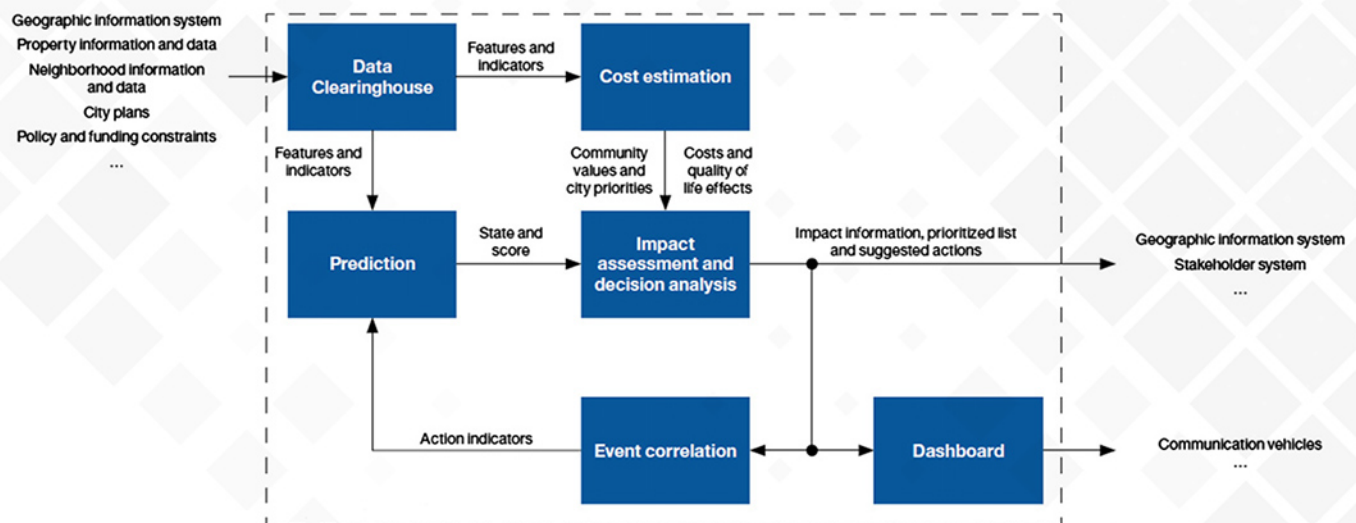

Fig.2.42. Predictive situational analysis system (Appel et al., 2011).

In short, the designed mechanism enables decision makers to transform their role from being reactive into proactive which can promote the decision making process not only for private entities but also for public and policy makers.

2.2.5. Conclusion:

This part started from broad perspective about reviewing big data, its main definitions and concepts, and what we really need from this data to turn it into value. Followed by a more specific illustration for the relation and the impact of big data on the decision making process, then on real estate in general and real estate investment management in specific.

Addressing and studying all this layers helped in building up a holistic overview in both areas and bridged the gap between big data and real estate domain, which helps in concluding the possible big data benefits and techniques that could be adapted into other real estate domain and real estate investment management for reaching more informed decisions.

In short, this chapter studied both area: real estate investment management and big data by reviewing literature, expos, lectures and some researches. The following part of the thesis will look into those topic into practice by investigating different methods in different investment firms and innovation firms, and interviewing experts. Thus the next chapter explains more deeply the research steps and methods to answer the research questions and validate the hypothesis in practice.

3. METHODOLOGY:

This chapter describes the methods of the operational part of this research in order to validate the hypothesis and build up an improved decision making model for real estate investors based on innovation and big data analytics. First, the research strategy is elaborated and the step by step research scheme, followed by the research instruments, and main techniques. Finally, a brief description is given about processing and analyzing the data.

3.1. Research scheme:

Tools & methods:
- Literature review

Problems definition: related to real estate investment
- Imperfection
- Lack of user behavior and preferences data.
- Difficulties in valuation.

Phase one

Tools & methods:
- Literature review,
- Semi structured interview with experts,
- Score-card,
- Data analysis

Acquisition Criteria for investment decisions

Collecting Data (Traditional ways)

Collecting Data (Innovative ways)

INPUT (What?)

Data Analysis framework (Big data & predictive analytics)
- Classification
- Clustering
- Regression analysis

Data visualization (Out put)

PROCESS (How & When?)

Phase two

Tools & methods:
- Delphi Expert Panel

Investment decision making model (Building & validation)

- Results
- Conclusion
- Reflection

Out-come: Better and informed real estate investment decisions
- Maximizing return.
- Risk-diversification.
- Right time to invest.
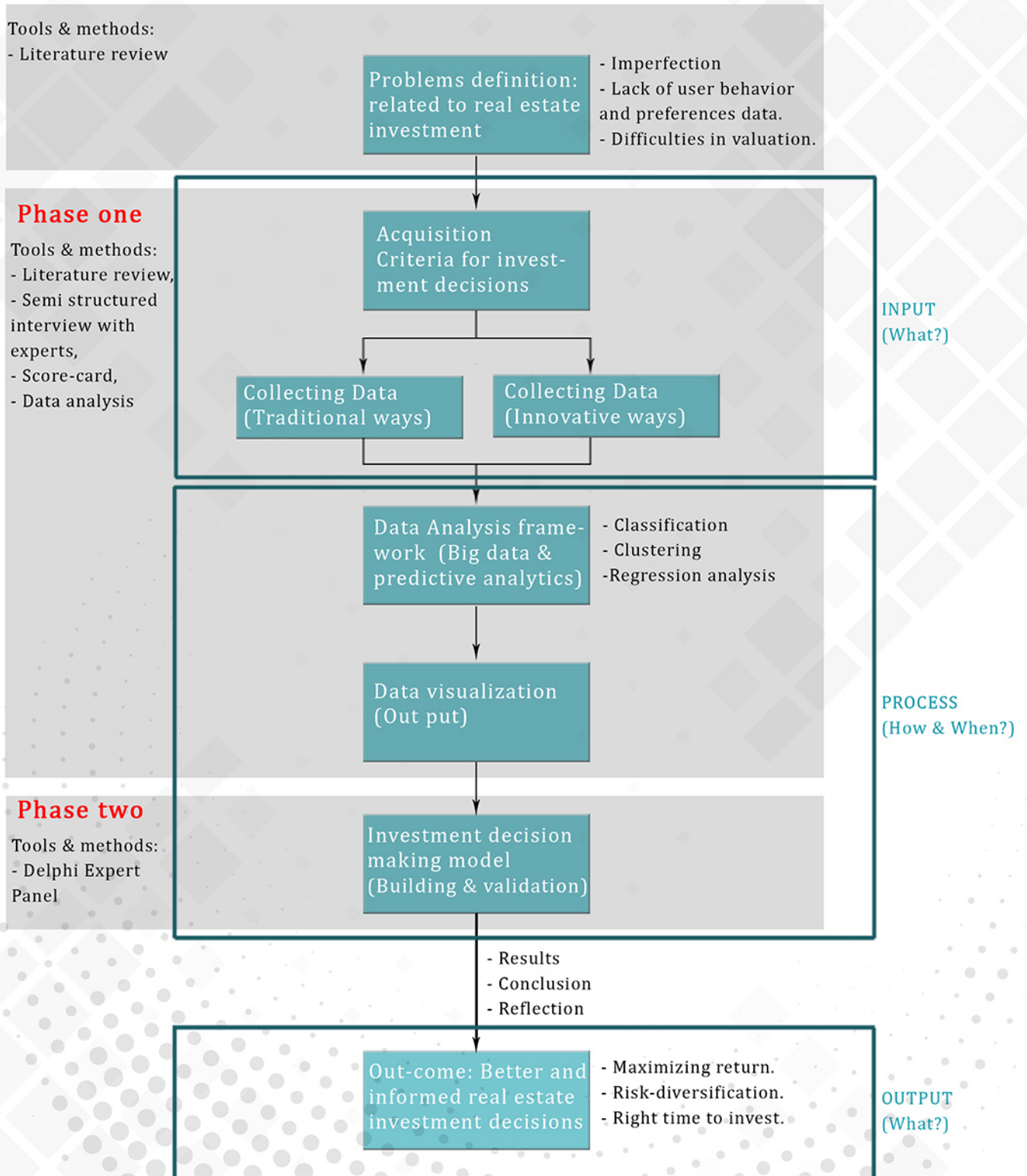
OUTPUT (What?)

Fig.3.1. Research scheme (own illustration)

The main topic of this paper is improving the decision making process in real estate investment domain for institutional investors by leveraging big data, predictive analytics and smart tools. This research is based mainly on qualitative methods and some quantitative analysis in order to achieve the aimed results and validate the hypothesis.

Qualitative research is mainly used for giving an inductive view of the relation between theory and practical research, through understanding the social world by incorporating its participants to explain and interpret the examined problem within this world (Bryman, 2016). Shortly, the qualitative research depends mostly on interviews and observations rather than collecting and processing quantitative data for generalization.

It is also important to point out that one of the main challenges of this inductive strategy is to fully understand the subjectivity of the open answers and translate it to objective terms related to the research goal for reaching the required results and answering the research questions.

Thus, the qualitative part of this research aims to develop hypothesis and a qualitative questionnaire for further testing the acquisition decision criteria that affect the rent level, the best way of collecting required data and the impact of big data implementation and predictive analytics within the real estate sector, in order to find out if it is beneficial for firms and how could firms adapt this new technology.

The quantitative methods are mostly quantification procedures. This method is employed to generalize findings about testing the impact of certain decision criteria on the rent level, the availability of data and the application of big data and predictive analytics within the decision-making process for real estate investment purpose. And this is by constructing this complex problem into a limited number of variables which leads to less subjectivity.

First, the problem is defined through literature review in order to be able to propose a solution that could tackle this problem. Second, the main indicators (variables) - that could influence the investment decision making process- are defined based on literature review and some interviews with experts in the real estate domain. Third, big data and predictive analytics are defined as a current solution and interviews, case studies and surveys with experts are held and analyzed in order to test those variables through traditional and smart methods as an input data. Fourth, the appropriate big data platform and methods for real estate are defined and analyzed. Fifth, a frame work (Model) for decision making process based on big data smart tools and traditional methods is developed and validated by experts.

This research is considered empirical research that aims to find out an appropriate framework for decision making process in real estate investment industry, by building up a hypothesis and validating it through the following research instruments. The main goal is adding to the current knowledge of real estate investment management for promoting the decision making process.

3.2. Research aim:

This research aims to find a solution for tackling the main problem of the real estate market as being an imperfect and complex market by basing the investment decision process on data instead of guesswork and wrong assumptions, and helping to achieve the current demand of business and organizations for being agile, smart and creating value, through making better and faster decisions. The main idea is finding out how to leverage big data, predictive analytics and smart analytical methods in favor of real estate investment management. In short, it is about transforming the real estate firms into data-driven organizations using smart tools. The outcome of research will be a real estate investment decision making integrated model which helps to achieve more informed decisions using the current innovative and smart tools of the big data era.

3.3. Research instruments:

This research makes use of mainly qualitative research, in addition to some quantitative research tools. First of all, the literature is studied in both area real estate investment management and big data. This literature study is important for bridging both areas by illustrating the possibility of tackling the main problems in real estate investment domain. Then, a process framework for decision making is developed to conclude the outcome of collected data in a structured way.

Literature study and review

The literature review describes both areas: the real estate investment management and big data, in order to review the current problem and methods in real estate market, current and innovative appraising methods, recent findings, and tools within big data that can be adapted to the real estate investment decision making process.

Interviews

Interviews with professionals and experts are the main core of this research for finding the appropriate criteria for decision making process and what are the benefits of big data and predictive analytics in the area of real estate investment. Then the developed model will be also validated by interviews with experts based on Delphi Expert Panel methods. Those interviews and discussions are also important in order to understand how it really works in real practical life.

Analysis of yearly reports

Official documents derived from the state, official documents by private reliable entities, national and international reports, and some virtual documents such as, websites and blogs. Those reports and documents are important for examining the future trends that could affect the office market which are necessary in building up future scenarios and reviewing some results of official surveys that could help in validating the research hypothesis about the big data, office market and the office space.

Case studies

Some companies that developed tools and platforms for real estate based on big data and smart analytics will be reviewed as cases for this research. The main mission, goals, values, models, tools and platforms of those companies are discussed, in order to understand the main benefits and challenges of adapting and using big data, and how can we make use of those tools in the real estate investment domain. The integration of different smart platforms and tools are the main concept of building the innovative decisions making model for real estate investment.

Additionally, reviewing feed-back of people working for those companies is also crucial for deeper understanding and also elaborates the journey of data-driven transformation for real estate organizations, through simulating a real situation from practice to test and validate the main hypothesis and findings.

Exhibitions and Events

As big data and predictive analytics are new trends within the current digital age, it is important to attend some exhibitions, events and workshops in order to broaden my perspective and gain more insights in that field. Gaining the knowledge about how those methods and tools work, gives me better opportunity to develop a holistic overview and reflection.

3.4. Data source:

The data for this qualitative research is collected from interviews and different documents and reports: official documents derived from the state, official documents by private reliable entities, national and international reports, and some virtual documents such as, websites and blogs. This data is analysed with the interviews and other cases for building new insights about the research topic, generalizing the outcome and answering the main question of this research.

The main reason of using official documents and companies' websites is to assure the quality and significance of the documents which can be explained through main four terms: authenticity, credibility, representativeness and meaning (Bryman, 2016). Those materials should be also readable, not only written specifically for the purpose of the social research, available for analysis and relevant to the social research problem (Bryman, 2016).

3.5. Research techniques:

The operation (practical) part of this research is divided into two main phases as shown in fig.3.1.:

3.5.1. Phase one:

Description: this part investigates the input and the different components of the real estate investment decision making process and model.

Methods: Semi-structured interview, score-card and reviewing cases and reports.

Qualitative interview (semi-structure or unstructured) reflects the interviewee's point of view and experience which is mainly related to the researcher concern, especially in explorative studies as it give more insights into the subject (Bryman, 2016). Thus, the qualitative interview is more flexible as it provides the ability of adding some related question during the interview for deeper understanding, which is more suitable to such a research as it tends to explore the new technologies within the market.

This part conducts a semi-structure interview by designing a list of questions as a guide during the interview, which could also be adapted according to the interviewee and the time.

The designed semi-structure interview (Appendix.A.& B.) contains 3 parts:

1- **The decision making process**: to investigate the process in practice by different investment firms. Some decision making models from theory are shown to the participants for validation and designed flashcards with steps are provided to ease defining the process in this limited time.

2- **Investment decision making criteria (Acquisition criteria)**: to investigate the current acquisition decision criteria that affects the rent level of the office market in the Netherlands and how they can be better collected. Additionally, a score-card (Appendix.B.) was designed to check the impact of different criteria from theory (table.3.1.) on the rent level of the office market now and in 10 years and whether they are available or not.

3- **Big data and smart tools**: to get more insights about big data, smart tools, their benefits, challenges, techniques and their impact on the office market and the real estate investment industry.

ECONOMIC FEATURES	LOCATION FEATURES	BUILDING FEATURES		CONTRACT FEATURES
1- Vacancy Rate. 2- Gross Domestic Product (GDP). 3- Absorption Rate. 4- Office stock & supply. 5- Office Employement Rate.	1- Distance to CBD and important places. 2- Distance to public transportation and railways. 3- Distance to High ways (Road infrastructure). 4- Parking. 5- Charisma of surroundings & Environmental amenities	1-The building size. 2- Building materials and its quality. 3- Building design. 4-Building Condition: age and structure 5- Building compatibility and formity with its surroundings. 6- Energy efficiency. 7- Parking. 8- Communication technology 9- Total floor area. 10- Number of floors.	11- The percentage of common space. 12- The percentage of unused space . 13- The number of elevators. 14- Building amenities and services. 15- LFA/GFA ratio. 16- Architectural quality. 17- Lighting. 18- Privacy. 19- Ceiling height. 20- Availability of external view.	1- Contract period (years). 2- Duration of rent free.

Table.3.1. Acquisition criteria for office space (Own illustration).

Selecting the sample:

This research is investigating the real estate industry from the perspective of investors. Thus it is important to decide which people affect the investment decision making. Looking at fig.3.2. the real estate investors lie between the supply side and the demand side, and to make a potential investment it is also important to understand the demand side (End user) and trying to match the supply side with the demand side. Thus, the interviewee are selected not only as investors but also end users and people from big data companies as shown in fig.3.3.
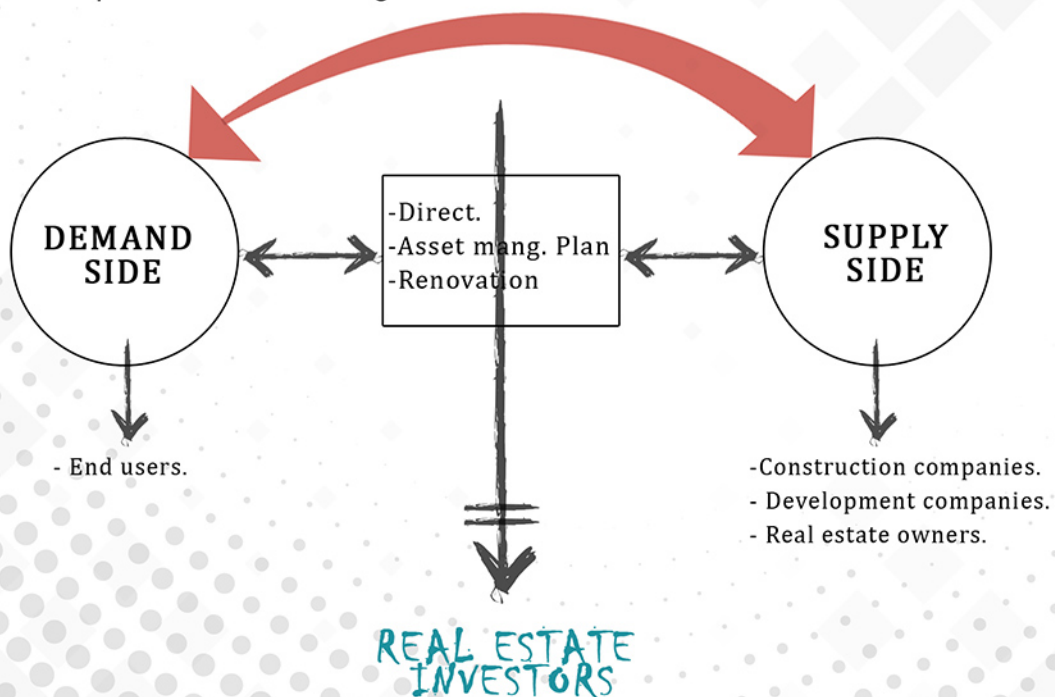
Fig.3.2. the real estate market (Own illustration).

Fig.3.3. Companies for interview and reports (Own illustration).

Data analysis techniques:

As the collected data is taken from open questions and observations, it takes the form of unstructured textual materials, which is not direct and difficult to analyze (Bryman, 2016).
The data analysis process of this phase is a combination between two methods: thematic analysis and narrative analysis.

1- Thematic analysis: is a common approach to analyze qualitative data, and thus through defining the main themes of the interview. Each theme should contain: identified category and codes, relates to the research and relates to the theoretical framework (Bryman, 2016). This process entail; reading the material, coding , elaborate many of the codes into themes, examining possible links and connections between features and write up the insights (Bryman, 2016).

2- Narrative analysis: this analysis is appropriate for the qualitative data that emphasizes stories, examples, experience or events that related to the research. This type of analysis should be conducted with reviewing documents and facts, not only the story itself (Bryman, 2016).

In this research the interview is translated into four main themes and each theme has its main keywords as the following (Table 3.2. : 3.5.) :

	Theme 1	Decision making process			
Interview/keyword	Process in practice	Excluded steps from theory	Average investment time horizon	Traditional methods	Innovative methods
Interview 1					
Interview 2					
Interview 3					
Interview 4					
....					

Table.3.2. Theme 1 'Decision making process' (Own illustration).

	Theme 2	Acquisition Criteria		'office market'	
Interview/keyword	Current Criteria (KPI's)	Added criteria in 10 years	Excluded criteria in 10 years	Data availability	Final decision maker
Interview 1					
Interview 2					
Interview 3					
Interview 4					
....					

Table.3.3. Theme 2 'Acquistion criteria' (Own illustration).

	Theme 3	Big Data & Smart tools			
Interview/keyword	Benefits to real estate investment	Main Challenges	Data 'Accurate, relevant, current'	Data accuracy assurance	Mind-set Acceptance
Interview 1					
Interview 2					
Interview 3					
Interview 4					
....					

	Theme 3	Big Data & Smart tools			
Interview/keyword	Social Media	Techniques for collecting and processing data	Techniques for analyzing and visualizing data	Changes in the decision model	The new role of appraisals
Interview 1					
Interview 2					
Interview 3					
Interview 4					
....					

Table.3.4. Theme 3 'Big data & smart tools' (Own illustration).

	Theme 4	Future trends & scenarios
Interview/keyword	Most likely future trends	The workspace in 10 years
Interview 1		
Interview 2		
Interview 3		
Interview 4		
....		

Table.3.5. Theme 4 'Future trends & scenarios' (Own illustration).

3.5.2. Phase two:

Description: this part is about developing a real estate decision making model based on the reviewed literature and the main findings of phase one and validate it.

Methods: Delphi Method (Delphi Expert Panel):

Is a significant research tool and consensus method with the aim of prioritizing topics and factors for managerial decision-making purposes by acquiring the most reliable concurrence and agreement of a group of specific experts within the research area on practice-related problem (Okoli & Pawlowski, 2004; Powell, 2003; Hasson et.al., 2000). The main objectives of this method can be summarized as: exploring specific assumptions or information through different judgments, seeking new information, correlating informed judgements in different disciplines or educating the respondents group (Hasson et.al, 2000).

The trigger challenge with this method is how to select the appropriate experts and principles and developing a communication structure during the process for reaching a valid study.

This method employs series of questionnaires with a designed feed-back and interaction procedures . The feed-back sessions between rounds are important for stimulating new ideas and adding new knowledge and experiences to the decision-making process (Powell, 2003).

Delphi methods can be represented in the following steps based on Okoli & Pawlowski (2004):

1- Designing a questionnaire.
2- Selecting appropriate and qualified group of experts for the research area.
3- Analyzing the first results and responses of the designed questionnaire.
4- Designing another survey based on the first one and its results.
5- Requesting the experts to revise their response or answering more questions in a group feed-back session.
6- Repeating the process till reaching a satisfactory degree of agreement among experts.
7- Generalize findings.

Due to the fact that Delphi study is mainly used to answer a specific complex question or problem, a general population or even a random representative for a general population might not be suitable for answering the addressed questions. Thus, this method requires selecting specific experts based on their knowledge and expertise with the research area (Okoli & Pawlowski, 2004; Powell, 2003). The recommended size of population based on literature is 10-18 experts in Delphi panel (Okoli & Pawlowski, 2004). In fact, the number of the panel is a debatable concept, as some agrees that the more experts the better, but there is no actual empirical evidence for validating that (Powell, 2003). Thus, the focus should be more on the expertise of those experts instead of the number of experts. The respondents in this method should be kept anonymous to each other's but not to the researchers during the process (Okoli & Pawlowski, 2004; Hasson et.al., 2000). In short, there are two main successful factors to this method: the panel size and qualifications of experts (Powell, 2003).

According to Jones et.al. (1992), Delphi method typically consists of three rounds (Powell, 2003) or three phases (Okoli & Pawlowski, 2004). The first round consists normally of unstructured questionnaire (open-ended questions)to give more freedom and flexibility for participants to reflect and explain the investigated topic (Powell, 2003). The qualitative analysis results of the first questionnaire are the main base for subsequent rounds which aim to quantify the main findings of the first round through more focused structured questionnaire (Powell, 2003). The data will be analyzed by using ranking and rating techniques , in addition to show the means and dispersion of scores that validate the end results (Powell, 2003).

This method has been chosen as suitable method for this research for many reasons: the research aims to answer specific complex question within specific area, the number of needed experts for the panel is modest which is suitable due to the limited time, budget and experts, the flexibility nature of the method and the feed-back rounds which result in reliable findings.

In this research, two rounds are applied due to the limited budget and time of the research.
Having experts with different perspectives results in achieving better performance and higher quality and acceptable solutions compared to a homogenous group of experts (Powell, 2002).

Selecting the expert panel (the sample):

In this research the expected sample is 10 experts with different perspectives and views, and the following points should be found in each expert:
    1- Area of expertise: real estate investment management (office market).
    2- Region: the Netherlands (Randstad area)
    3- Relevant working experience: Minimum 3 years.
    4- Obtaining current knowledge and perceptions in both areas real estate investment management and big data.
    5- Having interest in the research topic and willing to participate in the Delphi process.

Ten professionals are selected based on the previous criteria from 5 main firms from the first sample group shown in fig 3.3. The five main companies are: Bouwinvest, Carin real estate, CBRE, Spring real estate and Bnp Paribas real estate.

Data analysis techniques:

The first round of the Delphi process conducts qualitative data which requires content analysis techniques by using qualitative software such as: Nud*ist or Ethnograph (Hasson et.al., 2000). After collecting the data from the unstructured or semi-structured interviews at the first round, the data are classified and organized into groups. Afterwards it is reviewed by the respondents again to make sure that it is fairly represented.

The subsequent rounds of the Delphi process are reflection sessions and discussion between experts on the main findings and the integrated decision making model for validation. There are 5 sessions, each session is conducted in each selected company.

4. RESULTS:

This chapter concludes the main findings of both phases based on the conducted interviews and reviewed reports and case-studies by some companies.

4.1. Phase one:

This phase contains four main themes as described at the methodology part, each theme is analyzed based on the conducted methods and tools.

4.1.1. Theme 1: Decision making process (Appendix.C.):

4.1.1.1. Interviews:

<u>A. The decision making process in practice:</u>

The interviews with real estate professionals validated the given decision making models from theory, as most of the interviewees included most of the proposed steps from theory in building their decision making models. Furthermore, they added some steps which was not there in theory.

Generally speaking, most of the respondents started their model by the general investment strategies, decision criteria and goals, then collecting data, market analysis, followed by sourcing the product, and applying more focused analysis on the property itself till reaching the final decision as shown in (Appendix.G.).

> 'So we search for a property that would fit for our client, property research including all the tenants and the characteristics of the property. We setup a business case, that is more of this. On the basis of the business case, we make analysis that is based on the current market conditions and we collect more information about all the propositions and then you do the final return/risk assessment.'
>
> one of the repondents

Excluded steps from theory:

1- Socio-political analysis: is the most excluded step. Some respondents acclaimed that they don't do it at all and others stated that it is always there, so it is not actually part of the process as quoted by one respondent:

> 'Social-political analysis is a continuous analysis, we always have this analysis alongside the whole process, so it is not actually part of the process.'

2- Defined detailed strategy is excluded by some respondents claiming that the general strategy and risk/return preference are given by the investor or the client himself, then they set up some initial goals for the specific investment opportunity without having any detailed strategy as argued by one respondent:

> 'Step one is already known from the investor side (Risk vs return analysis)- but it is something known already for people who are within the business for long time- so they know their risk profile already. So I dun think that it is part of the real investment process.'

On the other hand, more respondents included all different levels of strategy and goals, given an example by one respondent of the different levels:

> 'The general investment strategy could be: we are opening a fund that invests in Dutch offices in cities of over 100,000 inhabitants or we are opening an European fund that only invests in retail (shopping malls, and supermarkets).
> Investor constrains are like: we have got a certain amount of money available, which is might be min. 10 million and max. 100 million. We could have constrains in terms of geographical area, not every investor is allowed to invest anywhere in the world, you need specific legal structure for that.
> Initial goals means: when do you want to acquire the capital, and when do you invest it in property, so this is like a time schedule.
> And the decision criteria could be: it has to be at least of 5000 sq.m. it has to be in a city of 100,000 inhabitants, and it has to have at least four tenants. And we need a return profile of 7%, something like that.
> The detailed strategy would then come as your work is going, and you can go more in depth and more focused on a smaller scale. '

Added steps from theory:

1- Sourcing capital
2- Sourcing product
3- Sourcing Debt
4- Business plan on the level of the property itself.

Fig.4.1.& Fig.4.2. show two of the most integrated process by two different types of investors. the first investor is long term investor who invest in core properties and uses full own equity (no debt), the second one invests in value-add properties (Equity + debt).
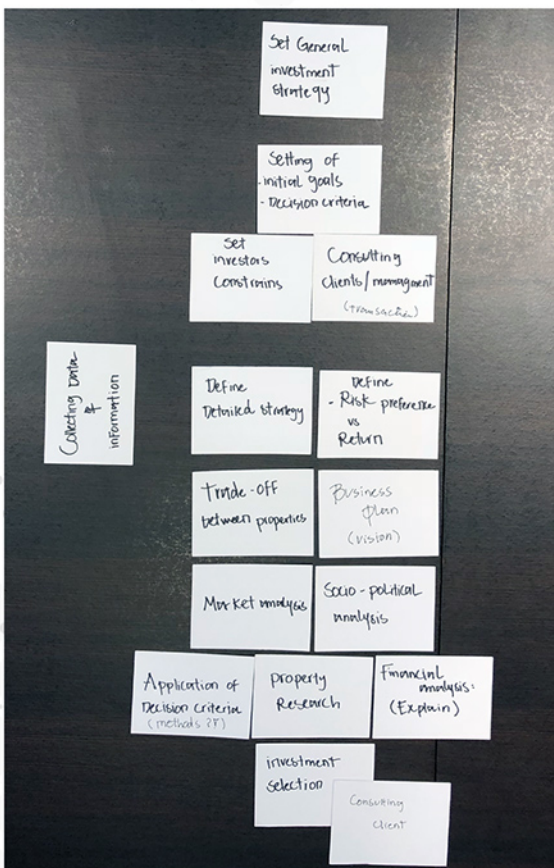
Fig.4.1. Built- decision making model by an investor (longterm - core)
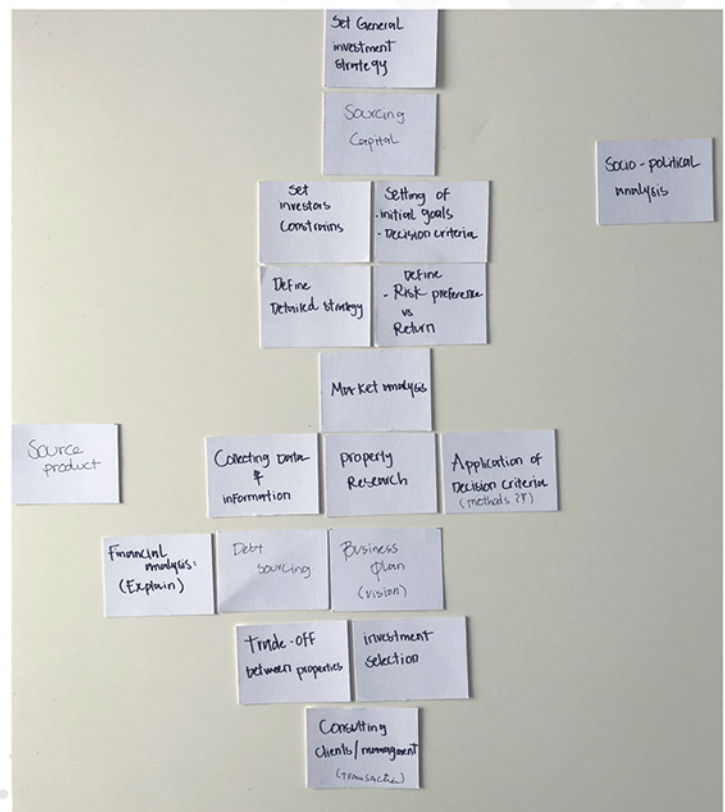
Fig.4.2. Built- decision making model by an investor (shortterm- value add)

It was also noticed through building up their models that the order of the steps can be changed depends on the size of the firm or the investment case as stated by one respondent:

'It is funny, all this stuff is happening right now in a couple of funds, it is very hard to make these in a straight line, because sourcing product is actually running in different stages (from here to here), because if we source capital from the capital markets, sometimes they ask for stuff before actually we define our risk profile, and it turns out that the property we found does not match our risk profile, then we skip it and find new one, …,'

B. The average investment time horizon (holding period):

The average holding period is based on two aspects:

1- Type of investor: opportunistic investors are willing to hold the property for less time than pension funds or insurance companies as quoted:

'It can be 2-3 years for the most opportunistic investors- for institutional investors (pension) longer than 5 years may be 10 years, insurance companies are fine with longer periods.'
'In principle we are looking for a holding period of 20 years, we are really long term investors, but we are relatively young company (this year 15 years), and some funds are relatively young, so we are actually only collecting and we don't sell that much property yet.'

2- Type of asset: 'core, core+ or value add'
Core assets normally has a way longer period than value add assets as quoted:

'The holding period depends on whether it is core, or core+ or value add. And normally the higher the risk the shorter the holding period. Could be 2 years but could be 10 years as well. core assets for example here in the south axis are owned by German investors and no need for them to dispose this assets, the holding period might be 10 to 15 years.'

C. Valuation methods:

Most organizations follow traditional ways of valuation: Net present value, Cash flow diagrams, Comparable transactions, hardcore yields in excel sheets, and some have some innovative methods only in collecting data which is discussed in theme 1 & 3 (Appendix.C. & E), as stated by some:

'For the financial analysis, you always use comparable transactions. ...So, you have the cash flow information, you know the rent, the gross income minus all the administration fees and additional cost, taxes, that brings your gross income into net income, you predict your cash flow and then calculate the Net Present Value and that is what we use.'

'You have property valuation through various ways. Let's say you have the basic hardcore yields, cashflow models, depending on the complexity, you chose what is the most suitable……. And we can value the property upon that.'

Additionally one respondent assured the necessity of having traditional excel models by stating:

'The financial models are needed always to be an excel because the institutional investors don't trust the pre written programs.'

A main challenge for valuation is 'uncertainty of perspective' (Rijksvastgoedbedrijf, 2017). To illustrate, it is about capturing the possible potential added values in different scenarios as quoted by one respondant:

'We have to do a lot of assumptions and calculations, future calculations, may be 20 years, so it is very hard, it is doable but still., and then we have to think, how much chance do we give for this transformation, .., in theory it is easy highest and best use, but in low and high scenarios what can be the highest and best use,? , Sometimes, it is very hard.'

4.1.2. Theme 2: Acquisition criteria (Dutch office market):

4.1.2.1. Interviews: (Appendix.D.)

A. Current acquisition criteria for the office spaces (Indicators) :

The following figure (4.3.) shows the current acquisition criteria for the office spaces as mentioned by professionals and some quotes from the interviews:
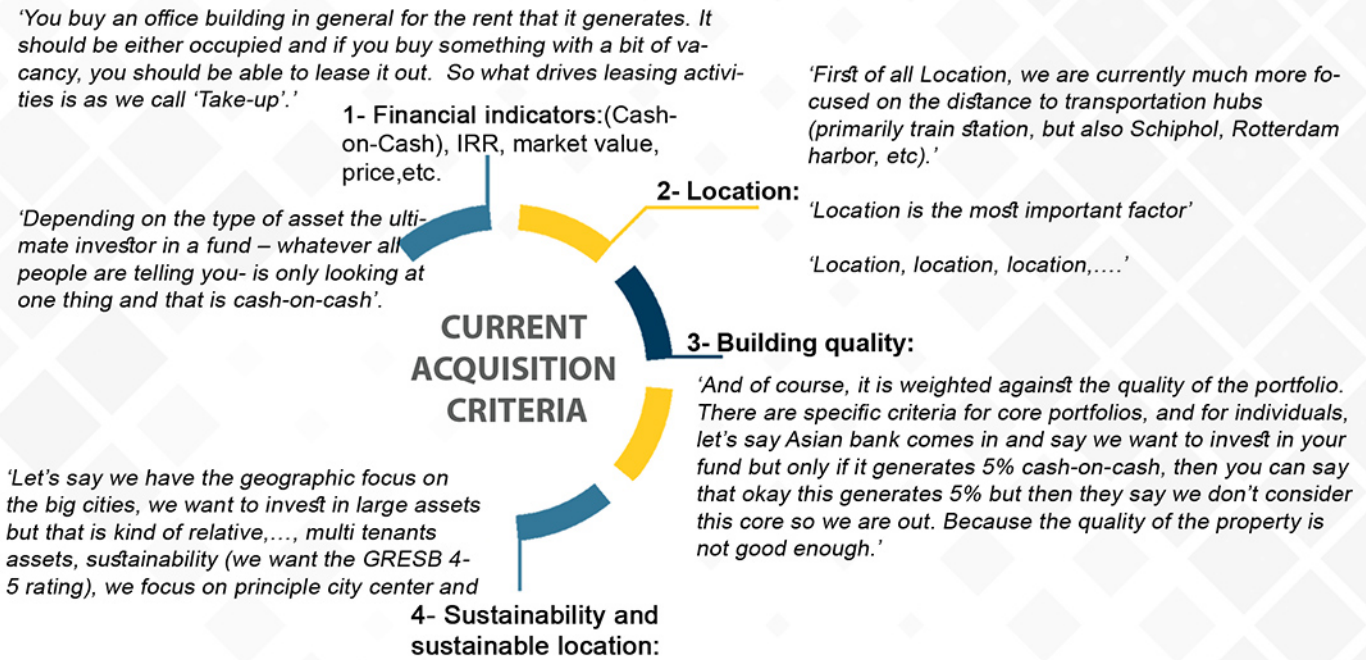
'You buy an office building in general for the rent that it generates. It should be either occupied and if you buy something with a bit of vacancy, you should be able to lease it out. So what drives leasing activities is as we call 'Take-up'.'

1- Financial indicators:(Cash-on-Cash), IRR, market value, price,etc.

'Depending on the type of asset the ultimate investor in a fund – whatever all people are telling you- is only looking at one thing and that is cash-on-cash'.

2- Location:

'First of all Location, we are currently much more focused on the distance to transportation hubs (primarily train station, but also Schiphol, Rotterdam harbor, etc).'

'Location is the most important factor'

'Location, location, location,….'

CURRENT ACQUISITION CRITERIA

3- Building quality:

'And of course, it is weighted against the quality of the portfolio. There are specific criteria for core portfolios, and for individuals, let's say Asian bank comes in and say we want to invest in your fund but only if it generates 5% cash-on-cash, then you can say that okay this generates 5% but then they say we don't consider this core so we are out. Because the quality of the property is not good enough.'

'Let's say we have the geographic focus on the big cities, we want to invest in large assets but that is kind of relative,…, multi tenants assets, sustainability (we want the GRESB 4-5 rating), we focus on principle city center and

4- Sustainability and sustainable location:

Fig.4.3. The current acquisition criteria for the office spaces(own illustration).

B. Added criteria (indicators) in 10 years :

The following figure (4.4.) shows the added criteria in 10 years by professionals and some quotes from the interviews:

'Sustainability is getting more attention, and we are currently focusing on that, because we think that this is the most natural way to do it but also because tenants,.'

'.. but I also think health in the building, well-being in the building should be much more exaggerated..'

'Soft aspects are becoming more and more important. And this something which is visible already now and will be more dominant in the future, '

2. Sustainability, health and well-being (soft aspects):

1. Social connection:

'I think that what you can do with big data and algorithms, you are able to make better, nicer, easier environment. And people don't see it as only a place to work anymore but as a social being.'

3. Sustainable location:

' .. because of the last crisis, investors are focusing more on sustainable office location, …. , so is it in a transport hub?, is it suited for a transformation in the future? , ..., '

ADDED CRITERIA IN 10 YEARS

4. Building services & flexibility:

'We used to have really large office building without any facilities,.., this is a bit out dated, but it is getting more services (,..., those services and amenities are becoming more important. There is an increasing demand as well for flexible office spaces or served office space.'

'Contracts and notice period will be more effective on the future because it is something to do with flexibility. … to give tenants more flexibility in making decisions before their agreement is expired.'

5. Political factors and policies:

'Policies of the municipality for example: they have special areas like here in the Houthaven which can be rented out only for creative agencies or companies, which creates a different market with an impact on rent. '

'…, it is quite common for small businesses to have a seven year lease which is crazy, that is huge risk you are taking upfront, so I think we will see changes in

6. Contracts flexibility, notice period:

Fig.4.4. The added criteria in 10 years by professionals (own illustration).

C. Excluded criteria (indicators) in 10 years :

Almost all respondents didn't mention any criteria to be excluded, but rather everything should be included as quoted by one of the respondents:

> 'I don't necessarily think any will diminish because all of them is like a cocktail mix that makes up the building, but, what I think is that some of them will be less important'.

In that sense some respondents confirmed that parking might be less important as quoted :

> 'the one big question that we have on mobility,...., we will try to come up with coherent idea about what the electrical self-driving car will mean for all the assets that we are investing in, so it will have an effect on the number of parking spaces, so the location in relation to parking, public transport, highways, that would be something that might shift. '

D. Data availability :

In general, not all data is publicly available or accessible especially for small firms, and the market is still not transparent enough, especially information about rental prices, transactions, end-users' preference and building characteristics. And if the data is available, it is not clean, accurate, updated nor ready to use, as quoted by some respondents:

> 'I don't think that there is sufficient data available on real estate transactions on both letting and investment transactions'

> 'Sometimes it is really difficult especially for small companies, we all have to call CBRE or big entities to get vacancy rates for example and other aspects, .., . **Real estate is still a business about knowing the right people.**'

> 'I think it is out there, I don't think it is clean, and I don't think it is ready to be used.'
> 'But I do agree that in terms of rent, transaction data are not available, there are always agents who acquire them and are not willing to share that with us. '

> 'So the market is quiet transparent in terms of each deal which is done and kind of listed somewhere but the details of all the deals are not available. '

E. The role of gut feeling and experience in the decision making process:

Some respondents acclaimed that there should be always a room for gut feeling especially for capturing the emotional side but not that high, especially if more data and information are available.

> 'I don't necessary think that there is that much gut feeling in the process. May be sometimes if you want to trade-off to very similar properties (irrational trade-off) in a very similar location.'

> 'The stock market in the US is probably the most transparent market in the world – I think- and there are still trades over there based on gut feeling. You cannot fully automate it, you can do 90% but the last 10% has to be done by people, in my opinion.'

> 'I think that gut feeling is important but we try as researchers to minimize the gut feeling ,… but I do think that estimated guess is may be 20% of the decision criteria, because it is always about the part that you cannot answer. '

Other respondents acclaimed that there is a big room for experience and gut feeling in the decision making process as there are some aspects which cannot be translated into numbers, as argued by some respondents:

> '50 % of gut feeling'
> 'some buildings can be evaluated for 20 million but can be sold for 80 million. There is a lot of emotions which are really hard to grab.'

4.1.2.2. Score-card (Appendix.I.):

As concluded from theory and elaborated afterwards in the methodology, the designed score-card to check the impact of different indicators on rent for the office market in practice is filled in by respondents (Appendix.I.), and the following are the analyzed results, the indicators has been divided into main four categories:

A. Economic features (fig.4.5.):
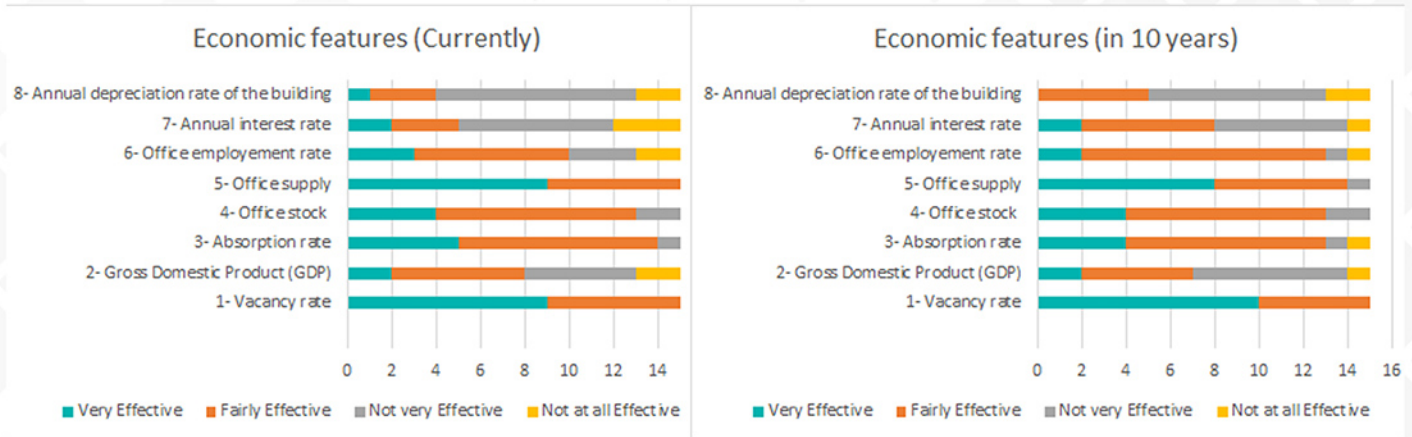
Fig.4.5. Score-card results- economic features (own illustration)

In general, The results show (fig.4.5) that the economic features are important but not very effective except for the vacancy rate and office supply, as they have the highest rating, on the other hand, the annual interest rate and annual depreciation rate of the building have not major impact on rent. It is also shown that the rating is almost the same between now and 10 years, which means that there is no major shift on the economic features in a relation to rent in the future.

B. Location features (fig.4.6.):
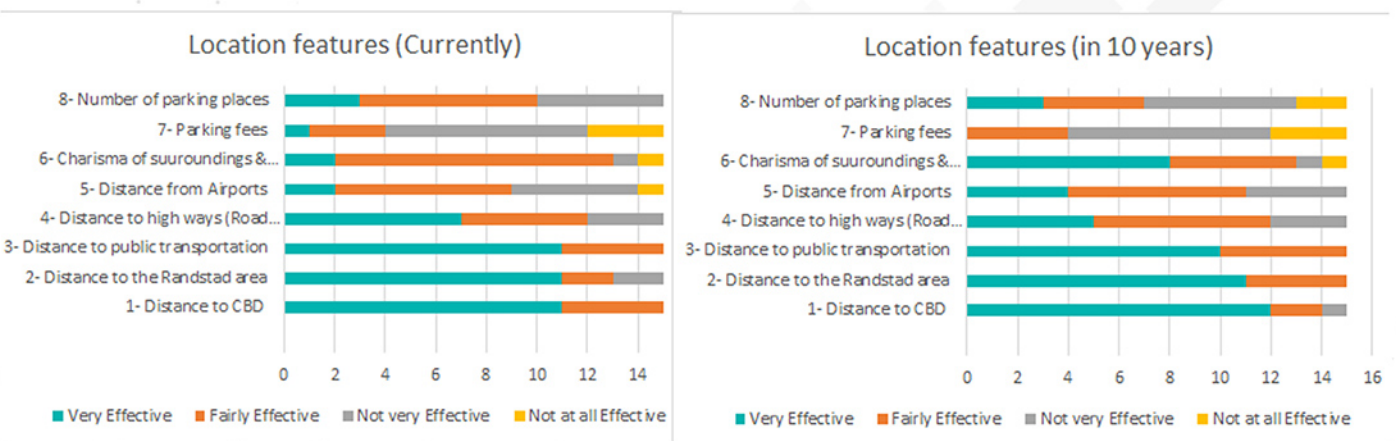
Fig.4.6. Score-card results- location features (own illustration)

In general, the results show (fig.4.6) that the location features are very important especially the distance to CBD, Randstad area, and will remain very important in the future. Charisma of the surroundings is important but will be much more important in the future. Parking has currently an impact on rent but will be less important in the future.

C. Building features (fig.4.7.):
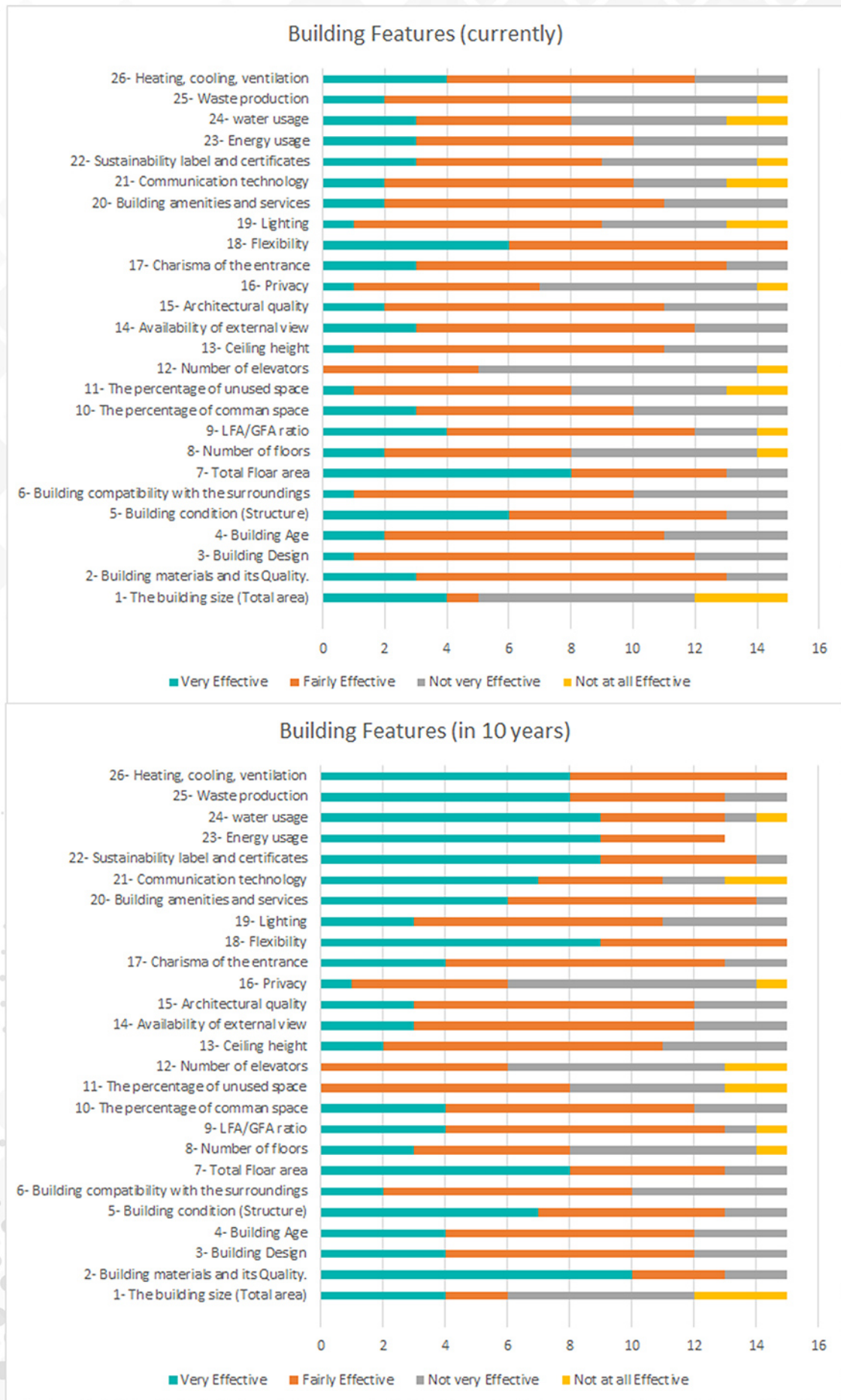
Fig.4.7. Score-card results- building features (own illustration)

In general, The results (fig.4.7.) show that the building features are important, but what is more interesting is that shift in the following indicators in the future: sustainability, energy use, water, technology, building quality and materials, and lighting, besides other soft aspects like: communication, flexibility, building computability with the surroundings and building amenities. Those indicators are expected to be very important in the future and have a major impact on the rent level of the office building.

D. Contract features (fig.4.8.):
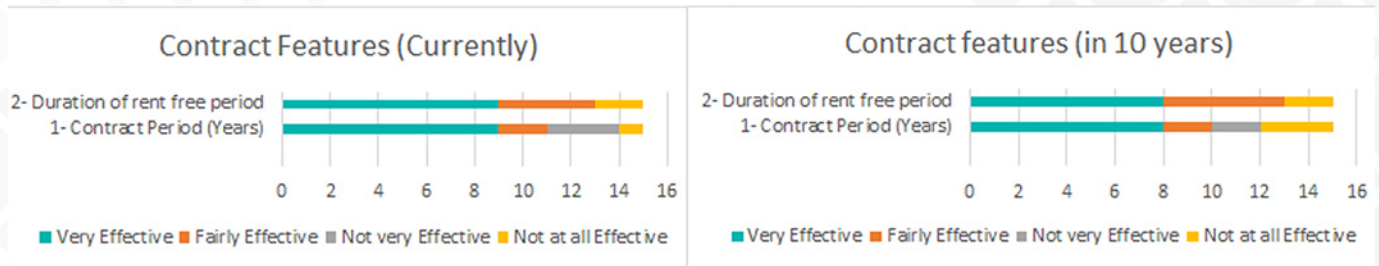
Fig.4.8. Score-card results- contractfeatures (own illustration)

In general, The results show (fig.4.8.) that the contract features are very important, and incentives will be more important in the future.

Finally, table.4.1. shows some added indicators by different respondents:

Indicator/ impact on return	3- Building Features							
	Currently				In 10 years			
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective
Building layout (Single/ multi)	1				1			
Renovation date	1				1			
Art			1			1		
Health	1				1			
Data-systems(measure, analyze & optimize)			1		1			
4- Contract Features								
Indicator/ impact on return	Currently				In 10 years			
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective
Policies			1				1	
Notice period			1			1		
Fitout contribution (investment contribution)	2				2			
break options (flex.)	1				1			

Table.4.1. Additional indicators for the office market by respondents (own illustration)

4.1.2.3. Reports:

Leesman: (Amsterdam, NL)

Specialization and focus:
The largest independent platform of workplace effectiveness data in the world.

Mission:
The main aim is examining how workspace support employee and organizational performance, in order to create an effective work environment which enhances productivity and fulfilling the primary goal of the organization. And thus, through designed online survey that contains five main area as shown in fig.4.9.

The results of the survey are used to calculate the Leesman Lmi (standardized performance indicator). Those results are processed in the online Leesman Analytics environment for assessing how to meet the employees' needs (Leesman, n.d.).

Fig.4.9. The leesman index concept (Leesman, n.d.).

Services:
1- Workplace benchmarking: Flagship Leesman office.
2- Leesman+ certification: an award for workplaces that score 70 Lmi or above.
3- Leesman consulting partner: giving advice or new insights into the current performance of the spaces for better performance.

Leesman report about workspaces:

Leesman conducted a research in seven years across 276,422 employees in 2,160 workplaces in 67 countries, for understanding the end-user perspective about the desired work space and how workplaces impact their experience for higher performance and productivity. From an investor perspective, it is also important to understand the market demand or what could be more attractive and adds value to his assets, how to capture more value.

Based on the results of the analysis and in terms of effectivity and productivity, the report argues the importance of integrating an amazing workplace culture and a great workplace with no dominance of any of them (Leesman, 2015). Big organizations always aim to create an environment that enables their employees to perform better. Thus, physical and virtual infrastructures are main factors for solving this equation. From an investment perspective, the physical factors are more considerable in detrmining the rent level. Fig.4.10. shows some physical factors and their importance for an attractive workspaces for employees.

Fig.4.10. The leesman analysis about the physical features of the workspace (based on Leesman, 2015).

Additionally, the initial results were based on the Leesman average which uses all the global data, but this huge sample could be insignificant and highly risky. Thus, Leesman+ high performance work place program classified the sample and justified the highest performing spaces for drawing more accurate conclusion. Fig.4.11. shows the top 6 differences between both analysis in physical and service features.

1 +34.6%

Informal work areas / break-out zones

Leesman Average	36.6%
Leesman+	71.2%

2 +34.0%

Variety of different types of workspace

Leesman Average	30.2%
Leesman+	64.2%

3 +33.6%

Atriums & communal areas

Leesman Average	41.5%
Leesman+	75.1%

4 +30.5%

General décor

Leesman Average	41.8%
Leesman+	72.3%

5 +21.2%

Quiet rooms for working alone or in pairs

Leesman Average	28.0%
Leesman+	49.2%

6 +20.6%

Reception areas

Leesman Average	62.3%
Leesman+	82.9%

Fig.4.11. Top 6 differences in physical and service featurs- Leesman Average vs Leesman+ (Leesman, 2015).

Main Findings:

• Communication technology has a major impact which can be seen in (WIFI network connectivity:71.6%, Computing equipment & mobile: 64.2%, remote access to work files or network 59.3%).

• Additional highly important factors: Natural light 75.5%, Air quality 70.2%, temperature control (Heating, cooling, ventilation) 79.8%.

• Parking is important but not highly effective as it scored 60.7%.

• Reception area (46%), architectural quality (general décor, 57.4), Amenities / leisure facilities onsite or nearby (46%) and office lighting (62.2%) are fairly effective.

• Common spaces: restaurant/canteen has a major impact 75%, but informal work area/break-out zones (54.9%) & atriums and communal areas (46.3%) have fairly impact.

• Variety of different types of work space are not very important (35.6%).

4.1.3. Theme 3: Big data & smart tools:

4.1.3.1. Data companies, cases and reports:

Different leading data companies in the Dutch market have been selected for different arguments as shown in fig.4.12., those platforms could improve the decision making process by providing sufficient data, algorithms and smart models. This part describes the different tools by those companies and some cases if found.
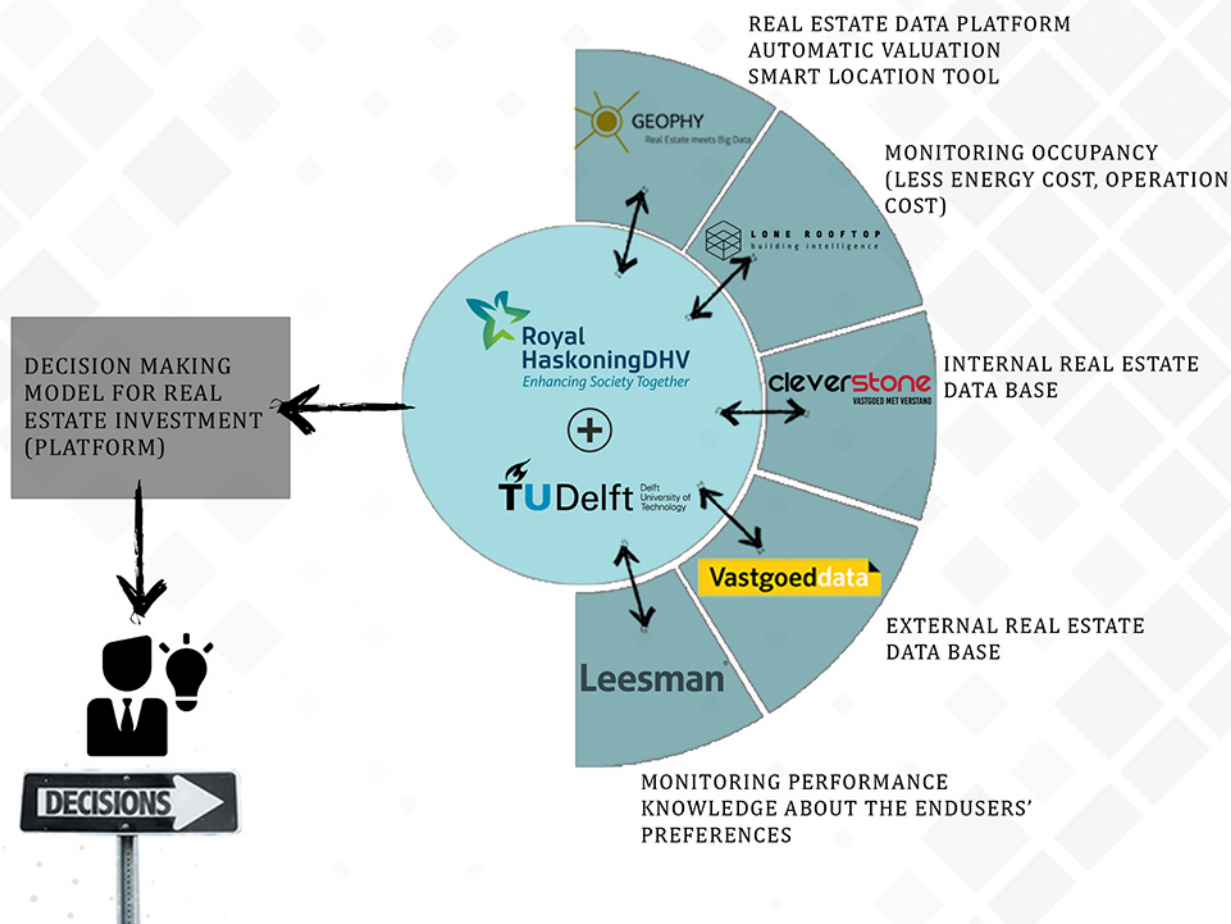
Fig.4.12. Integrated different data platforms for building better decision model (Own illustration).

A- Geophy: (Delft, NL)

Specialization and focus:
Tech company in real estate with focusing on the Dutch real estate office market.

Mission:
Creating highly accurate valuation for commercial real estate with continuous feedback loop, based on applied AI by building a data management platform in a cooperation with the largest lenders and investors in real estate around the world.

Values:
Accuracy: the accuracy of the current model is 7.9% (Median predicted value).
Real time & instant: Daily updated model with new market transactions.

Main Models of valuation:
1- Location Quality.
2- Carbon footprint: Carbon footprint model that integrates consumption data with local grid efficiency.
3- Asset Quality: Stress test model + Geophy + Macro-economic models.

Current combined data bases:
Building features + Location (Accessibility) + Transactions Data

Manual appraisal (problems):

Although real estate is the largest asset class in the world as illustrated from reports and literature in the first part of this research, the process of real estate valuation remains manual and appraisals still base their decisions on gut feeling or wrong assumptions (Cannon and Cole, 2011). The interviews with professionals showed that most of the organizations are still following the traditional way of valuation. In other words, appraisals are commonly derived from the capitalization of the net income of an asset based on yield or cap rate (NOI/ ASSET VALUE) of comparable assets or neighboring transactions (Kok et al, 2017). As mentioned by Burns - Head of business development department of Geophy- during the interview (2018) *"People always consider the value of an asset based on the cashflow and the cap rate of the building which are always very important and the cap rate"*. The main problem is that transactions of comparable assets are never correctly comparable either in time or characteristics due to the heterogenous nature of the real estate (Kok et al, 2017), which leads to determining approximate value that lag the real market value (Cannon & Cole, 2011).

Currently most appraisals use Hedonic (regression analysis) which is easy to implement and understand, but the main problem of this model is building only one predictive formula which is constant with all the variables, although many variables has non-linear relation with the rent level for example (Kor et al., 2017). Consequently, this way is not the most accurate way of determining the asset value.

Additionally, lenders and investors bases their decisions on the appraisal- based price indexes and use it as a benchmark, instead of accurate pricing data, which leads most of the time for bad decisions with higher risks, and that was the main driver for most of the bad decisions taken in the downturn period of 2017 (Kok et al, 2017). Based on the analysis of the accuracy of the U.S. commercial real estate sector (1984- 2010) which is done by Cannon and Cole (2011), appraisals are more than 12% plus or minus the actual transaction price (deviation of 12%).

Recently, more and more data about assets are available besides the great innovation in machine learning modelling and artificial intelligence which can be adapted to the real estate industry as well.

From Manual appraisal to Automated valuation:

Geophy as a company is working on fully automation of the valuation process through creating a machine-based valuation model based on the combination of practical application of big data and sophisticated modelling techniques (Kok et al., 2017).

The input data of the model contains the traditional standard demography and economic features, in addition to some modern factors such as: proximity to music events, bars and restaurants, green space and local crime incidence (Kok et al., 2017). This model uses (stochastic) decision trees which has the ability to combine thousands of variables, training and testing on randomly selected parts, in order to determine the precise predictive performance, rather than traditional hedonic models which are restricted statistically (Kok et al., 2017).

The main benefit of this automated valuation model is having a lower absolute median error (9%) and producing instant, accurate and informed value at every moment in time with really low cost (Kok et al., 2017).

Model 1: The Geophy automated valuation model (AVM) for multifamily assets in the US:

The model uses regression tree algorithm which predict continuous variables as the value of the asset is continuous. Those decision trees are able to handle categorical variables, fast even with large amount of data and easy to understand. The following is the main idea as shown in fig.4.13. (Kok et al., 2017):

1- Minimizing the variance of a regression between every set of the dependent and independent variables. (ordering the variables)
2- Each variable represents a node within the regression tree. The first node is called the 'root node': contains the whole dataset . the split point of the root node is determined by the best predictor variables through applying cost function which minimize the variance for both subsets.
3- The second layer of the tree is called the 'leaf node'. The order of importance is calculated again in this layer. The best- performing independent variable is calculated again for the split.
4- The process is repeated in all the branches until certain limit (the desired depth of the tree).
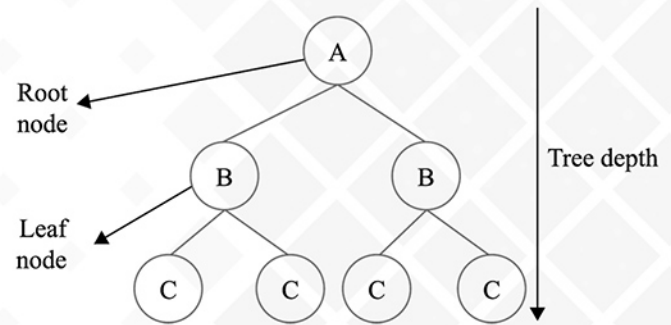
Fig.4.13. Machine Learning Model - Example of decision tree with four nodes (Kok et al., 2017).

In short, for every predictor (dependent variable) the data is split at one of the nodes of the tree based on the strength of its relation to the independent variable (the rent level) according to the following equation:

$$Node= min (Var_1, Var_2, ..., Var_m) \quad .... (1)$$

where Var_m is the variance (or standard deviation) of the explanatory variable in subsample R_m.

The downside of the decision trees is that they have unlimited vertical growth, which results in a lot of noise that leads to poor prediction (Kok et al., 2017). To overcome this limitation, multiple decision trees can be created and obtaining the average. This process is the basis of the random forest model or stochastic boosting (Kok et al., 2017).

Input variables:

Due to the fact that data availability remains a big challenge. The focus in collecting the data is on multifamily assets because their data is available. The collected information is about NOI and property characteristics.

Because not all the transactions contains the NOI information, three models are developed: one including NOI, one excludes NOI and one includes modeled NOI (using NOI model) (Kok et al., 2017). Besides, the data base was enhanced by adding detailed information on the building level (characteristics) , information on tax, and detailed locational information. Table.4.2. shows the four panels for determining the value (Kok et al., 2017).

		OLS	Random Forest	Gradient Boost	XG Boost
Panel A: Transaction Price/Unit (excluding NOI)					
	MdAPE	22.6	22.3	18.8	19.1
	R^2	0.58	0.64	0.74	0.73
Panel B: Transaction Price/Unit (including NOI)					
	MdAPE	10.8	13.4	9.3	9.6
	R^2	0.84	0.80	0.89	0.92
Panel C: NOI/Unit					
LA MSA	MdAPE	20.8	15.3	9.9	9.2
	R^2	0.25	0.62	0.79	0.78
Three-State	MdAPE	12.8	9.8	8.5	8.6
Model	R^2	0.73	0.86	0.89	0.88
Panel D: Transaction Price/Unit (including modeled NOI)					
	MdAPE	15.6	15.2	14.3	13.9
	R^2	0.76	0.78	0.80	0.82

Table.4.2. Model performance - OLS vs. Machine learning model (Kok et al., 2017).

This table shows that the machine learning model has better performance comparing to the simple hedonic model, which proves that that more innovative modeling techniques are more beneficial for the real estate industry.

Additionally fig.4.14. shows the different categories of variables and their importance to each model. And fig.4.15. shows the most important variable on the value model and NOI model but in the residential sector.

	Amenities	Census	Location Market Dynamics	Property Attributes	
Value Model A Excluding NOI	36%	7%	40%	17%	83%/17%
Value Model B Including NOI	25%	18%	33%	24%	76%/24%
NOI Model A 3 state model	50%		11%	23%	16%	84%/16%
NOI Model B MSA LA model	23%	8%	21%	12%	36%	52%/48%

Fig.4.14. Model attributes - Location vs. Property (Kok et al., 2017).

Value Model

NOI per unit
Green space within 30 min
Year of construction
Size (sq feet)
Density in 10 min
Interest rate (%)
Ratio without high school
Studio price level
Music events within 30 min
Schools within 15 min
Bars within 3 min
Employment rate
3 bedroom price level
Mean income
Water body within 30 min
2 bedroom price level
Market Health Index
S&P 500
Mortgage delinquency rate

NOI Model

Mortgage delinquency rate
Median income
Taxable rate per bedroom
Music events within 3 min
Green space within 10 min
Improvement value
3 bedroom price level
Land value
Interest rate (%)
2 bedroom price level
# of units
Music events within 30 min
Studio price level
Schools within 15 min
Bars within 3 min
1 bedroom price level
Bars within 10 min
Year of construction
Employment rate

Fig.4.15. Model attributes - Explanatory variables (Value/unit) (Kok et al., 2017).

This fig.4.15. shows that property attributes has the least important on the rent level, amenities are so important and market dynamics are also important.

Main Findings:

- Determining the market value of real estate properties is disconcerting mission which is still done by manual procedures through comparing the asset to comparable transactions and takes a lot of time.

- Machine learning , growth of data availability and advanced analytics and modeling techniques can ease the valuation process, reaching better, more accurate and faster values.

- The market value of an asset is mainly dependent on the NOI, and in case of lacking information about NOI, developing an NOI model for estimating it, leads to more accurate value.

- The automated valuation models are not only beneficial for the investors but also for the lending side with the debt coverage ratio and the loan-to-value ratio through an accurate and instant re-valuation process for assets.

- The fast, accurate and instant valuation process can open new investment and business opportunities for different entities.

- Significant education process is needed by leading investors and lenders for the market players to adopt automated valuation process rather than the traditional ways for getting faster, instant and cheaper valuation.

Model 2: 'Grapevine Dashboard' Site selection tool (Location, Location, Location)

Since Location is the most important factor that impact the acquisition process of the real estate, expecting the areas that may gentrify is critical for both investors and developers (Kok, 2017). Traditionally, site selection process uses commonly data on demographics (population, employment and income growth), but those data are not beneficial enough after selecting the city for capital allocation (Kok, 2017).

In the big data era, a lot of different layers of frequent data are available in the city level such as data on: bars, coffeeshops, restaurants, galleries, social media, Wi-Fi hotspots, etc, which can be accessed through API's and used in making data-driven & informed decisions for investors, developers and lenders (Kok, 2017).

Based on that, Geophy developed the 'Grapevine Dashboard' for Site selection:

> 'The Grapevine Dashboard pulls a vast real-time dataset of physical venues and one-off events in a city to provide a detailed view of arts, nightlife and other leisure activities. This includes the exact location of amenities like bars, cafes, art galleries, music concerts, food festivals and exhibition openings.' (Kok, 2017).

This tools enables investors to have an overview of the city and the different locations of it in a relation to their question or strategy. And this through applying proprietary methods to calculate locational proximity and venus or events to spatially rank different places across the city as shown in fig.4.16. (Kok, 2017).
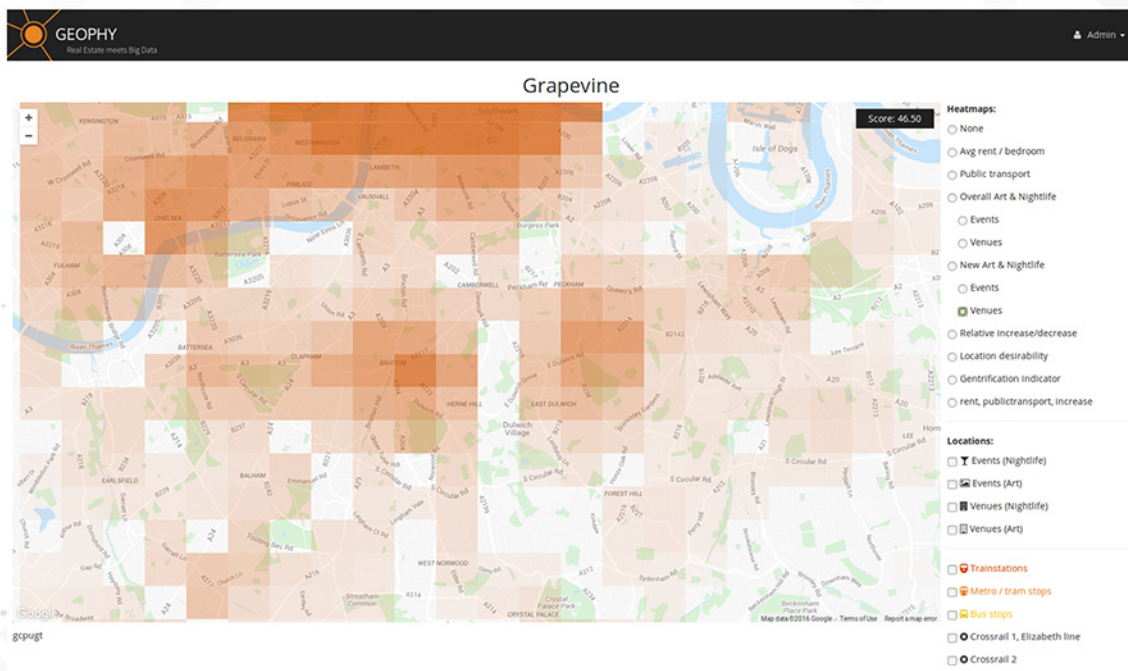
Fig.4.16. What's hot and what's not—bars, cafes and restaurants opened during the last two years (Kok, 2017).

Another advantage of the tool is the capability of chronologically analyze the data for disclosing long-term neighborhood trends. Fig.4.17. shows the last two years overall increase or decrease number of venue openings and events within an area which reflects how vibrant is an area.
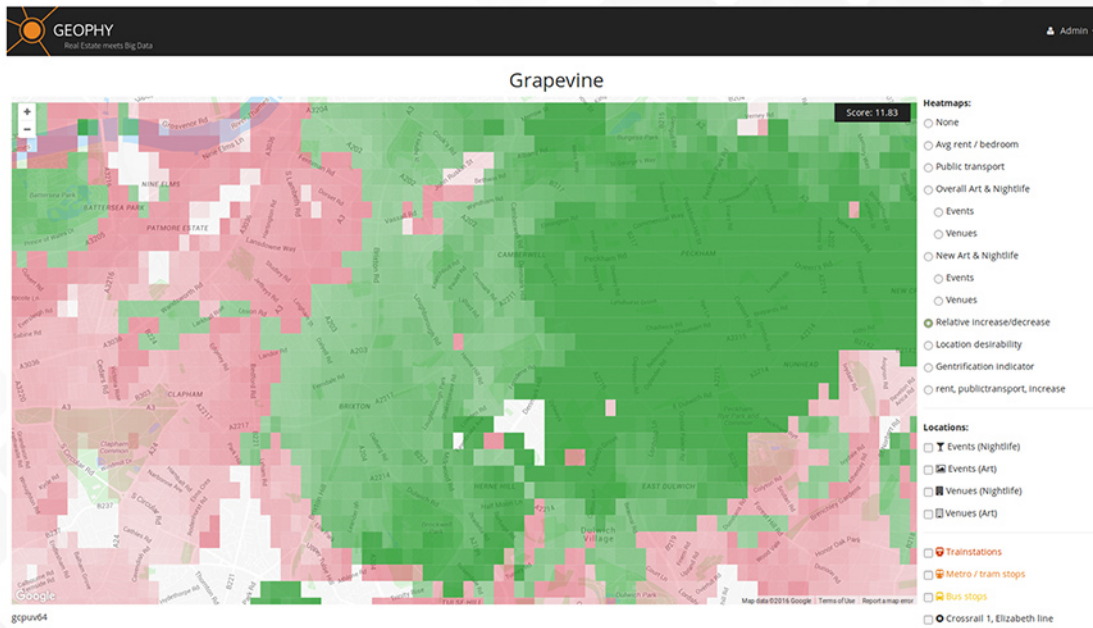
Fig.4.17. Measuring changes in local vibrancy—changes in art and nightlife events and venues (incl bars and restaurants) (Kok, 2017).

In short, the Grapevine dashboard allows us to anticipate the crucial real-time trends which are altering the characteristics and market value of an urban areas (Kok, 2017). From a financial perspective, this gentrification could be related to rental increase in addition to correcting it against macroeconomic indicators (interest rate, employment rate) as shown in fig.4.18. (Kok, 2017).
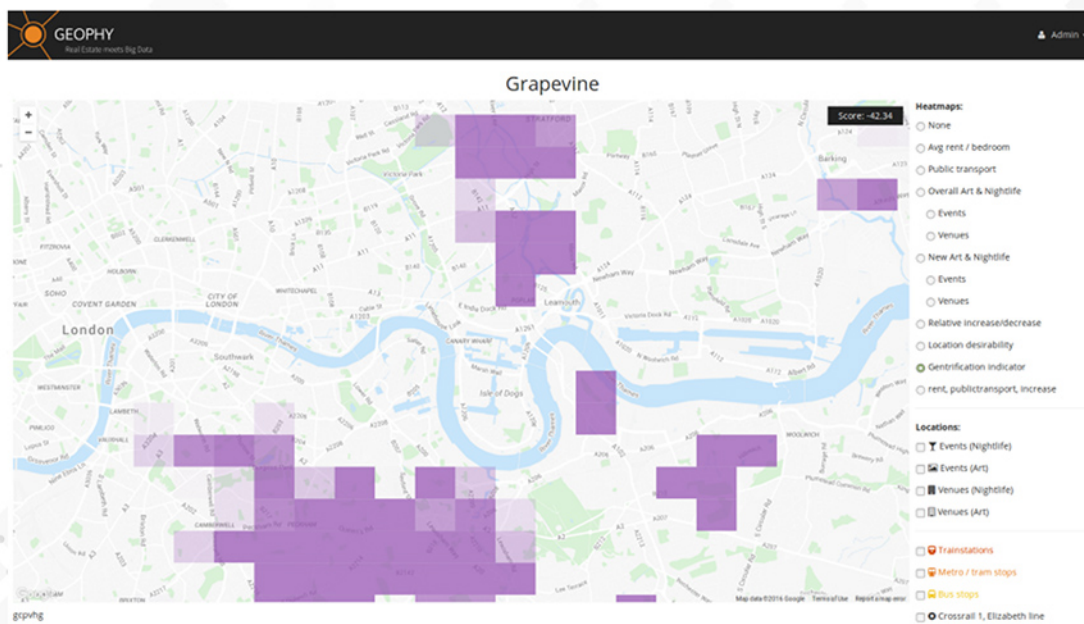
Fig.4.18. Gentrifying areas—low rents combined with a strong increase in "vibrancy"(Kok, 2017).

B- Lone Rooftop: (Amsterdam, NL)

Specialization and focus:
Realtime occupancy platform for real estate (office space).

Mission:
1- Real time occupancy.
2- Energy saving.

The created platform 'Position Intelligence Engine (PIE)' calculates the amount of people and their position within the building using the Wi-Fi and other sensors with the aim of turning the building into intelligent building as shown in fig.4.19. (Lone Rooftop, n.d.c.).

Values:
1- Hospitality
2- Efficiency: optimizing occupancy and reducing energy use.
3- Sustainability: by reducing energy waste.

Current APIs platforms for developers and investors:
1- Historic API. Providing all historical data of 1 minute and older.
2- Present API. Providing real-time data, e.g. all data that is less than a minute old.
3- Future API. Providing all predictive occupancy data from our prediction engine.

Current Partnerships :
Lone RoofTop has partnerships with leading network vendors and IT Infrastructure specialists.
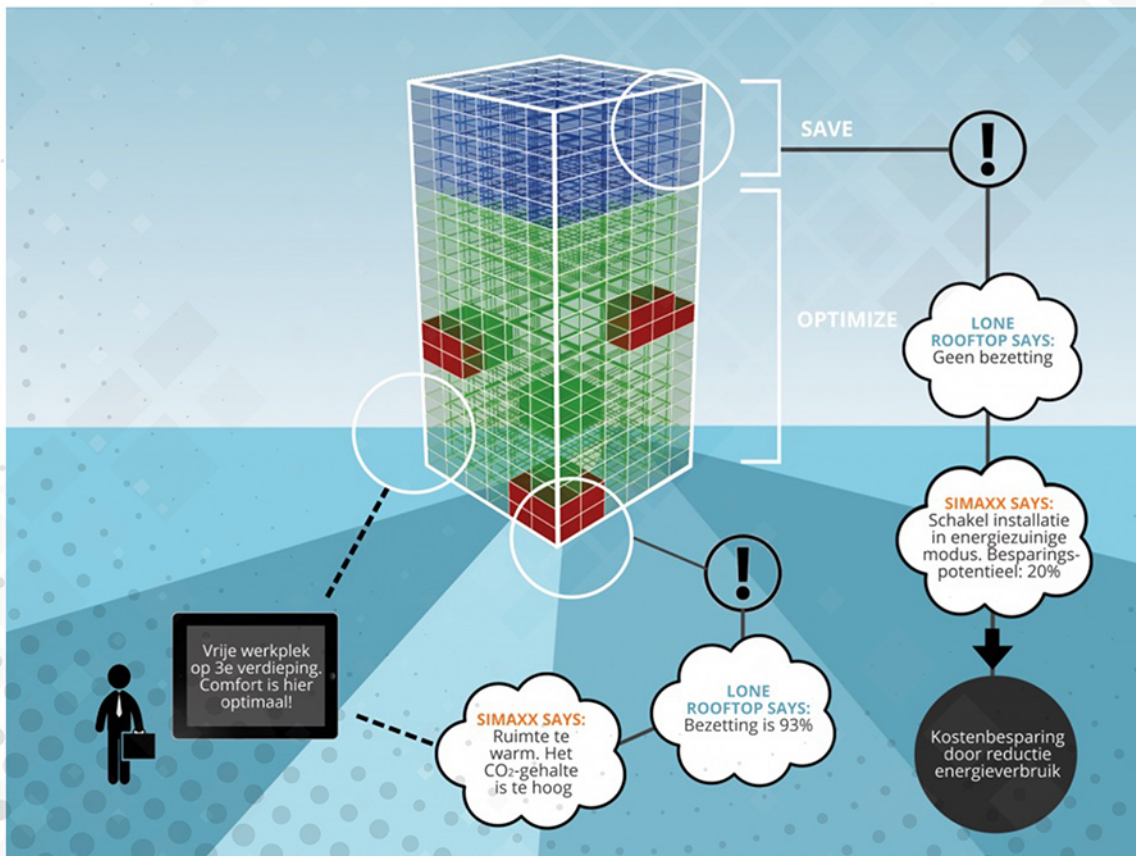
Fig.4.19. Position Intelligence Engine (PIE) (Lone Rooftop, n.d.c.).

Case study:

Case ABN AMRO bank: The rise of data driven facility management (Lone Rooftop, n.d.b):

ABN AMRO experiences a change in many ways and currently they have a strong focus on the collection and application of data which drove the facilities dep. to be transformed from cost centre into value centre.

Problem:

As consequence of the economic crisis, many bank offices in the Netherlands have been closed or merged. ABN AMRO closed some and the main challenge was to accommodate more employees in the Zuidas branch (the Head Office). The new situation requires accommodating twice the original number of people that intended to be (High occupation ratio). As described by Mark van Rijt, Managing Director of Facility Management, ABN AMRO.

> *"The concept of flexible occupation rates up to 60% based on The New Way of Working has been left behind us. Newly introduced Agile working methods like Scrum involve completely different parameters in the working environment. Interdisciplinary teams are now used that can change their composition at the drop of a hat. From a facility management perspective, we are therefore required to come up with flexible solutions, so we can implement fluid working environments that basically adapt to the needs of our employees."*

Solution:

To solve this problem, accurate and up-to-date data is needed for designing an accommodation and facility service plan.

By looking into Google Analytics tool which observes and track the behavior of website visitors, Marcel Lamers – cofounder of Lone Rooftop – initiated the concept that building can be treated as websites and by monitoring their behavior we will be able to estimate how many people are in any building and where. Consequently, Lone Rooftop developed a Position Intelligence Engine (PIE) for tracking the occupation ratio based on Wi-Fi networks and other sensors. This data can be also available for employees through wally app for example, in order to obtain a real-time overview of workspaces in the building.

The occupation ratios were shown in numbers into employees to experiment how they perceive it, but they were really interested in knowing where the vacant place is. Therefore, the numbers were turned into words: 'room here', 'busy here' and 'chatty here'.

This concept can be applied to cleaning service by determining which spaces are in need of cleaning and priories them. It could also be applied on energy consumption for more cost saving, as stated by Broekman - Head of Business Intelligence FM at ABN AMRO - *"We can apply the same method for climate control: automatically link the facility systems to the occupation ratio. In the long term, this could lead to significant savings in energy use."* (Lone Rooftop, n.d.b).

Finally, as privacy is a very important aspect for ABN AMRO, a solid privacy agreement has been established with legal, IT and the work council. Lamers explained *"The data is anonymized; we are only dealing with numbers and not with the associated names,"*, and Broekman added *"The discussions we had about this with ABN AMRO have also helped us to guarantee the highest possible standards of privacy for our product."* (Lone Rooftop, n.d.b).

Main Findings:

• Capturing value in real estate investment is not only about maximizing revenues, but also about minimizing cost. About 30% of the total energy cost of office buildings are wasted on both climate and lighting systems that are operated in vacant spaces, due to their poorly adaption to the actual occupancy of the building (lone rooftop, n.d.a). Thus, turning buildings to be smart by connecting the management system to a smart tool like PIE for basing lighting and climate on occupancy data, will decrease the energy waste of the buildings and subsequently the energy cost as well.

• Gathering and analyzing all this data about the workspace will generate an opportunity for being able to capitalize on the fast changing housing need for any organization and optimizing occupation.

• Privacy is very important in such an open data world, thus legal agreements are needed for saving the end-user's and customer's rights.

C- Cleverstone: (Utrecht, NL)

Specialization and focus:
Real estate portfolio management (Public & Commercial real estate) by focusing on the end-users.

Vision:
'A good decision is made on the basis of knowledge. The world of real estate is fundamentally changing. Dates of buildings and the environment is becoming faster and better available. Analyzing it effectively and applying that information enables you to make better and quicker decisions then take your competitor.' (Cleverstone, n.d.).

Mission:
Adding value by collecting crucial information about the building, the user and the environment, and applying smart real estate solutions, in order to achieve significant saving in the rental portfolio, through the developed GRIP dashboards.

Shortly, the main aim is to match the right people to the right building or space.

'It is our job to connect the right data to the right customer'

Yassine Zaghdoud, partner at Clever Stone.

Values:
1- Smarter and efficient portfolio analysis.
2- Focusing on the end user: by focusing on the right solution instead of the transaction.

The Grip Concept: is an interactive platform with essential internal data by added by customers which is well structured in real time as shown in fig.4.20.

'What we do that we let companies add their data either manually by filling the application or by extracting the data from their data base to the website. Then they got an overview of their data, and they are free to take the decisions themselves or ask us and they you saw our data, what do you think the most interesting buildings to invest our time in (benchmarking within their data).'

Yassine Zaghdoud, partner at Clever Stone
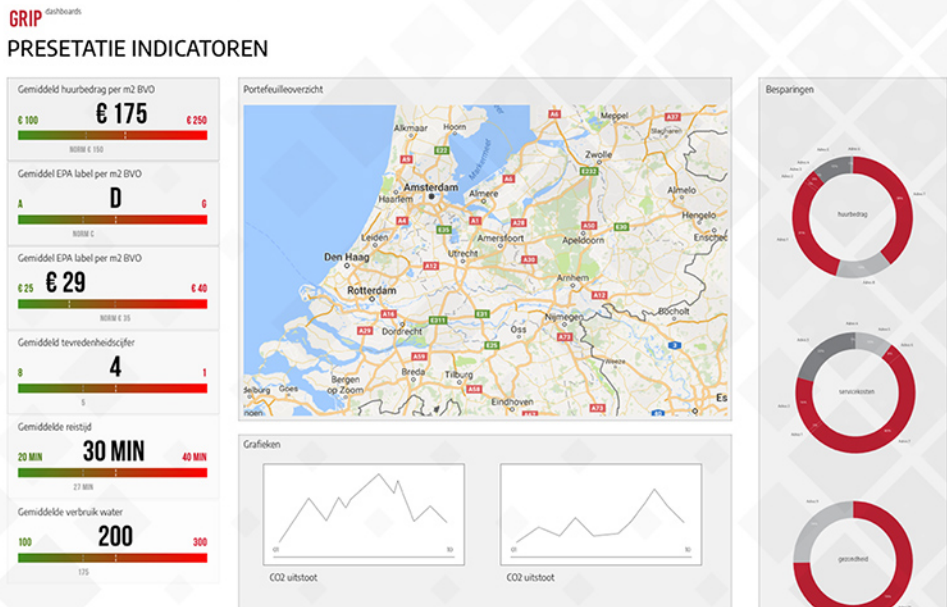
Fig.4.20. The Grip dashboard (Cleverstone, n.d.).

Benefits from collected shared data:

Having such an integrated platform that contains all the information about real estate will allow you to have a better overview on the real estate market and more insights for the decision making. For instance, you can find easily and fast more information about: the average rent/sq.m., ROI, how sustainable is the portfolio, how healthy is the portfolio, user satisfaction, biggest tenant, contract period, service cost, etc. (Cleverstone, n.d.).

The internal collection of data secures more accurate information.

D- Vastgoeddata: (Amsterdam, NL)

Specialization and focus:

Vastgoeddata provides Dutch real estate professionals with information about commercial real estate. The Vastgoeddata database contains information about all commercial real estate in the Netherlands (over 400,000 properties), and about more than 1.3 million end-users. Linking these data into one integrated system creates many new insights and opportunities. This information is accessible through a unique database with linked data from, among others, government organizations, brokers and credit information providers (Vastgoeddata, n.d.).

.
Mission and goal:

- Collecting more details about the commercial real estate in the Netherlands, integrating them in one database and connecting them to the right building in one fact sheet.

*'we are kind of micro-managers, so we want to know a lot of detailed information about buildings, while other companies have broader view, for us the details do matter, because if you have detailed information, you can trust your results more. So **our slogan is** 'we are with you', so our clients are real estate agents, investors, banks, governments, consultants,...,*

So we are with you and we are not competing, we are not valuating buildings ourselves, and we are also not planning to do that in the future, there is a lot of shitty work that you have to do before you can valuate a building and we want to do that for you,'

Christiaan Swen- Director at vastgoeddata

Benefits for investors:

1- Never too late for a view. Receive an alert when a new announcement or zoning plan is published. Always on time for a view.

2- Receiving an alert when the creditworthiness of your tenant changes.

3- Investigating which rental transactions have taken place through relocations and the rental transactions collected by Vastgoeddata and Strabo.

4- Finding reference transactions that meet self-selectable characteristics.

5- Saving costs. Integrated Real estate data platform is more advantageous than buying and accessing all available data yourself.

6- Saving time. With simple search options, buildings and end users are quickly found.

'Vastgoeddata helpt mij efficiënt en effectief werken en de beoogde resultaten te behalen. Met behulp van Vastgoeddata hebben wij twee huurders gecontracteerd! Ik heb met behulp van Vastgoeddata een doelgroep geselecteerd, deze partijen heb ik telefonisch benaderd en twee partijen hebben daadwerkelijk een huurcontract getekend! '

R. (Ramon) van Stekelenborg, Asset Manager, PingProperties BV

(Vastgoeddata, n.d.).

'De recente huur- en kooptransacties uit Vastgoeddata zijn een waardevolle toevoeging aan onze eigen database en gebruiken wij dagelijks voor interne en externe doeleinden.'

R. (Roger) Heaver, Asset Manager, Cyclus Property BV

(Vastgoeddata, n.d.).

Data Sources:

'we buy data bases with information about commercial real estate, we also collect our own data about the Dutch commercial real estate market, and we connect those data bases to our system, and therefore you can search and the results are more accurate and faster. So if you want to research the value of this building, basically what you want is comparable transactions, ……, the point is to get good references and/or exact references, because we have so many data bases, it is possible to research on really refined way to get the results.'

Christiaan Swen- Director at vastgoeddata

Fig.4.21. shows the different data sources.

Fig.4.21. Different data sources for vastgoeddata (Vastgoeddata, n.d.).

4.1.3.2. Interviews (Appendix.E.):

The most general question is that whether people in the real estate industry are with or against transparency. fig.4.22. shows that most people acclaimed that they are with full transparency.

'I think it is better for the market if it is, ..., but you know it is not my goal to make the market more transparent, but it is a side effect of what I am doing.'
Christiaan Swen- Vastgoeddata

'From a general real estate point of view, I think it should be but for the company it is a bit risky?, who is going to invest in it and who is going to benefit from it? ' I am with transparency, but the way is a bit tricky'
Martijn Martijn (W.M.) de Jager –
CBRE

''I think it is important, yes,.., I don't know why shouldn't you?!,.. I think your starting point should be transparency'
Agnes Wittink- RVGB

PROPONENTS

'In the last crisis, banks had huge loses because they didn't have enough information, investors are making a lot of money because they know something that we don't know, and the data needs to get transparent'
Martijn Witvoet – ABN AMRO bank

'Yea, I am fine with that. But I think what you now see that it takes a lot of time and resources '
Raphael Rietema - CBRE

'I am with it. I think eventually it will be better for the real estate market in the Netherlands, because it will enhance trust between parties, liquidity which is a good thing,.... On the other hand, our competition will become much harder'
Fabian Marchand – Carin Real estate

'Yes, I do. I would like to see that everything that I do manually now is available on data base that contains all the transactions and required information'
Sjors van Iersel – Spring real estate

'for Geophy, we are working towards transparency , we think that it will change the dynamics of the market which will open opportunities. '
Brittany Burns - Geophy

'It is also good for the office market to make the data available'
Anna Mira Brethouwer - Geophy

'we are really in favour of more transparency, because we think smart cities are much better than smart buildings and if you want to create smart cities you have to share data. So that is something that we see for the future, on the other hand, we have privacy issues, so we cannot share certain data, we simple are not allowed to share certain data,..'
Jeroen Jansen- Bouwinvest

'-It should solve both. It should solve the problem of transparency, but to a certain level '
Saman Mohammadi – Re-born real estate

'No, this market is totally different than a typical governmental public market. Because we also have our advantage because we know certain information that other parties do not know,.......... but at the end I am with transparency as it has more advantages than disadvantages'
Ivar Hillerstorm – Spring real estate

OPPONENTS

'No I don't agree. Then you lose a lot of opportunities. If you are better than average. And that is why the good side of the market will not cooperate with that.'
Sebastiaan van Nimwegen - CBRE

'It shouldn't be that transparent. The only difficulty is that If all people have the same information and if everyone is using big data, then the real estate will be like buying a share on the stock market due to the public available information.'
Martijn van den Eijnden – Carin Real estate

No, because then the fun is gone, then the interesting side of investing and trying to get your hands on a deal is gone, it becomes purely emotionless, then the whole idea of doing deals and the whole risk and return is gone, so I don't believe in it.'
Maurits van Schie- BNP Paribas real estate

Fig.4.22. Proponents and opponents to transparency (Own illustration based on the conducted interviews).

A. Benefits of big data in real estate investment :

All the respondents agreed that there are a lot of benefits of adapting big data to the real estate investment domain as shown in fig.4.23. and (Appendix.E.) the following are some mentioned benefits:

1- More transparency by providing sufficient required data and information.
2- Making better, faster, more accurate and cheaper decisions.
3- Reducing risk.
4- Adapting faster to the change of the end-users' preferences.
5- Giving the opportunity to approach potential investors whom you never seen before.
6- Better knowledge and insights about the prices and the real estate market.
7- Better future expectations especially about the future possible building use.

'It comes more transparent. We are still young and we cannot imagine the time where such things like google maps for example were not there,....10 years or 15 years ago all these platforms like Geophy or Vastgoeddata didn't even exist. I cannot imagine doing the same thing 15 years back,'

'Big data can provide information that wouldn't be rather accessible, there would be better fit between demand and supply. Better information, better knowledge of prices, (more accurate and faster decisions)'

'I think the obvious reason is that you have better arguments to do or do not invest in a certain property, better argumented decisions,'

Better, faster, cheaper decisions

More transparency (better data)

Reducing risks

'It leads to more accurate decisions in the right moment. Because what we see now that organizations still making decisions based on the wrong assumptions.'

BENIFITS OF BIG DATA

Adapting faster to user's preferences

'You can have more accurate comparable, market insights, how tenant preference will change, (user preference), then you can adapt to that more quickly.

Better future expectations

better knowledge of prices & the market

Approach potential investors

'It also provides you by enough information which can be shared among people, in order to see possibilities, which are not seen right now (better future expectations). '

'.. in terms of big data you are working of large scale, which allows you also to approach new investors that you have never seen before. ...., You can approach him much quicker, because I am not going to read all the newspapers and magazines for all the countries'

'I would say that the transformation into using predictive analysis and I think that is the most important part '

Fig.4.23. Benifits of big data to the real estate investment process (Own illustration based on the conducted interviews).

B. Challenges of big data:

Many challenges are mentioned to adapt big data as shown in fig.4.24. and (Appendix.E.) , especially to small firms:

1. Data accuracy and quality was the main challenges of many respondents.
2. Privacy and moral issues.
3. The willingness of people within the industry to share information and cooperate (the current mindset).
4. It highly requests a lot of money, technology and time to invest.
5. The market will be at the same level (no competition).

'One of the challenges is the accuracy of data, ...,
I believe this is a big challenge to get the data and
information correct'

'Getting accurate data. That is not publicly avail-
able........... How you keep the quality of the data?'

**Data accuracy
and quality**

**Knowledge &
skills of people**

'.., but it means also gathering data from the
people who are in the building which is also a
privacy issue'

**Privacy and
moral issues**

'To have the data, ..., Updating the
data, and data quality and the knowl-
edge and skills of people working on it,
and I think the third part is security or
safety of the data in combination with
the privacy issues.'
'

'if big data is available so the quality of the data
provided by different companies probably will be
at the same level. '

**CHALLENGES
OF
BIG DATA**

**No competition
(the market will be the
same)**

'It is not suitable for our company as it is small
company and big data needs a lot of investment'

'Explaining it, that is the hardest thing because
it does seem to be like a black box, but getting
investors onboard is actually hard and taking a
lot of time '

**Alot of money, time, re-
sources and technol-
ogy to invest**

'The willingness of all people col-
laborating, it is a challenge to get ev-
eryone in.'

**Current mindset
(willingness of people
to share & cooperate)**

' I think what you now see 'it takes a lot of time',
so you need to invest a lot of time and resourc-
es to make the information transparent and also
that is what we try to do. '

Fig.4.24. Challenges of adapting big data to the real estate investment process (Own illustration based on the
conducted interviews).

C. Data 'Accurate, relevant, UpToDate'? :

The interviews showed that the current available data is not accurate enough and not updated as
stated by some respondents:

'No, never, it is not very accurate, ….., I don't think that data is completely correct, I would
rather say that it is not accurate at all'

'Not accurate enough.'

'So normally when you have transactions, then you have multiple input times for entering
a transaction, there is only one correct number. Given you an example, if you read back
the news about the properties that are sold, and you have done the deal yourself, almost
never the information which is there, is absolutely correct. It is almost never.'

'No, no one option is correct about what is actually the available stock, there are several
sources and each of them published another figure, so what is the available stock of the
office market in the Netherlands for example?'

On the other hand, one respondent approved the high accuracy as he relies on a data company who
dedicate a lot of effort to assure the accuracy of the data:

'In practice, we work with vastgoeddata.nl and the data allows us to be more informed and
make better decisions. The information is in my opinion for 95% reliable and accurate.'

D. How to make sure of the data quality and accuracy? :

The data quality and accuracy remains a big question, the respondents claimed the importance of focusing on the input side, the following are some suggestion and trials by different respondents, in order to tackle the accuracy problem and some arguments as mentioned by some:

1. **Manual input, but it takes a lot of time.**

   > 'But the good thing about manual work is that it is very accurate and precise. So let's say he will scrape Funda and he will take the amount of sq.m. that stated on the Funda page, but if you read the description there might be a difference because the text is always adjusted to the actual supply, and then you will get the wrong number. So it is a lot of work but it is very precise.'

   > 'Manually because not all the transactions are available in public and we also believe in the human touch'

2. **Internal data input.**

   > 'The benefit that we have is that our data is mostly internal data from the companies themselves not an open data. Rather companies give us their data which is the most valuable and accurate data (Financial, technical, contracts,.....).'

   > 'The accuracy needs to be on the input side. We needs to define systems for that and that is what we are trying to do here as well.'

3. **Data providers should have market experience:**

   > 'The data companies, I think they lack market experience, I think they are clever with data and scrapping, but they cannot assure the quality of the data because they don't know the market. For example, If someone put a vacancy on some websites like Funda, in theory you can scrape those information from the website but if you put it online, it means that this space is available, it might be false information because there was no way of actual check.'

4. **Comparing different data bases to assure the quality of the data, and manual check:**

   > 'A lot of work, there is quality assurance team, it is mix between manual checking for the excel files ,.., and checking the confidence of the model if the confidence is not good enough we go back and recheck again (before and after).'

   > 'Through standardization & random checks, an accuracy of at least 95 till 99% could be achievable. It depends which data. For example: building costs, profits of a real estate developer etc. (more the financial/economic variables) would be difficult to score a high accuracy.'

   > '...., the best thing is that to use multiple data sources which are describing the same thing but from different perspectives. And that is kind of what google is also trying, one data doesn't say anything but if you have 5 data sets, you can put them on top of each others,'

5. **Hiring location specialists:**

   > 'What we are planning to do the coming years to be more accurate, we will start in 2019 with a location specialist who knows a lot about certain area and this person will take pictures of building from the front and back side of the building and will count all the parking spaces because there is no data on that, ..., Our company is inspired by the American company Costar, they also employ location specialist,..,'

6. Blockchain technology:

> 'Blockchain will prove that as well. '

To illustrate, ABN AMRO bank and IBM started a new experiment using the Blockchain technology which based on Bitcoins through developing new tool 'Torch'.

Torch (Faster, Easier, More transparent):

Torch gives banks the ability of having easy and up-to-data insights into status of commercially let property (ABN AMRO Innovation Centre, 2017). The main benefit of employing such a technology is having more reliable data and information faster and cheaper with no need to banks.

How it works:

Different parties' computers are connected together through very secured network, and each party can access this network through specific portal for exchanging information (ABN AMRO Innovation Centre, 2017). Additionally, each party has his own unique digital key to be able to access information or edit with his identification information (ABN AMRO Innovation Centre, 2017).

In commercial real estate as shown in fig.4.25. (ABN AMRO Innovation Centre, 2017; ABN AMRO, 2017):

1- Different parties share their files that contains information about the property and lease data, within the network (Commercial real estate agents, real estate investors, land registry, chamber of commerce).
2- By comparing different inputs and the smart contracts, data is validated and exchanged though the network.
3- Based on the data, the property is appraised and a report is added.
4- The bank gets up-to-date overview about each property.
5- Finally, the Dutch central bank can access the whole package, in order to check how properties are appraised and financed.
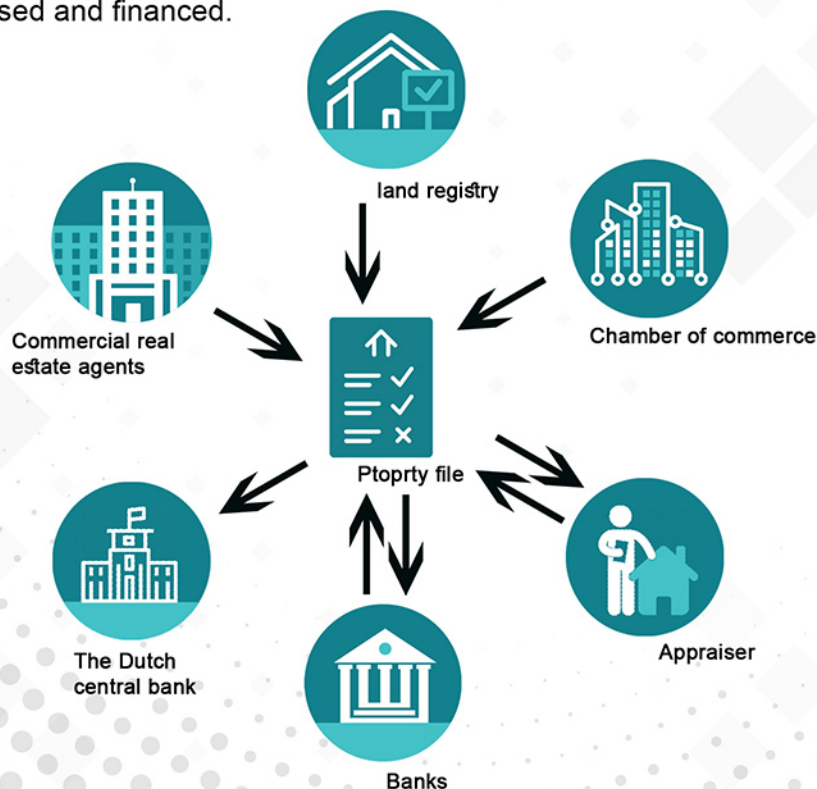
Fig.4.25. Torch concept by ABN AMRO bank (Own illustration).

Eventually, data is stored with the most suitable entity, and is only be shared through API's upon request (ABN AMRO, 2017). Blockchain creates a 'hash' of this data and share it with the entire network which enables everybody to have right away the most recent added information about particular property or transaction (ABN AMRO, 2017). Whenever the data is added the other party can validate it by using their own 'hash' (accuracy) (ABN AMRO, 2017).

To sum up, Torch and Blockchain will make the job 'simpler, faster, more secured, with less errors, lower costs and more benefits for the clients' (ABN AMRO Innovation Centre, 2017).

E. Mind-set acceptance for big data and fully automation of the decision making process :

Based on the interviews and their analysis shown in (Appendix.E.), the current mind set is ready for big data and its analytics by claiming that it is coming anyway. Regarding the full automation of the decision making process, most respondents disagreed with the full automation of the decision making process for the following mentioned arguments:

> 'I don't think that you can fully automate it , I think that data can facilitate the process, because this market is also more about seeing the opportunities which are not directly translated to numbers. But there is a human touch in this world…….. The same is with doctors, they can use machines to make it more precise but at the end their still human eye who has to check if it is going well and intervene if it is not.'

> 'I think you can automate a lot of those steps especially if you know the specific market to invest in, assessed it and liquidity. That is more hard requirement and that is something that you can easily measure, but other factors are less tangible which are difficult.'

> 'First of all, I don't think that you can fully automate a decision making process……., You cannot fully automate it, you can do 90% but the last 10 % has to be done by people, in my opinion.'

> ' Not fully, the final check, you always want to check what is the outcome is and if it matches your gut feeling,….,then if not, you are looking why, you try to convince, you always need to know if there is a match, yes or no, no, so why?, may be you can find good reasons?'

On the other hand, few respondents expect that we can automate the process in the future and some companies started already working on that like Geophy as quoted by one of the repondents.

> '…, I only think that today it is not possible in the office market because the data is too heterogenous, but I am quite certain that in future, we will have far more data, and not only about the office building but actually about this actual room,…., too much data for us, and then I think automated valuation can be possible in 20- 30 years in the commercial market.'

Based on that, the role of appraisals and investment managers will not diminish in the future because there should be always experts who can match demand and supply, rather they will be more data and it driven, as described by some respondents:

> 'I think that what will never change is that you have to match the seller to the buyer. So you have to have specialists everywhere to match. What is now it is more at consulting level, but it will be more it and data driven.'

> 'I think we already see signs that the market is getting there. Although some properties have special conditions, and you will still need an expert for that.'

'Checking the data instead of searching for data and fill in their ow decision making model. In a certain way the data gives you the results, only one thing is checking the results, combine the variables and make the good decisions.'

' Checking whether the data is valid, asking the right question, is this is outliner yes or no, so I think for the time being, there is still a case for almost every type of job, that would change much more towards checking, questioning, thinking of new questions than doing the actual work.'

F. Benefits of social media to the investment real estate decision making process:

The followings are some mentioned benefits by experts during the interviews and some quotes for their arguments:

1- Predicting the needs of your potential tenants (end-users preferences):

'…., Social media usually adds profiles to the real estate in appositive way. …..Expecting the preference of the end-user: sure branding and social media attract people, as people wants to be in that space in terms of tenants.'

'To see what they are doing and where they are going……, you can determine better what type of use they prefer, how they currently use it versus how they would like to use it. There is always a mismatch between demand and supply and if you never go to the source, you will always keep this mismatch. '

'Two examples of Instagram and Facebook. Instagram, they can predict if you have depression from the pictures you are posting, and in china they have an experiment now that based on your behavior, they can predict if you are getting ill or heart attack or something. So if you understand your data better and build up a predicting modelling on top of it, you will be able to understand the needs of your potential renters better.'

2- Good marketing tool:

'Marketing tool to boost properties. Social media from my perspective is not really. Is only for networking.'

3- Using face book (Venues and events) to measure the vibrancy and level of attraction of some area like the tool developed by Geophy which described before:

'From the social media data, we used mostly Facebook events to see how vibrant an area is by knowing how many events are in certain area and see whether it attracts a lot of people. …………, What I am using is a combination based on Facebook events and Facebook venues (Places) ,.., And I also have another layer of the land use mixes. What you actually see is that when an area gets really attractive, it is more of a mixed environment. '

On the other hand, some respondents denied any related benefits for social media to the investment process in the office market or that might be but in the future:

'I think this is a tough one, because for a house, people talk about their houses in social media, but If I am looking for a new office, I don't post on twitter 'oh I have seen such a nice office, I might want to rent it', because the price will go up. May be I am too old for this, but I don't see many possibilities at this moment, but maybe I am wrong. '

'I think we can, but we are not even nearly there yet. But I think that social media is one of the potentials.'
'Why social media? And not through a yearly survey with the end user. '

G. Techniques of collecting, analysing and visualizing data:

Many companies has their own data base which they build mostly manually. Small firms don't have big data base and they use some sources such as: the cadastre, land registry, PropertyNL, etc. or data companies like: Geophy , vastgoeddata, etc. as shown in (Appendix.E.), and argued by some:

> 'We use GeoPhy, only on collecting data (Subscriptions) , but we determine the value ourselves.'

> 'Manually, we have the data base of approx. 14.000 building around Netherlands, ……….., We have our call center tool who calls tenants around whole Netherlands, we retrieve this data manually and add it to our database.'

Banks and data companies have many ways to collect their data such as: manually, building scrappers for structured websites and social media, connecting to other data bases through API's , etc. as shown in (Appendix.E.), and quoted by some:

> 'We made an application and put it in the market 'GRIP@'. So companies has the possibilities to enter their data manually through the application or link their data base to the website.'

> 'we collect data mostly from Excel and format of CSV and then our data scientists use python language for merging the data and storing it in GET LAB and the model is done in their computers , and the most important thing is that the data is stored in our semantic core data base that we built ourselves.'

> 'API's for data collection from social media, but this depends on which website, for example Facebook have one.……We also use scrappers, similar to data mining …. It is for automatically extracting the data from structured website.'

> 'People can use our data via an API in their own system, and we get some information via API's from our data vendors, and we have web interfaces, sometimes we get it via excel sheet because this is how the vendors sell their data, and we have our own research team (5 People), they are collecting a rental transactions, and we type it ourselves, so sometimes we get a pdf files or an excel sheet, that is manually.'

Finally, for the analyzing and visualization part, almost no response was given either because it is too much technical or they are not that far with big data and smart analytics. The given answers are shown in table.4.3.

(Big) data firm	Techniques for collecting and processing data	Techniques for analyzing & visualizing data
Geophy	- Own data platform & engine - Manually - Using API's - Scrapping structured websites	- Spatial programming. - Statistical models and analytics
Vastgoeddata	- Using API's - Manually (rental transactions)	- Web interfaces - Elastic search engine
Cleverstone	- Manually - Connecting API's to different data bases	- Own developed GRIP® application, GRIP dashboards and other web based applications

Table.4.3. Techniqyes for collecting, processing and visualizing data (Own illustration based on interviews).

4.1.3.3. Score-card:

This part shows the data avalaibility for the main four catogories of indicators, based on interviews by analyzing the filled-in scorecards (Appendix.I.).

A. Economic features (fig.4.26.):
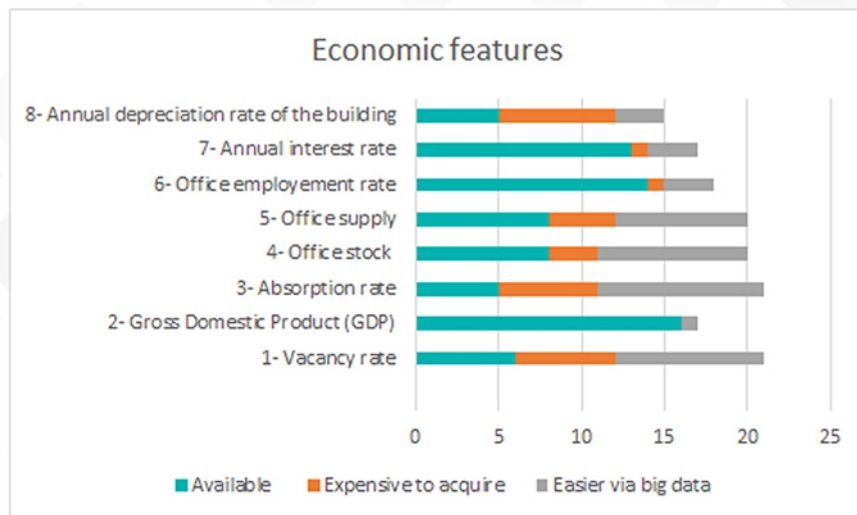
Fig.4.26. Data availability - Economic features (Own illustration based on the conducted interviews).

The results show that economic features is mostly available, but some indicators could be more percise through big data such as: vacancy rate, office stock&supply and absorption rate.

B. Location features (fig.4.27.):
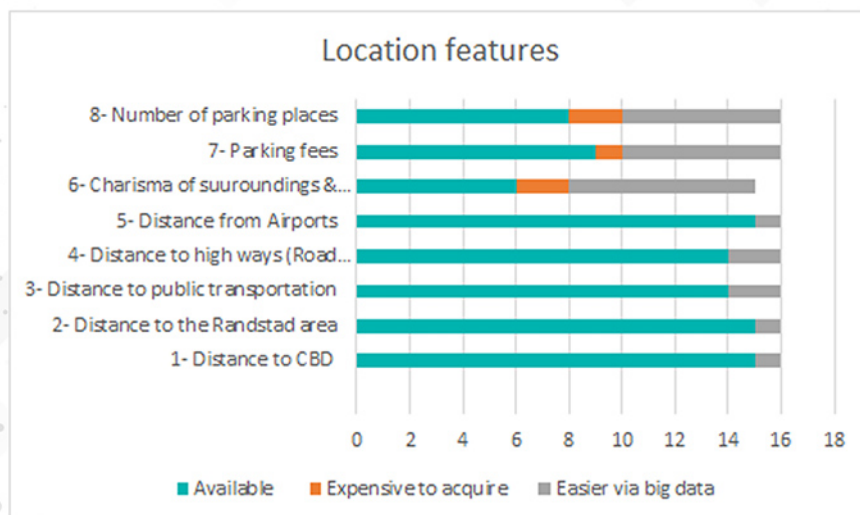
Fig.4.27. Data availability - Economic features (Own illustration based on the conducted interviews).

Location features are generally available and accessible except for parking and charisma of the surroundings.

C. Building features (fig.4.28.):
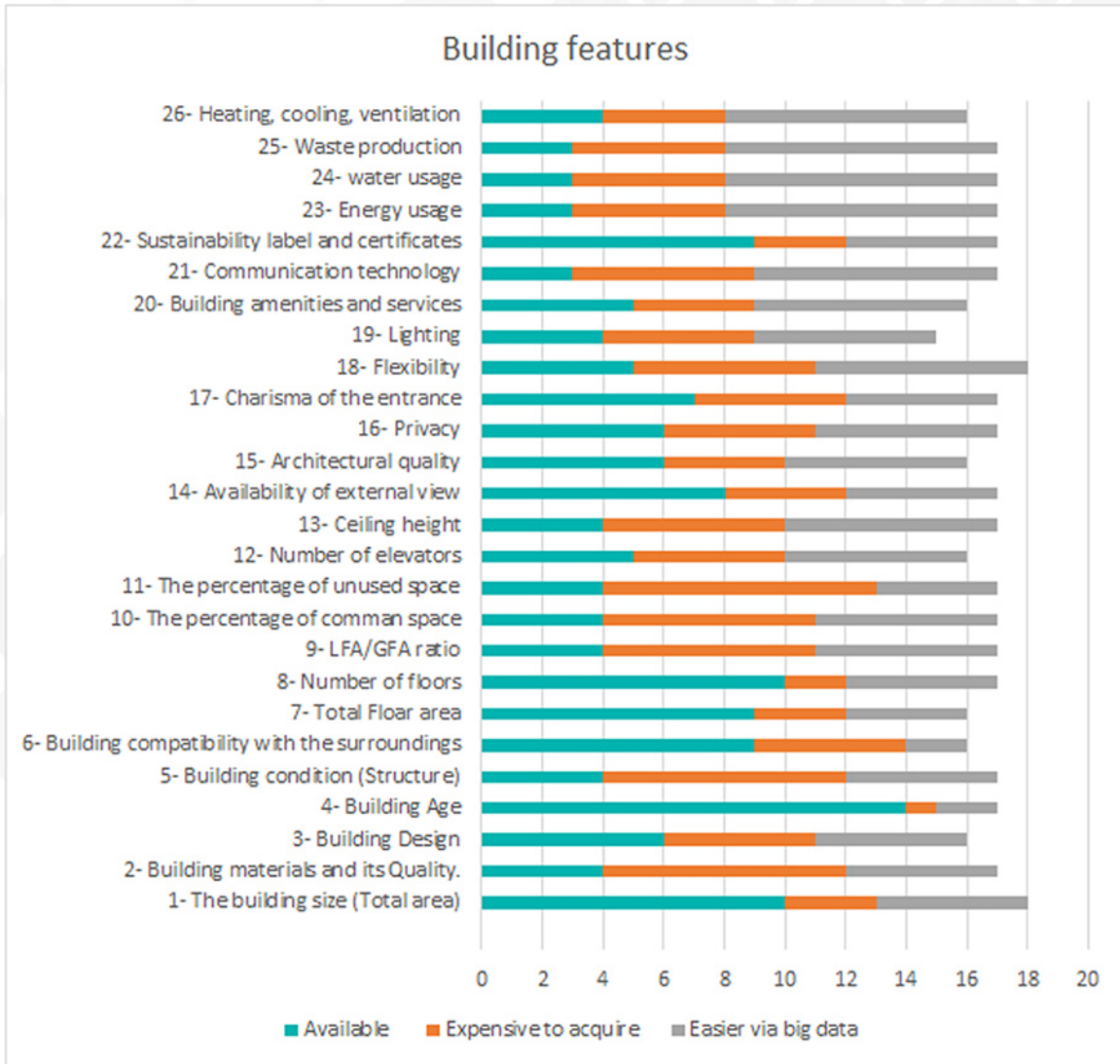
Fig.4.28. Data availability - Building features (Own illustration based on the conducted interviews).

Most of the building indicators are not available or easily accessible, which requires deploying big data analytics or building data bases to have this important information.

D. Contract features (fig.4.29.):
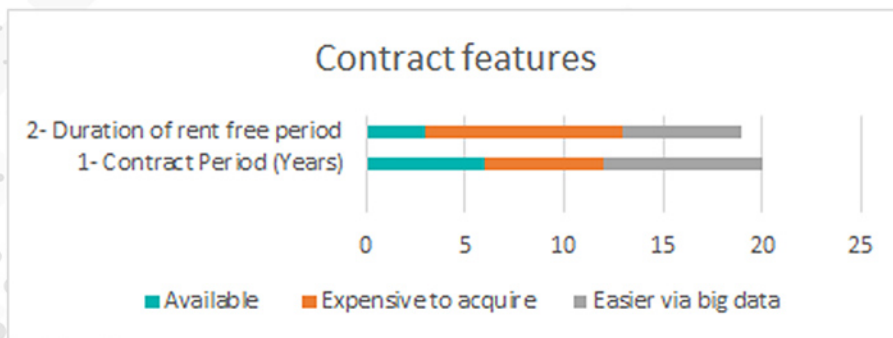
Fig.4.29. Data availability - Contract features (Own illustration based on the conducted interviews).

Contracts' details and incentives are mostly not available, especially information about incentives.

To sum up, the following table (4.4.) summarize the data availability to show which indicators are already available and which could be more percise by using big data, smart tools or building data sets.

	Available indicators	Easier to be collected via big data analytics, smart tools or building and combining different data sets
A- Economic Features	1-GDP 2- Office employment rate 3- Annual interest rate 4- Annual depreciation rate of the building	1- Vacancy rate 2- Absorption rate (Net/Gross) 3- Office stock 4- Office supply (vacant stock)
B- Location Features	1- Distance to CBD 2- Distance to the Randstad area 3- Distance to public transportation 4- Distance to highways (road infrastructure) 5- Distance from airports 6- Parking facilities/fees	1- Charisma of the surroundings & Environmental amenities 2- Number of parking spaces
C- Building Features	1- The building size 2- Building age 3- Building compatibility with the surroundings 4- Total floor area 5- Number of floors 6- Availability of external view 7- Privacy 8- Charisma of the entrance 9- Sustainability labels and certificates	1- Building materials and its quality 2- Building design 3- Building condition (structure) 4- LFA/GFA ratio 5- The percentage of common space 6- The percentage of unused space 7- Number of elevators 8- Ceiling height 9- Architectural quality 10- Flexibility 11- Lighting 12- Building amenities and services 13- Communication technology 14- Energy usage 15- Water usage 16- Waste production 17- Heating, cooling, Ventilation 18- Building layout (Single/ multi-tenants) 19- Renovation date 20- Health
D- Contract Features		1- Contract period 2- incentives

Table.4.4. Data availability - (Own illustration based on the conducted interviews).

4.1.4. Theme 4: Future trends & scenarios:

4.1.4.1. Reports:

This part discusses the impact of predictable future trends on the Dutch office market and the real estate investment process aswell.

Future trends and clusters analysis and the impact on the office property and real estate investment decisions:

In the current digital era, technology, demographics and environmental aspects became striking values for organizations to achieve for maintaining their competitive position within the market (Brechbuhl, 2015; PWC, 2014). For the coming years, real estate investment industry will experience significant change due to the fast economic and social change which affects the whole built environment. Consequently, eight main clusters of trends that could shape the future and demand of real estate of business will be discussed. The clusters and trends are shown in table.4.6. The growth will be achieved through Value-creation activity rather than cap-rate shift, which turns the current and future demand for high-quality assets.

The major challenge in the European industry is the shift in real estate as a financial asset to real estate as a product or a service (PWC & ULI, 2016).

1-Regionalization:

Some companies are more centralized in a certain area but expanding their branches in other regions around the world (Centralization).In other words, there are many divisions around the world but the general management is centralized in one of the main central business hubs around the world which makes those central business and financial hubs attractive and potential investment locations for investors.

2-Globalization:

Reflects the intention of firms to expand globally and compete with other firms around the world for better reputation and attract more investment. This cluster contains many trends such as: Rise of global competition - Future of mobility (raising the demand of electronic payment around the world) - Future accessibility – Financial inclusion – Expanding products and services (Brechbuhl, 2015; Singh, 2016).

3- Sustainability:

Sustainability became a hot topic that influences all the business and firms globally. Moreover, it includes environmental, social and economic sustainability. Sustainability includes many trends such as: social and economic sustainability – accessibility to new markets- smart in the new green – sense of place (Brechbuhl, 2015; Singh, 2016).

Furthermore, climate change phenomenon, governmental regulations and high energy cost push sustainability to be prioritized in the agenda (PWC, 2014).

4- Technological innovation:

The digital age and technologies presented new way of thinking in all life faces. This new era will influence all business and result in higher demand for flexibility- new ways of working- reducing space to user ratio . Based on Brechbuhl (2015) and Singh (2016), this cluster includes other trends such as: rise of digital currency- digitalization of matter- innovation to zero.

Due to that technology and digitalization, the office space is more likely to decrease. Additionally, the office culture has been changed and workers are accepting now video-conferencing and digital files, which is a big driver to spend more time on working from home or satellite office (PWC, 2014). In short, this trend will transform the whole real estate.

Technology will help also developers to manage efficiency within the building and monitor the real usage and vacancy of the building by adapting some sensors with data analytics.

Space as a service:

According to the interview held by PWC and the Urban Land Institute about emerging trends in real estate: reshaping the future in Europe, 15% strongly agreed that the real estate business models and valuation of real estate investors are changing as a result of moving towards 'Space as a service', and 53% agreed (PWC & ULI, 2017). Additionally, the results of the survey showed how advanced data collection, analytics and digitalization enhances the real estate investment decision making and traditional ways will be less relevant as shown in fig.4.30. (PWC & ULI, 2017).

Source: *Emerging Trends Europe* survey 2018
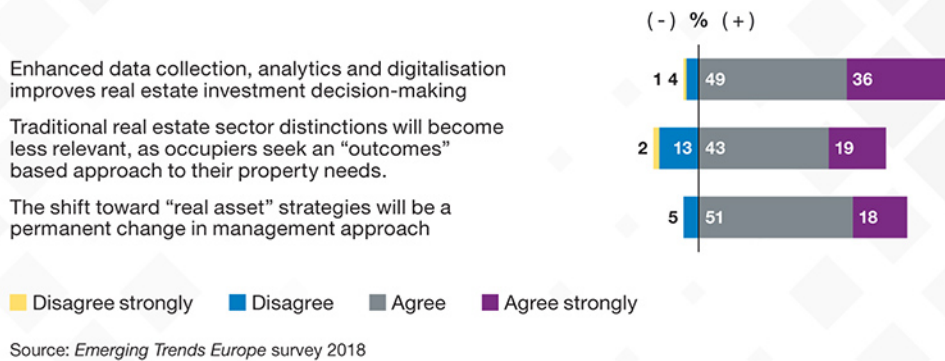
Fig.4.30. Changing how the real estate industry operates (PWC & ULI, 2017).

One further step is shifting from the mixed use developments into omni-use developments by enabling people to work anywhere, shop anywhere and to relax anywhere (PWC & ULI, 2017). Fig.4.31. shows the changing face or real estate as a result of technological and innovative transformation.
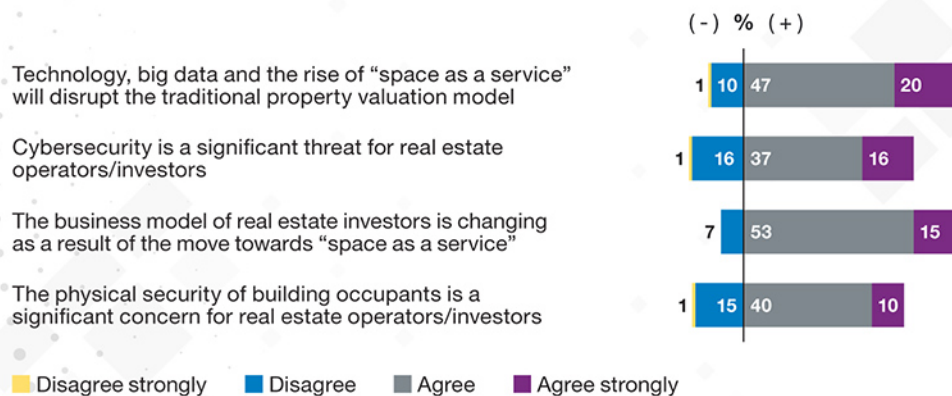
Fig.4.31. The changing face of real estate (PWC & ULI, 2017).

5- Changing economy and geopolitics:

Changing in the global economic structure and performance (the way it operates and functions). And it will affect the number of employee, needed space and financial flexibility as well. Subsequently, it has a large impact on the business portfolio and office space demand.

Political instability is ranked at the top of the respondents' list of concern in the Emerging trends Europe survey (Brechbuhl, 2015; Singh, 2016). Brexit has also a major impact as it is expected that many business and firms are planning to leave the UK and some global equity originally directed to UK would be directed to other Europeon countries, which might open additional investment opportunities for the Netherlands, especially Amsterdam (Brechbuhl, 2015; Singh, 2016).

From an economic Perspective , we are at the peak of the global growth cycle but there are still potential growth in Europe. Accordingly, real estate investors are pressured to invest but at the same time afraid of that real estate is being late in the cycle with high prices that brings a lot of risks and fear (PWC & ULI, 2017).

Looking at the Europeon market in 2017, Amsterdam is regarded as one of the major 10 most active markets that are judged to be doing well in the real estate industry in terms of political and economic stability with an expected increase of 3.9 in rents and 3.69 in capital value in 2018 as shown in fig.4.32. (PWC & ULI, 2017).

		Rents	Capital values
1	Berlin	⌃ 4.09	⌃ 3.90
2	Hamburg	⌃ 3.94	⌃ 3.81
3	Munich	⌃ 3.90	⌃ 3.82
4	Luxembourg	⌃ 3.87	⌃ 3.82
5	Frankfurt	⌃ 3.89	⌃ 3.78
6	Paris	⌃ 3.81	⌃ 3.81
7	Amsterdam	⌃ 3.90	⌃ 3.69
8	Vienna	⌃ 3.72	⌃ 3.84
9	Copenhagen	⌃ 3.65	⌃ 3.69
10	Madrid	⌃ 3.69	⌃ 3.64

€31 London   €9 Berlin   €8 Paris   €7 Frankfurt   €7 Madrid   €6 Amsterdam   €6 Munich   €4 Hamburg   €3 Vienna   €3 Copenhagen
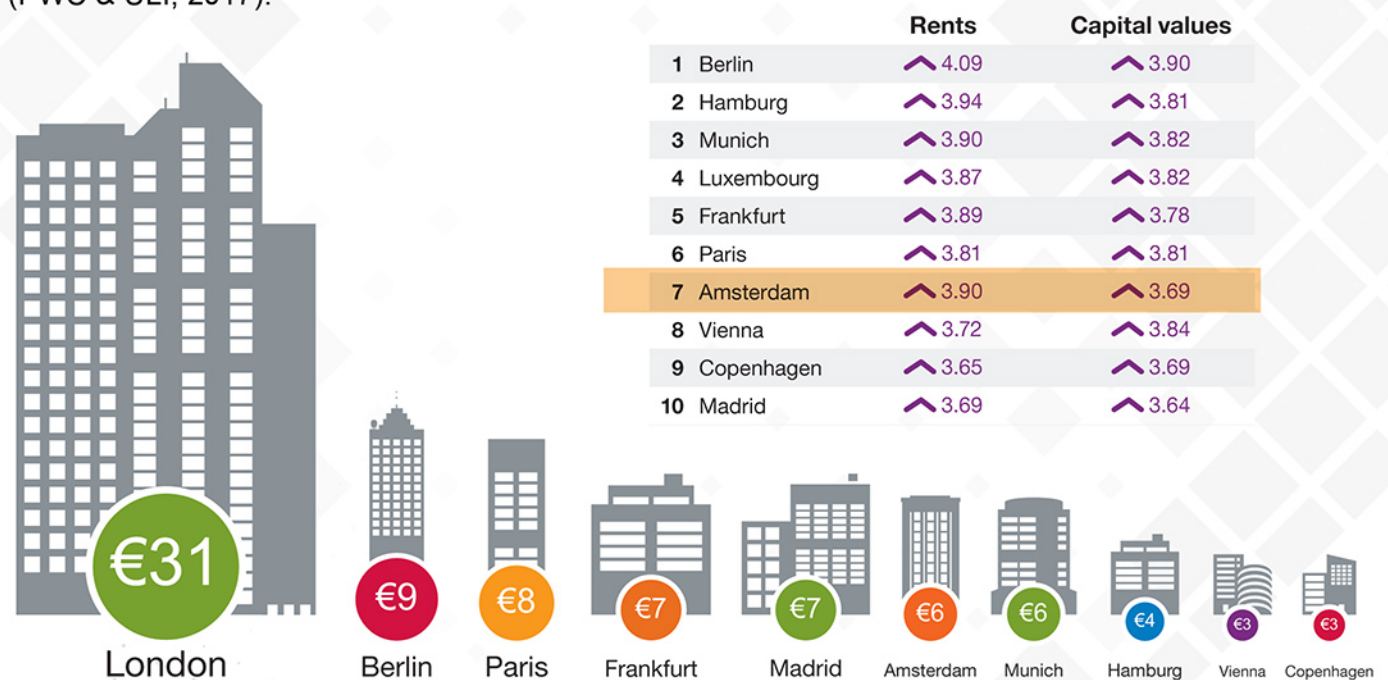
Source: Real Capital Analytics
Note: Figures are provisional as at 23rd October 2017

Fig.4.32. Europe's 10 most active markets, Q4 2016-Q3 2017 (PWC & ULI, 2017).

Amsterdam is seen as an interesting technological base for many global business with a lot of young and innovative people (PWC & ULI, 2017). Consequently, technology, innovation and flexibility are the new values for office spaces to attract global equity.

6- Global security:

 According to the internet era and digitalization, the demand for privacy and security become crucial for more protection as it becomes easier to access the information and data.

7- Changing demography:

Demographic shifts to middle class for example and changing in the demographic components of the population (gender, age, employment status, location, homeownership, etc), will have a major impact on the real estate demand especially the residential sector, while the office sector will remain as a major sector and less influenced by both shifts (Brechbuhl, 2015; Singh, 2016; PWC, 2014).

Lees (2008) also argued that many countries are now seeking to enhance and integrate the social structure (Urbanization- social integration- Growing middle class) of the cities to enhance their the social and economic base.

Furthermore, Urbanization are expected to continue growing for the coming years. For instance, it is expected that there will be around 37 mega cities and 12 of them are going to be in emerging markets by 2025 (United nations, 2012a), and the urban population will expand by 75% to 6.3 billion by 2050 (United nations, 2012b). Moreover, the square meter price in prime urban structures will continue in rising in successful and well-designed cities as they attract more people (PWC, 2014). Thus, affordability will be a harder question, and developers will seek new smart ways of designing commercial space to use it more and more efficient (densification).

On the other hand, densification will be associated with major risk in transportation system which can not cope with this amount of people. Thus, it is important to take into account this cost in boosting any city.

8- Legislation:

Changing global policies and regulations to restrict or enable activities for the firm. That would have a further impact on the core business and as a result on the real estate portfolio of the firm as well.

Based on the described trends and their impact on real estate, PWC described six main implications for real estate investment strategy (PWC, 2014):

1- **Think globally**: the expected global real estate expansion will enable much more investment opportunities, and economics of scale will be much more important. Subsequently, real estate players will be in need of higher level of expertise in more specialized area with higher ability to identify investment trends at early stages.

2- **Understand the underlining economics of cities**: The real estate investment can leverage the current competition between cities for becoming dominant regional service centers, as massive new attractive opportunities will be generated, but wider risk horizon. Thus, investors should have clear strategy and goals (higher risk opportunistic development: lower risk prime investment).

3- **Factor technology and sustainability into asset valuation**: technology is a big driver for decreasing the traditional office space demand and increasing new types of warehouses. The real estate investment players should leverage technology and data in determining tenants preference and owners intendency for making better investment decisions. Real estate managers should understand these new insights and values to remain competitive.

4- **Collaborate with governments to enable economic and social progress**: work with governments (e.g. Public Private partnerships) will mitigate many risks for mega projects.

5- **Decide where and how to compete**: Real estate players should concentrate on the market they more understand and its demand.

6- **Assess opportunities to reflect a broader range of risk**: there are more risks due to the global, complex and competitive world. Those risks can be seen in political conditions, social conditions, physical damage of properties, changing societal habits and life style, more locations with different regulations, etc. thus, real estate players should develop the required risk analysis and strategies in early stages.

In short, the fast technological, innovative and social human behaviorr changing leads us to rethink of the real estate world based on 4 main perspectives as illustrated in fig.3.33.(PWC & ULI, 2017).
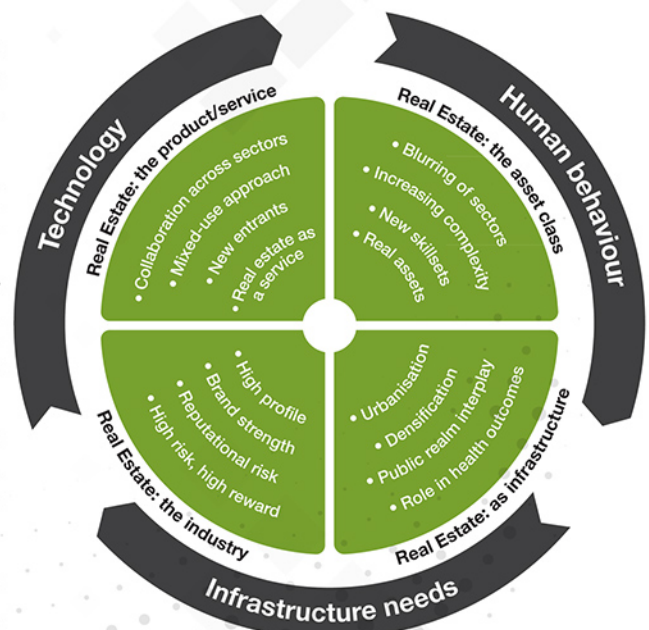
Fig.4.33. Rethink of the real estate world - model (PWC & ULI, 2017).

to sum up, table.4.5. shows the future clusters and trends that affects the office real estate industry and investment decisions.

CLUSTER NAME	REGIONALIZATION	GLOBALIZATION	SUSTAINABILITY	TECHNOLOGICAL INNOVATION
TRENDS NAME	- Centralization.	- Rise of global competition. - Future of mobility. - Future Accessibility. - Financial inclusion. - Expanding products and services.	- Social and economic sustainability. - accessibility to new markets. - Smart in the new green. - Sense of place.	- Rise of digital currency. - Innovation to zero. - Workplace innovation - Digitalization of matter. - Future Flexibility. - Reducing space to user ratio -Data analytics.
CLUSTER NAME	CHANGING ECONOMY	GLOBAL SECURITY	CHANGING DEMOGRAPHY	LEGISLATION
TRENDS NAME	- Economic growth. - Financial flexibility. - Financial inclusion. - Geopolitics. *affecting no. of employees and needed space. -Cost efficiency.	- Privacy. - Security.	- Growing middle class. - Social trends changes. - Urbanization. - Social integration.	- Increasing of global regulations and policies.

Table 4.5. Future clusters and trends (Own illustration).

4.1.4.2. Interviews (Appendix.F.):

A: The work space in 10 years:

1- The physical workspace:
Based on the interviews with experts, the need for physical workspace or office space will remain for the human interaction, but will diminish within time due to flexible workspace solutions, as quoted by some respondents:

> ' Well I was thinking about it and would we still need an office building in 20-30 years, but I do think that there will still be a need for it, because you won't be working 5 days from home because you need human interaction, not only for productivity but also as human being, we are social people so we would like to have contact with each others. And I think these things wouldn't change.'

> ' Now you can see a lot of flexibility, however, I think on the long term, it will stay almost the same or a little bit the same as nowadays. I think that most companies will still use physical offices on a regular basis. It is good that people can work on the flexible base but I don't think that the future will become completely flex. Offices will be still required and will remain places where people can retreat. It is good that you can go to an office every morning because you are totally in different surroundings than working at home with too much distractions.'

2- Flexible workspaces, ' Space as a service' with more amenities and leisure (soft aspects and user satisfaction):
Most respondents mentioned flexible work spaces with more amenities as a current hot topic that could enhance productivity and cope with the current demand and culture, as stated by some respondents:

> ' More quality in new office building with the goal to increase the productivity of the users and efficiency in operating costs.'

> ',....., or you have a way other work environment that you have now, also flexible but more community like.'

' In terms of workspace, you might even have fewer desks, but what you will see is that your leisure, what I have seen and I am not that old, that people of 22, 23, 24 years of the age, they can go to the gym during the lunch, they quit at 5, so the working ethics are a little bit less, this is also the market.'

' Here in the bank, we just try to cut cost and I don't think that this is the best. I see some investors who are putting more social stuff into their buildings and they also have a rating by their tenants, how satisfy they are for renting in that building when they put more social manners in the building to let people connect better to each other, The satisfaction and production level will get much higher. I believe more social models are getting more than cutting cost.'

On the other hand, some respondents acclaimed that those flexible working spaces are not suitable for everyone, and there should be mix of different workspaces:

' We have come from the new way of working to more classical way of working because ,now from our experience, not everyone is suited for the new way of working, or not every company is suited, plus we work here in an open floor space in our office, and I like it because it is more fun to work, you have contacts with all your colleagues, but it can be really annoying as well if you have a call or if you want really to concentrate and everyone is walking around your desk, so the new way of working doesn't work,..'

' Personally, I prefer a combination of the two. I like working at home and doing a lot of stuff online but I don't like to do that for 5 days in a week. I really like to connect with colleagues. I also want to feel part of the team.'

3- Mixed use buildings:

The demand is shifting in the future to more mixed-use buildings where you can work, stay and do different activities, as described by some respondents:

' Mixed use (all type of uses blurred in one building) .'
' New building combined with residential and other commercial buildings .'

B: The most likely future trend that could affect the office market:

The described trends in the previous section (4.1.4.1) from the international surveys and reports have been written onto flash cards to be ordered on the predictability/impact on the Dutch office market matrix by interviewee as shown in (Appendix.H.).

The results are shown in table.4.6.:

Trend name	Predictability	Impact on the office market
Globalization , Regionalization	Moderate	Moderate
Sustainability, space as a service	Moderate : High	High
Technological innovation, big data:	Moderate	High
Mobility:	High	Moderate : High
Changing economy, Financial flexibility:	Low	High
Global security:	Low	Low to moderate
Changing demographics, Densification, Urbanization:	High	High
Legislation, Geopolitics:	Moderate	low

Table.4.6. Future trends and its predictability and impact on the office market (Own illustration based on the conducted interviews).

C: Real estate as a service (master class by Twynstra Gudde):

The main driver to start this concept is that real estate used to be not more than buildings, although it is made by people and for them as stated by Sjoerd Memelink - senior adviseur/projectmanager huisvesting & vastgoed at Twynstra Gudde – (2018) *'city doesn't revolve around buildings but rather around people who use buildings, and that should be the main focus in our opinion'*

Thus, a lot of initiatives started providing real estate as a service and working on this model to improve it for higher end-user satisfaction.

> *'.., our massage is that it is (real estate) more than spaces, it is something where may be the office owner, the investor, the project developer or another company will take full responsibility for managing an office for the end user, and what are the main incentives and goals to serve the end user in the optimal way, and this is going further than buildings'*
>
> Sjoerd Memelink- Twynstra Gudde

The problem:

The main problem faced Twynstra Gudda in their current accommodation is the fixed huge amount of space which is based on their max. number of employees, which fluctuated intensely as shown in fig.4.34. and they had to pay the same amount of rent each year (Memelink, 2018).

Another problem was that they have the most occupancy within their office on Friday, and the rest of the week is not that high, which is also different than other firms as shown in fig.4.35. (Memelink, 2018).

Aantal medewerkers?
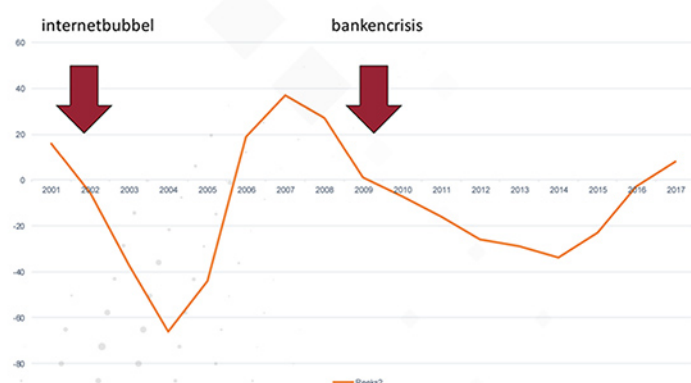
Fig.4.34. No. of employees 'Twynstra Gudde' (Memelink, 2018).

Fig.4.35. Office occupancy-rate during weekdays 'Twynstra Gudde'(Memelink, 2018).

Starting from 2016, Twynstra Gudde started to look for another accommodation that can fulfil their new demand and requirements rather than the current situation by looking at the following trends (Memlink, 2018):

1- Flexibility: in terms of technical issues and contract.
2- Sharing economy.
3- Co-working
4- Mobility
5- HR instrument: in terms of branding and mixing.
6- Sustainability (energy neutral building)
7- Circularity.
8- Integration to the community: multi tenants buildings with public areas for the community.
9- Technology and innovation.
8- Full service.
9- High quality spaces.

The solution:

After looking at different providers to this concept, they ended up with a building that will be developed by Schipper Bosch, who is a local developer and investor in Amersfoort.

The proposed new location is around 15 mins by walk from Amersfoort railway station but it is more integrated into the community as shown in fig.4.36. (Memlink, 2018).
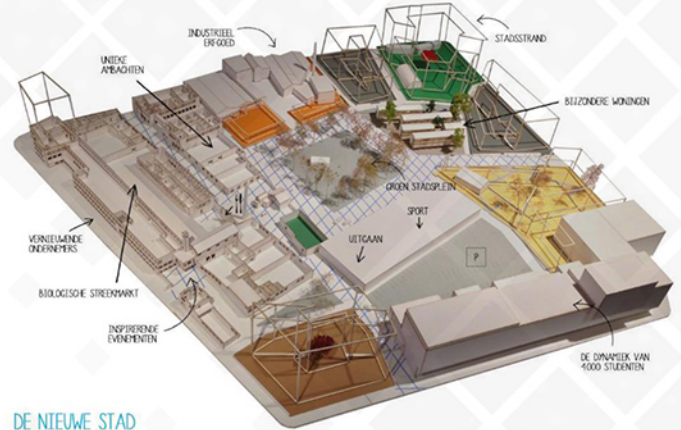
Fig.4.36. New location for'Twynstra Gudde' head office (Memelink, 2018).

They also offered a floor plan that integrates different activities and uses for higher productivity and user satisfaction as shown in fig.4.37. (Memelink, 2018).
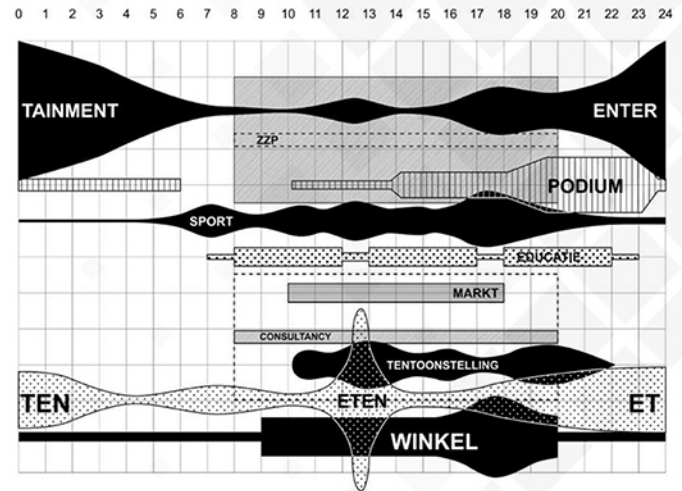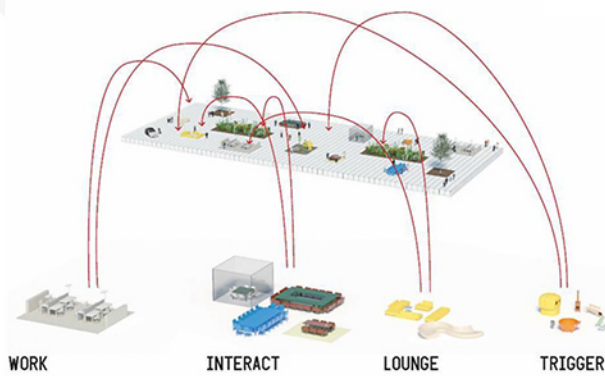
Fig.4.37. The new office concept of Twynstra Gudde (Memelink, 2018).

Finally, to solve the main problem they offered different rental plans for different spaces to allow the rent following the number of employees more for higher efficiency. Fig.4.38. showed a fixed space to rent which can cover the maximum occupancy during weekdays, the flex space is to be rented in Friday and other peak periods and the vacant space is an extra space to be rented in case of company expansion (Memelink, 2018).
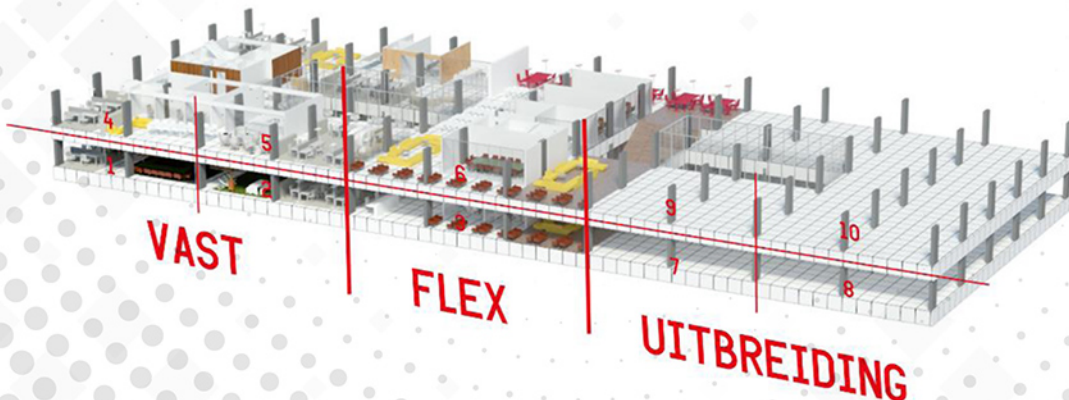
Fig.4.38. The new office floorplan of Twynstra Gudde (Memelink, 2018).

Results:

This plan offered them the main 4 pillars of their new accommodation strategy: technical flexibility, volume flexibility, higher quality and better service (fig.4.39.). Additionally, it is more financially efficient (fig.4.39.) (Memelink, 2018).

INDELINGSFLEXIBILITEIT
Customized typologie

VOLUMEFLEXIBILITEIT
Reservering tbv bijhuren en mogelijkheid tot afstoten

KWALITEIT
Uniek gebouw, uniek interieur & unieke context

SERVICE
One point of contact voor beheer & diensten

	Huidig	DNS
Huur	965k	580k
Parkeren	140k	100k
Overige kosten	395k	50k
Afschrijvingen	---	25k
Catering/printpark	150k	ntb
Totaal	**1.650k**	**755k**

Fig.4.39. Results of the Twynstra Gudde new plan (Memelink, 2018).

Main Findings:

• This case shows that the end-user preference is shifting towards new concepts that should be taken into account in the investment and development process, in order to sustain attractive and competitive in the real estate market.

• Real estate investors should work on a new business model and cashflow diagrams in case of providing this concept.

• New soft measures should be defined for capturing real estate value: productivity, satisfaction, etc.

4.2. Phase two:

This phase aims to develop a decision making model based on the results of phase one (practical + theoretical framework), which integrates (big) data analytics in the real estate investment decision process. The following steps are the followed logic sequence to visualize the main findings of the analysis till reaching the final detailed flowchart of the decision making process. Then, theses illustrations and models are reviewed for the expert panel to be validated with the main findings of phase one.

The main trigger of having this model and adapting it to the real estate investment process is not only being able to be prepared for the future but also predicting and being it. To illustrate, the vast availability of data and technology is forming a very complicated market, and to sustain in such a market, real estate players should think beyond the bricks and change their role from being re-active into pro-active based on predictive analytics and real time analytics, and to be more connected to end-users and demand.

4.2.1. Building the model:

1- It is argued in the results and discussions in theme one of the first phase that the whole real estate investment process cannot be fully automated because experience are still and will remain important but for asking the right question, checking or validating the data and the model results. Thus, the first goal of the model is to integrate three main components: data, technology and experience.

DATA   **TECHNOLOGY**   **EXPERIENCE (HUMAN FACTOR)**
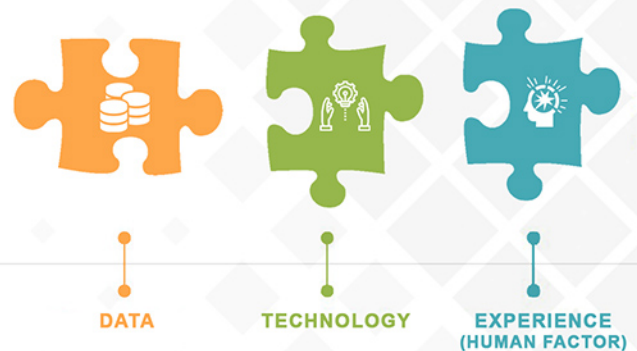
2- Based on the theoretical framework and the interviews' analysis, fig.4.40. shows the required data and type of analysis and methods for improving the real estate investment decision making process.

01

REQUIRED DATA:
(based on form)

A- Quantitative data: transactional data, building data, location, contracts, economic, etc.

B- Qualitative data: location data, user preference, user satisfaction, etc.

02

DATA SOURCES:
(based on the collection method)

A- Internal data sources:
  *Internal data bases (Api's, automatic, etc.)
  *Sensors and machine generated (Real-time data)
  *Manual human data

B- External data sources :
  *External data bases by data providers
  *Social media / web.

03

ANALYSIS TYPE:

- Descriptive & Exploratory
- Estimation
- Prediction

04

ANALYSIS METHODS:

- Analytics
- Predictive analytics
- Real time analysis
- Location based analysis
- Statistical & mathematical analysis
- Social networks/web analysis
- End-user's preference and satisfaction surveys

Fig.4.40. Required data and analysis (own illustration based on the results' analysis)

3- The model input contains 4 main data layers for acquisition: building & contract features, location features within the economic features, comparable transactions and end-use (behavioral) features. Besides another layer of real-time data for the optimization phase. Each layer conducts different type of analysis and algorithms. First, the rent should be determined by using the first two data sets and analytics. Second, the estimated rent will be compared to market prices for validation by using the comparable transactions data set. Then, end-use & emotional features layers will be added for capturing the growth potential or future-proofing value for any asset. Finally, the real-time data will be used for monitoring the asset performance in the operation phase, as shown in fig.4.41.
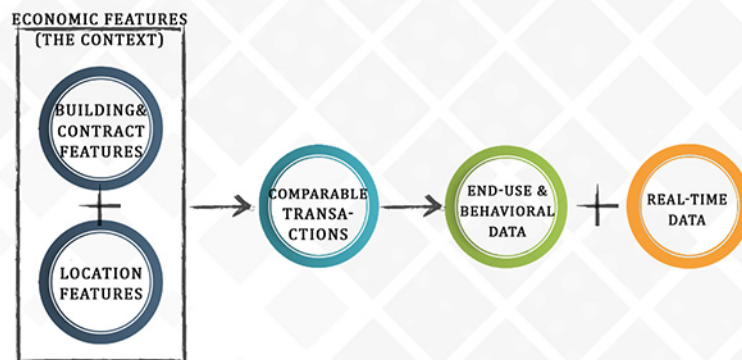
Fig.4.41. Required data layers (sets) (own illustration based on the results' analysis)

Furthermore, table.4.7. concludes the indicators and their availability to determine which needs to be improved, in addition to some studied data tools and platforms that could help, based on the previous analysis and results. The economic features were available on the state level but hardly available on the neighborhood level .

	Available indicators	Easier to be collected via big data analytics, smart tools or building and combining different data sets	Some available companies and tools in the Dutch market
A- Economic Features	1-GDP 2- Office employment rate 3- Annual interest rate 4- Annual depreciation rate of the building	1- Vacancy rate 2- Absorption rate (Net/Gross) 3- Office stock 4- Office supply (vacant stock)	**1- Geophy:** Real estate data platform Automated-valuation Smart location tool (grapevine)
B- Location Features	1- Distance to CBD 2- Distance to the Randstad area 3- Distance to public transportation 4- Distance to highways (road infrastructure) 5- Distance from airports 6- Parking facilities/fees	1- Charisma of the surroundings & Environmental amenities 2- Number of parking spaces	**2- Vastgoeddata:** Data platform that produces data sheet for buildings with most of the required indicators. **3- Cleverstone:** Real estate data platform Tool: Grip
C- Building Features	1- The building size 2- Building age 3- Building compatibility with the surroundings 4- Total floor area 5- Number of floors 6- Availability of external view 7- Privacy 8- Charisma of the entrance 9- Sustainability labels and certificates	1- Building materials and its quality 2- Building design 3- Building condition (structure) 4- LFA/GFA ratio 5- The percentage of common space 6- The percentage of unused space 7- Number of elevators 8- Ceiling height 9- Architectural quality 10- Flexibility 11- Lighting 12- Building amenities and services 13- Communication technology 14- Energy usage 15- Water usage 16- Waste production 17- Heating, cooling, Ventilation 18- Building layout (Single/ multi-tenants) 19- Renovation date 20- Health	**4- Lone rooftop:** Monitoring the occupancy rate, energy, lighting, etc. (operation phase- real time analysis) Tool: PIE **5- Leesman®:** Tracking the end-users' preference and workplace performance. **6- Torch (ABN/AMRO):** Managing portfolio in a reliable, efficient and secured way. (blockchain technology) **7- OfficeApp:** Managing the workspace. **8- WPA:** Managing the workspace.
D- Contract Features		1- Contract period 2- Incentives	

Table.4.7. Office market acquisition indicators, availability and available data solutions (own illustration based on the results' analysis)

4- Fig.4.42. shows the main real estate investment decision making process based on the analysis and results of the interviews (appendix.C. & appendix.G.). The theoretical frame work and the analysis of the interviews approved that the decision making process in practice is more iterative process (non-linear), thus the model is more circular and the inner arrows illustrate that in some steps of the process we should go back for either using some previous steps or checking the compatibility between different goals, strategies, constrains and the product.

Sourcing capital & sourcing debt are not included in the model steps because there is no fixed position for them, respondents placed sourcing capital alongside the first half of the process and sourcing debt later in the whole process. Another reason is that some investors use full equity.

Real estate investment decision Making Process

1- Defining general investment strategy

2- Defining initial goals / investors constraints/ risk-return preference

3- Defining related specific business questions/ decision making criteria (KPI's)

4- Macro Analysis: Market analysis, Socio-economic analysis

5- Sourcing products (Available sq.m. in the market)

6- Micro analysis: Property research, financial analysis, applying decision criteria, etc.

7- Future-proofing & predictive analytics

8- Financial analysis & business plan of different scenarios

9- Real estate investment opportunity selection/ consulting client.

10- optimization phase/ monitoring performance.

Sourcing Debt

Sourcing Capital

Fig.4.42. Real estate investment decision making model (own illustration)

The next part integrates all the mentioned steps and data types and analysis in more detailed flow chart. This flowchart (fig.4.43) contains input, source, process and outcome.

4.2.2. Real estate investment decisiom making flowchart:
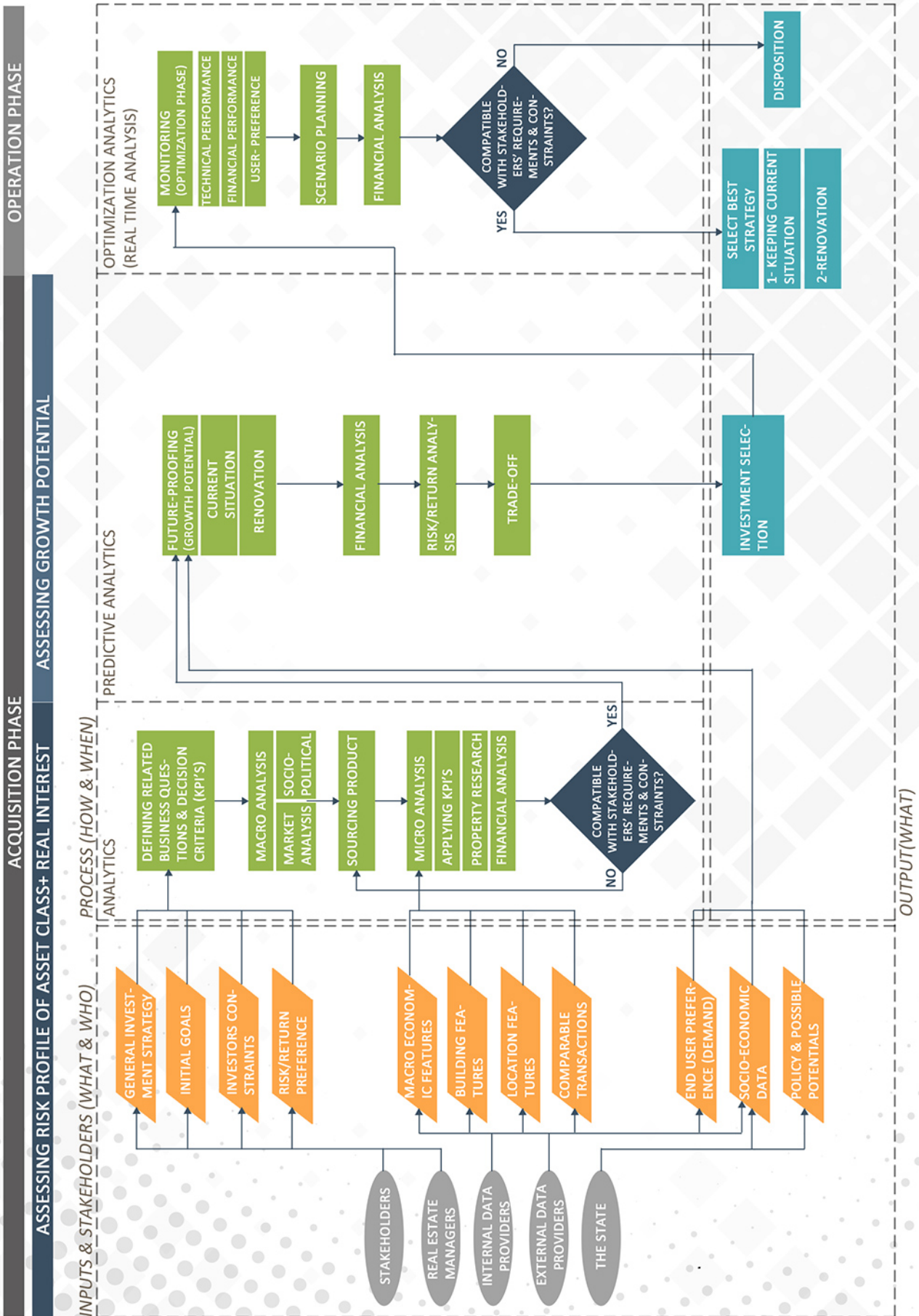
Fig.4.43. Real estate investment decision making flowchart (own illustration)

4.2.3. Validating sessions with experts (the expert panel):

Generally speaking, the main findings shown for the expert panel (Appendix.K.) are validated by them. Professionals agreed and confirmed the concluded answers of this research and the designed hypothesis as well. Furthermore, investors found it interesting to combine all the process in one graph as mentioned by them that those process are mostly what they do within their firms by stressing on some parts such as scenario planning and different analysis as stated by one investor *'good and nice to have such an overview, …, this is more or less what we are doing here, it is captured in one graph'*.

Some points and comments were mentioned by professionals in order to improve the developed real estate investment decision making model and flowchart. In the model, although professionals agreed to allocate sourcing capital along the right side through the first phases of the process and sourcing debt later in the process as explained during building the model based on the results of the interviews of phase one, it is proposed to convert it to a whole circle alongside the whole process as there is no specific position to that during the process and it differs from investor to another and from case to another as stated during one session with investors *'Sometimes you want to know how many debt you can attract early at the process,…, it differs for investor,…., even after the acquisition may be you want to optimize your debt or your equity structure, it is active in the whole process'*. Thus, both components are converted to sourcing and optimizing capital structure which is through the whole process as shown in fig.4.44.
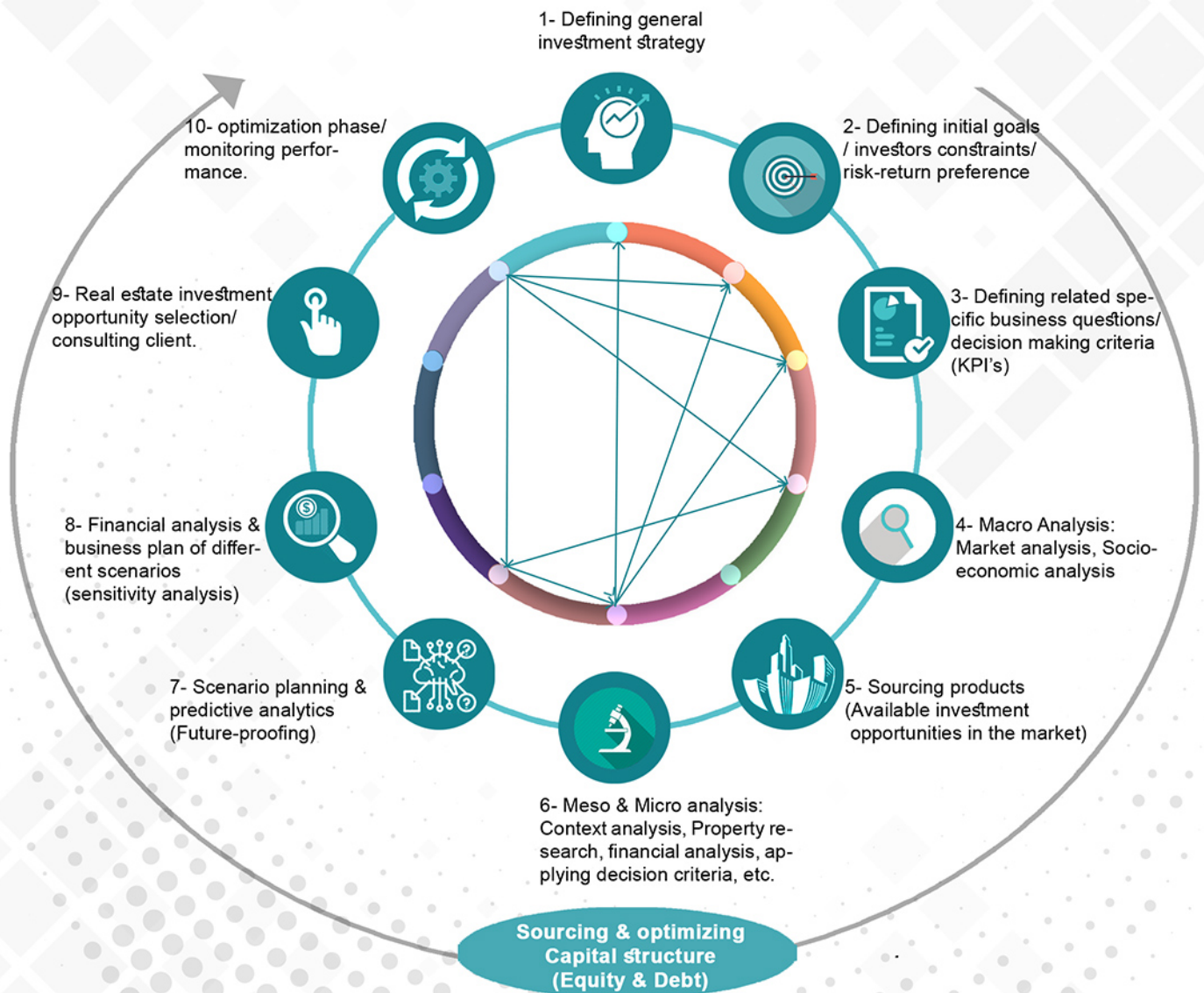
Fig.4.44. Final real estate investment decision making model (own illustration)

Furthermore, the following figure (4.45) shows the most steps to benefit from (big) data analytics and available tools and platforms within the market for assessing those analysis through the real estate investment decision making process.
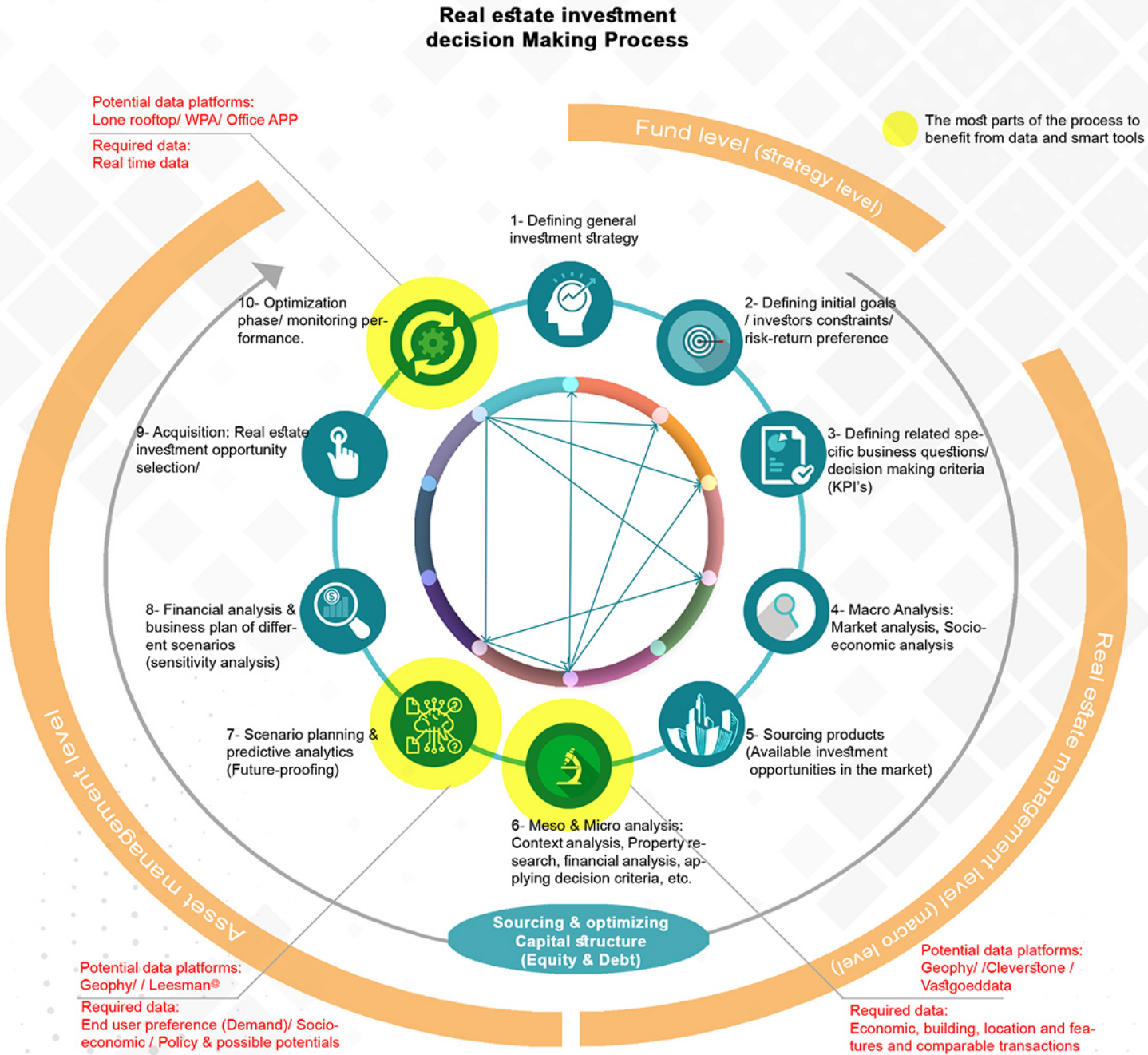
Fig.4.45. Real estate investment decision making model with elaborating (big) data potentials (own illustration)

Furthermore, few other changes were mentioned during the validation sessions for improving the flow-chart such as, adding a decision block before the investment selection and changing the renovation option in future proofing into asset management plan due to the fact that there are many options rather than renovation. For instance, it can be small investment, marketing, adding some floors as the case of the world trade center of Amsterdam or the atrium, etc. The final flowchart is illustrated in fig.4.46.

Looking at the final flowchart, it always has a closed loop in each stage till reaching specific investment or disposition. Thus, if the first loop of acquisition kept looping without finding the suitable product it should give an alert for stakeholders to redefine their main goals and criteria as stated by one expert:

> 'if it keeps looping, and if we don't have product, so you have to consider your initial goals and criteria'

Regarding the acquisition criteria and the availability of each indicator, professionals agreed to the con-cluded table.4.8. But only three additional indicators were mentioned (Appendix.K.). The first one is special clauses in the contract (e.g. breaking option, the right to sublease, etc.) which is seen as an important factor by many respondents and not available or easy accessible as well as mentioned during one of the validation sessions:

> 'This is really difficult,.., this is one of the most important parts actually,…, those are only available when it is up for sale via a broker otherwise you cannot get this information,.., I think you should include breaking options '

Another striking mentioned indicator is distance to different amenities as restaurants, bars, cafes, etc. and lease size can be also important.

One of the chief findings of the analysis is that the whole process cannot be totally automated and there should be always human intervention, in other words, it is about integrating human and machines rather than replacing human by machines. During the validation sessions and after explaining the auto-mation of some parts of the process, professionals acclaimed again that automation and data will help and improve the industry but it will never completely replace human especially in the outcome analysis and final decisions as acclaimed by some:

> 'the information and automation are perfect but the interpretation of that information is still human'

> 'the thing is because you are not dealing with homogenous commodity, there is so little data available for each individual transaction, and each individual transaction needs sort of validation of the data'

> 'If it goes to yes, you will still have to decide go or no go, and no go can be influenced by ex-ternal influence which can be something happened in-between, before you go to the deci-sion criteria, then you will always need someone to check because something might happen with economy, the state itself, or in the period between starting your model or the process and making the decision, I think there should always be a go or no go'

To illustrate, human intervention should be generally in starting the model by asking the right question and defining the main decision criteria, data validation, financial analysis, analysis interpretation, sce-nario planning, sourcing product, compatibility checks and final decisions. Thus, it will be more analyti-cal role. Fig.4.47. shows a heat map above the developed flowchart for illustrating how many respond-ents stressed the importance of human intervention in specific step based on the analysis in appendix.K. As argued also by some:

> 'sourcing product for now will always be a human touch, because it is not an open market'
> 'sourcing product is in contemporary market still human-driven.but I can imagine that will change, look at Funda in the housing market, …., I think you can minimize the human inter-vention there but you will always have a certain level of human interaction involved in sourc-ing product'
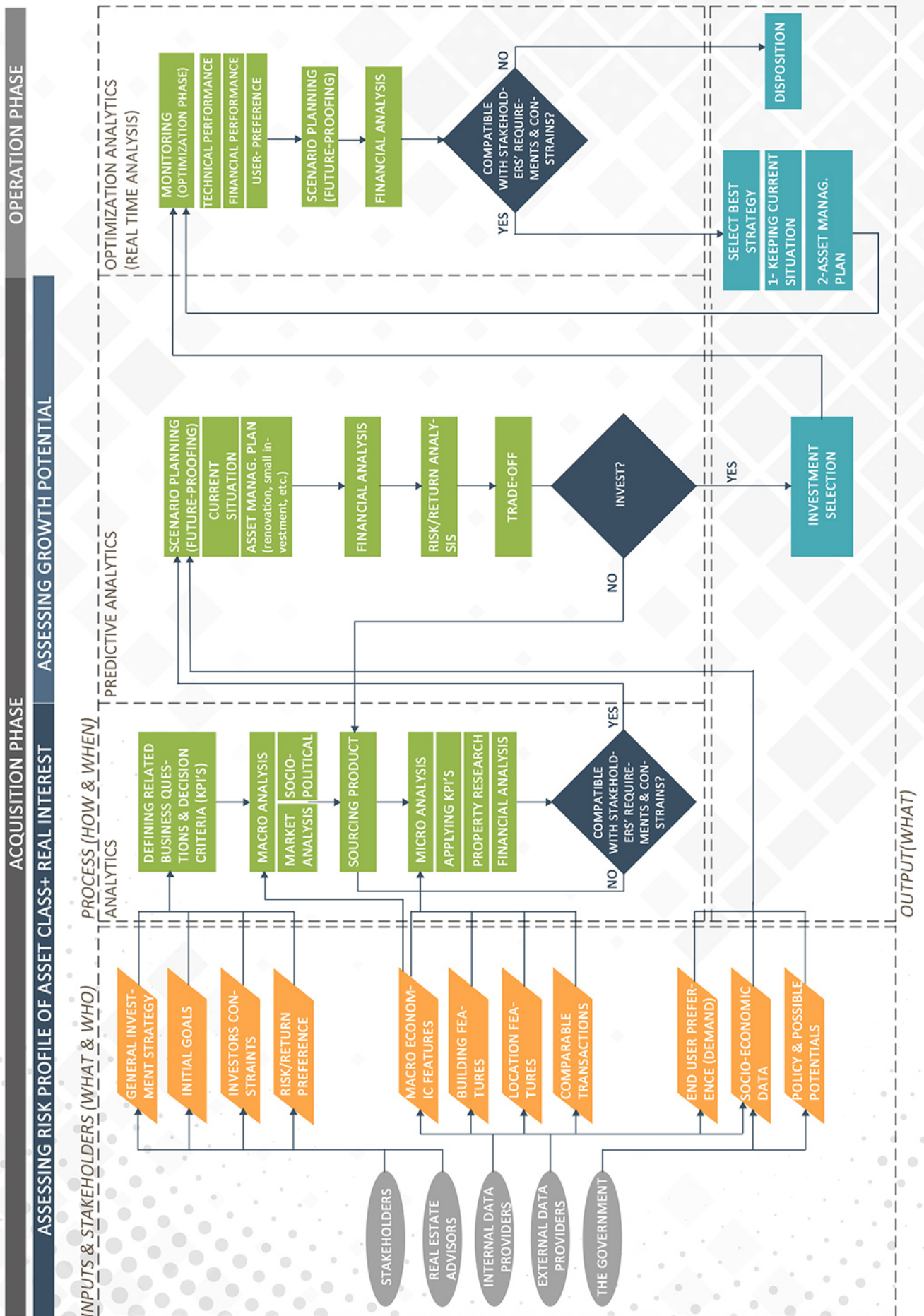
Fig.4.46. Final real estate investment decision making flowchart (own illustration)
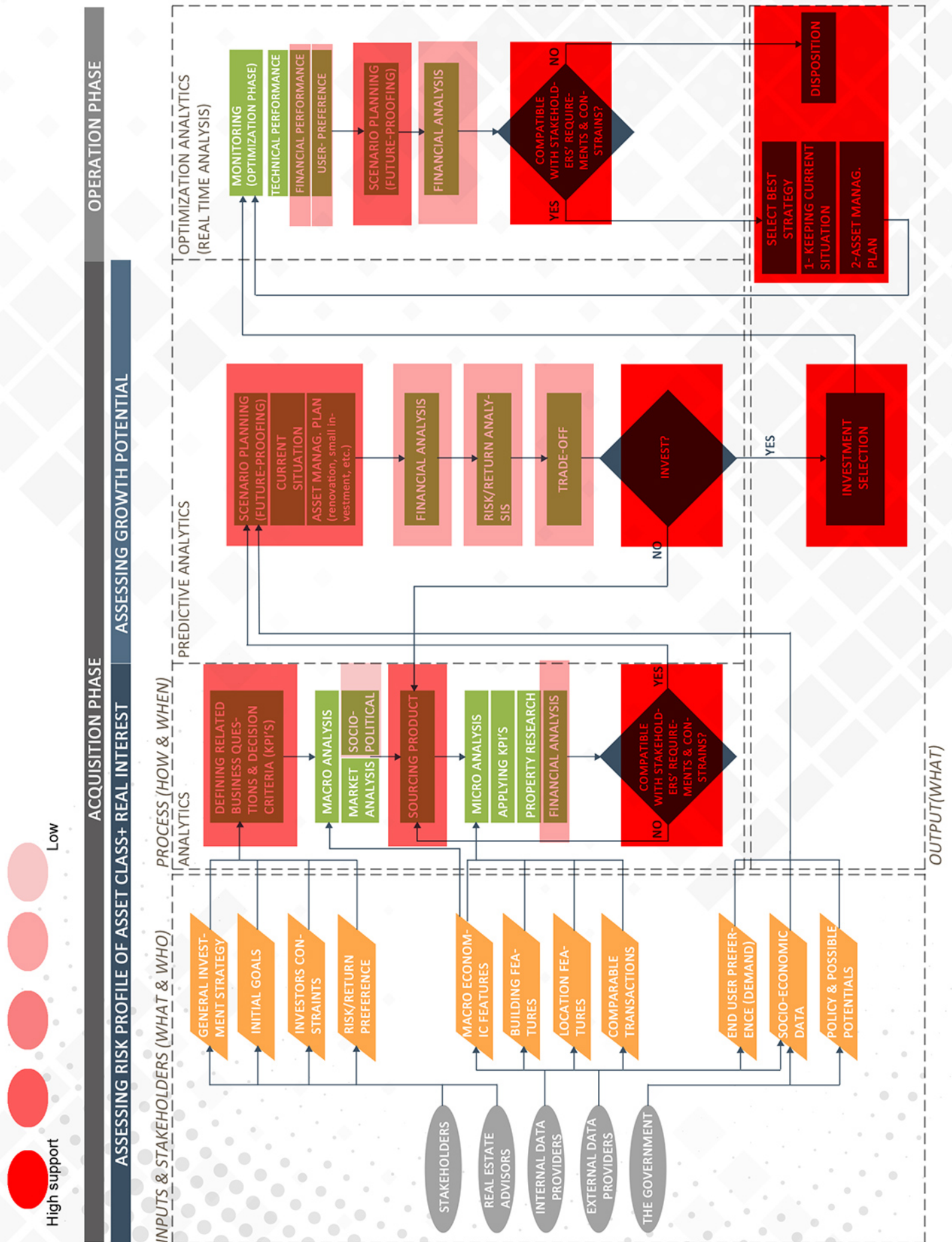
Fig.4.47. Required human intervention through the automated process (own illustration)

> 'the financial analysis, you can automate it till a certain level, or it becomes a black box, I think it is very dangerous if you rely on computers, …, you really have to know how it works, if it is all automated then people don't know what actually states and they cannot in-terpreted it'

In addition to the main mentioned benefits of adapting big data analytics and smart tools to the industry, professionals stated that having such a process and data bases will ease their role by achieving faster and better decisions, less human error and making them more focused on the outcome rather than the process for capturing more value and finding better investment opportunities as quoted by some:

> 'you can speed up the process, be faster in the competition, have the first check on your KPI's or your decision criteria, to see whether something really suits your need, and then you can act faster'

> 'this would be really perfect, if it is totally automated with this provided data, we always need to call brokers,..'

> 'the obvious answer is always in this case, finally we will have more time to just deal with the outcome instead of dealing with the process'

On the other hand, data availability, data accuracy and the mindset 'willing's of people to share and co-operate' remain big challenges, especially that many firms believe that acquiring more data and infor-mation is so beneficial for them to sustain in the market and sharing this data is considered as big risk for them and their competitive position in the market which results in losing their value as supported by some professionals:

> 'people don't want to cooperate because they think that they lose their benefits by sharing their data,….., you can have two perceptions on data of course, sharing is better so every-body will generate benefits of it but other people think that sharing is risk'

Furthermore, the more data available, the more moral debate is there. Privacy and moral issues are the opposite force of data growth and this moral debate is growing more and more. Accordingly, the cur-rent question changed from questioning about our ability to deploy and adapt big data analytics to inves-tigate how far we shall go and dive into this analytics. This moral debate is expected to grow and to even change in the coming years. That is what also noticed now through applying the GDPR (General Data Protection Regulation) by all entrepreneurs and receiving all emails about this new policy or regu-lation protecting personal data and informing users about what they are doing with their data. In that sense, some respondents approved that this moral issues are big challenge by stating:

> 'moral issues are a very big challenge,.., and I also think that knowledge and skills are very important,.., extremely'

> 'I think it is happening (Humanizing technology and technifying man), and for the time being I can fully understand that I can support it, but there is a moral debate about how far should you go, and the moral debate in 20 years will be different debate than the one that we have now'

Finally, automation and big data analytics are expected by professionals to be a main reason for dimin-ishing a lot of jobs and roles within the industry. Advisors believe that their role will diminish and there will be less need for advisors as one of their main roles in the market is providing data and information as the real estate market is not transparent, and if data is available and some models were developed to automate most of the process, then their role will decrease as quoted:

'I do think so because when you look at the housing market which has more data, 15 years ago, there was no computer and you really needed a real estate agent to sort of set a value on your house, etc. and now we can really sort it out ourselves,..'

'The more they know themselves, the more data is there, the smaller our position would be'

On the counter side, advisors are always needed even if the market is fully transparent. For example, the stock market is transparent market and there is still competition and need for advisors. Advisors are important because they know the market and they can have better insights and better interpretation for the outcome of the model in different phases for capturing the emotional value and making better decisions, taking the liability and providing the feeling of certainty as stated by some:

'The more data there is, the more transparent it is going to be, the less work field for us as advisors,.., however, I believe on the counter side that there is always a human aspect of advising and we are close to the market, I think that this benefit will always sustain'

'Advisors have the experience by doing what they do, .., and also think for larger private investors who are in the stock market or in real estate, for some reason advisors, can be more efficient because you can put your time into other stuff, then you can do more things at the same time because you have advisors, it is also liability question to hire legal advisors, not because that every step they do is that difficult and you wouldn't be able to do it yourself, but to have the liability of the legal advisors if something goes wrong, for some people it might be also a feeling of certainty to get the comfort,'

Moreover, may be the current roles or position will be diminish but different new roles will appear to run the model and validate the outcome. Technology is an infinite world and the human nature will never be satisfied. Thus, it is anticipated that we will be always working on developing new and better tools for improving the same process, it is an ongoing process that will never end, as quoted by one investor:

'…,if I looked back 10 years, I was still working on data gathering and I think that this will still continue, the more data and tools you have, the more you want to dive into those tools, …, you will be never satisfied, in ten years we will be also busy with the same thing (automation) but with different tools,…'

5. DISCUSSION:

This research started by addressing the main problems of the real estate market of being a complicated and imperfect market due to the lack of required information, that leads to unreliable investment decisions which based on guessed work instead of data. Subsequently, the purpose of this research is to investigate how to leverage big data and smart tools for reaching better and more informed decisions. This chapter discusses the main findings of both phases based on the conducted interviews and reviewed reports and case-studies by some companies in a relation to theory (the theoretical framework), trying to analyze the four themes in order to answer the research questions and validate the final developed model and main findings.

5.1. Phase one:

5.1.1. Theme 1: Decision making process:

- In general, almost all respondents validated the collected models in theory through building up their own models, using the proposed flash cards.

- First of all, the behavioral analysis of the decision process which was described in theory by Ahlers (1975), still plays an important role nowadays as noticed from the interviews that in practice, experience plays an important role and if one's gut feeling is not okay with certain property, the further analysis and models won't be even done. Which means that the mindset in real estate is leaking a bit behind in the data and IoT era and the process itself is mostly traditional. Gut feeling and experience are still and will remain important but for asking the right question, checking or validating the data and the model results, as this experience and gut feeling are not enough and contributed in a lot of bad decisions in the last crisis.

- It is also interesting to observe that most investors are still using the re-active traditional strategy and business model, although the shift in the market should be towards more pro-active role for sustaining in the fast changing context. Predicting the future opportunities and possibilities (predictive analytics) should be the new direction in the decision making process rather than analyzing the current situation and acting upon that, especially that more data is becoming available and the real estate investment task will be more challenging. From that perspective, real estate investors and advisors should change their business model to be more predictive and pro-active. Bouwinvest was the only respondent who claimed that they are shifting to more advising and pro-active role, and Yassine Zaghdoud from Cleverstone described that real estate investors should change their business model in order to be able to capture the soft side of the valuation process by defining the future possibilities.

- The decision making process in practice is more iterative process (non-linear), and flexible according to each case. Through building the decision model by respondents, it is noticed that they were going back in many phases for checking the compatibility between different goals, strategies, constraints and the product. Additionally, there was no standard order as many respondents couldn't place some steps in fixed position and put them alongside the model, which means that this step could be done in many phases or along specific phase.

- The decision making process differs according to the type of investor, for example in terms of financing: some investors are using their full equity and don't make use of debt, others finance part and the other part through using debt. In the latter case, the decision making model included more steps such as: sourcing capital and sourcing debt.

- Although the international surveys and reports that have been discussed in the results showed an important impact nowadays for the socio- political analysis on the investment process in the office market, most respondent excluded this step as part of the process.

•The holding period for office spaces are also related to the type of investor and asset. To illustrate, Bouwinvest are willing to hold the property for at least 20 years as they are long-term investors (Institutional investors and pension funds) and looking always for core properties. Cairn real estate are more short-term investors who are focusing on value-add properties can hold the property for 2,3 or 5 years. Additionally, advisors from other companies claimed that opportunistic investors might aim for even shorter period and insurance companies for really longer term (more than 20 years).

•Lastly, the valuation analysis is still done through very traditional approaches on excel, although many innovative and more accurate models are discussed in theory and other industries for decision making process such as: classification, regression trees, random forests and penalized regression, especially that the relation between the real estate decision indicators is not always linear. Moreover, the current mindset doesn't accept and trust automated valuation although they are claiming that it is possible and coming anyways. For example, Geophy started working on an automated valuation model which is based on the decision tree approach for more accuracy, but some respondents don't trust that and stated that they get the data from Geophy and doing the valuation traditionally themselves. People in the real estate industry should trust more in machines and collaborate with them for faster, better and more efficient decision.

5.1.2. Theme 2: Acquisition criteria (Dutch office market):

•In general, almost all respondents started by mentioning the financial performance of an asset when it comes to acquisition decision, which is logic as the main purpose of investors is making profit as stated before in theory by Manganelli (2015). However, long-term investors consider creating value by their investments through achieving some soft, healthy and social aspects with their assets. Those soft aspects can be seen in sustainability targets, healthy environments and creating communities. But at the end, their financial model should be satisfying enough.

•The mentioned indicators by investors are mostly exogenous indicators such as: rental level, vacancy rate, office take-up, demographics, location, sustainability, etc. which made it questionable if they are really considering the physical indicators in valuating an asset or in the decision making process. Of course, core assets should be high in quality but there is no specific criteria mentioned by investors or advisors. Furthermore, one investor realized in the interview that they only care about the exogenous indicators and they don't have specific hard indicators except the size of the building which is not also a restrict indicator.

•There is a significant shift in considering sustainability, health, indoor quality, user satisfaction, building and material quality, building amenities, charisma of the surroundings, energy use, ventilation, etc. as shown in the results of the open questions, survey by Leesman and score-cards. Most investors are doing that because it is highly demanded either by tenants especially corporate tenants or the government. However, long term investors are considering them as main values to the organization for their image and the quality of their portfolio.

•Location is the most important factor as described also before in theory that location is the first factor to affect the property value (Lusht, 2001), and will remain significant and important which could contrast to the study done by Kuyper (2014). Sustainable locations and charisma of the surroundings for the office market are getting more attention and parking will become less significant due to mobility, sustainability, electrical cars, etc.

•The theory concluded that vacancy rate has the most significant influence on rent followed by GDP and absorption rate, but in the practical frame work (score-card results), the vacancy rate is the most important factor as well with office-stock and supply but the absorption rate got more ranking than GDP in relation to rent.

Moreover, the theory stated that employment rate is significantly related but the results of the score-cards showed fair impact on the rent level.

•Contract length has a positive impact on rent, but incentives (free rental period , investment contributions, etc.) have significant impact, as approved from theory and practice. Furthermore, the new trend about flexible contracts, shorter term contracts and space as a service might form new risks for real estate investors, in terms of: less security, less predictable fixed cashflow, and financing as well. To illustrate banks will require higher margins and lower LTV ratio. Thus, investors should think more about attracting tenants and keeping current tenants for more security through increasing their building qualities and amenities.

•The data about all those indicators is not always available, reliable or accurate. Building a reliable, accurate and up-to-date data bases is the current significant key for investors to sustain in the coming future. More data leads to better, instant and more accurate decisions, as investors and advisors should focus more on their business models.

•To sum up, the required decision criteria and information for the valuation and decision process can be clustered in five main categories as shown in fig.5.1. the first two categories contain the technical (building), contract features and location features within the economic features as a context, that are necessary to estimate the rent level, through different possible methods such as: decision trees, regression, etc. then the third group which contains the historical comparable transaction will be used to validated the estimated rent in the previous step. The following step is trying to capture the emotional soft side of the property which can be potential future use. And this is by tracking the end-user preference, policies, masterplans, regular market research, etc. Finally, a real-time data is required for the optimization phase to trach the technical, financial and social performance of the building.
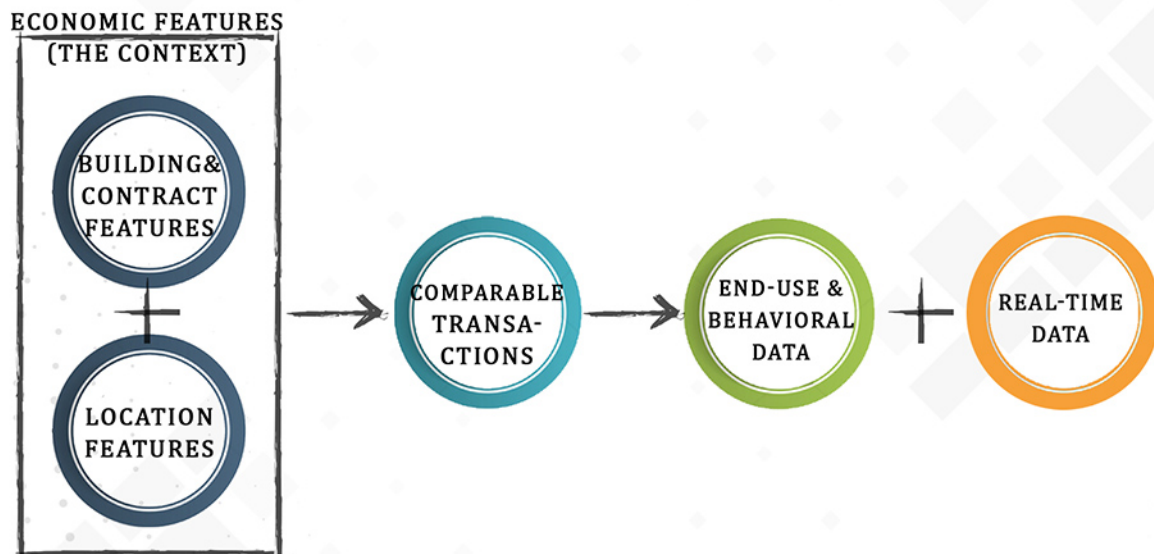
Fig.5.1. Required data and information for real estate investment management(own illustration)

5.1.3. Theme 3: Big data & smart tools:

•Transparency remains a big question. To illustrate, although most of the respondents stated that they totally agree with making the real estate market transparent, it wasn't really seen clearly in their responses, for instance: some of them couldn't disclose about some information as it is business related, others deploy transparency only internally within their firms.

It is also related to how big the investment company or the advisory company is. Big firms who acquire a lot of information and data were slightly against it because they have already big potential by acquiring this data, small firms were totally with transparency as data is not easy accessible for them and it is not also feasible or logic for them to invest in deploying big data analytics within their firm. Thus a mediator who can collect, process and acquire the data might be a solution. Moreover, they should be ready for it, as acclaimed by most of them that it is coming anyway, so it is better for investors to focus more on their business models and how can they capture value and potentials from this data as having the data is not enough. At the end, if we are really with transparency, one entity should start or the government should put some regulations for sharing specific data.

•All the mentioned benefits of big data were stated also by the interviewees such as: faster, better, instant and more accurate decisions, better real-time data, better insights and overview, better arguments, informed decisions, better future prediction, etc. However, they are still not actually working with big data but rather building some huge data bases to store comparable data and different characteristics. In other words, the real estate market is leaking a bit behind in terms of big data. The shown case of ABN/AMRO with lone rooftop for saving operational cost and tracking occupancy through sensors, Torch tool by ABN/AMRO bank and the location tool and automated valuation by Geophy represent good examples of deploying big data analytics, but other trials which have been mentioned in theory by google, such as, monitoring demand-supply, user preferences, leveraging social media, potentials for diversified investments, etc. are still not deployed in the Dutch real estate market, furthermore, some respondents believe that we are not there yet and it is far away.

•Although the theoretical framework mentioned many challenges as: complexity, mindset & culture, privacy and security, it ignored the most important challenge which has been mentioned in practice 'data availability and accuracy', and the willingness of people to share information. Another important challenge is the required money, time and effort to invest in big data. Thus, people within the industry should change their mindset, share, and cooperate to reach more accurate and accessible data. Therefore, real estate companies and data companies should be integrated and not competing, in order to reach faster and more efficient big data solutions, as it is not wise for each firm to do the whole process by itself. Real estate firms can also use the available data companies and might reflect on their methods and models to enhance their performance which is better also for real estate companies, as they will be more focused on their business and what they are good at.

•The significant shift in sustainability, energy use, water, technology, building quality and materials, and lighting, besides other soft aspects to be more important in the future (fig.4.7.), in addition to the unavailability of those indicators (table.4.4.) are main drivers for real estate investment firms to make use of big data and smart tools for capturing more value.

•Blockchain is striking solution that can tackle the accuracy, privacy and security issues as illustrated through the developed tool 'Torch' by ABN/AMRO bank, in addition to the different proposed solutions by interviewees, such as, comparing different data sets, manual check, random statistical check, acquiring the right skilled people who acquire it and real estate knowledge, internal data sets, etc.

•Finally, people within the real estate industry should trust in machines more and cooperate with them, trying to leverage all innovative methods and tools for further improvements. The integration of experience, data and technology through the whole process flow will enable decision makers to reach more informed decisions and will improve the real estate industry in general. So let's humanize technology and technifing man!

5.1.4. Theme 4: Future trends & scenarios:

•Value-creation should be the new future theme for real estate firms, which forms a big move towards high-quality assets with high quality services. The big move in the office market to 'Space as a service' - as agreed by most respondents in the held interviews by PWC and the urban land institute (2017), and the interviews of this research – will alter the business models and valuations for real estate investors.

This concept might result in more flexible and shorter contracts, higher operational cost, less price per sq.m., less required space, etc. as shown in the case of the new accommodation of Twynstra Gudde, they found a solution for having a flexible and less space with higher services and quality, but they could not find a solution yet for having a flexible contract.

To translate that for investors, it can result in big risks as there will not be fixed predictable cashflow. This could also mean more risk in terms of financing which might end up with having higher interest rate and less LTV ratio. Therefore, investors should develop new business model and valuation for future possibilities.

•Another important issue for valuation is the ability of valuing mixed use buildings and omni building based on the percentage of each use. This shift depicts new challenge for the traditional valuation models.

•Although political instability is ranked as one of the most concerned factors in the Emerging Trends Europe survey (2016), and Brexit is expected to have a major impact on the Dutch office market due to the fact that many companies should move to Amsterdam for its great location, the interviewees of this research ranked them to have moderate predictability and low impact on the Dutch office market.

•Whilst, changing economy is one of the most striking trends especially in the current stunning situation of the Dutch market as shown in fig.4.32., respondents gave it low predictability. Additionally, densification, changing demographics and urbanization are ranked as high impact and predictability in both reports and interviews.

•Technology and globalization are important future trends that vanished a lot of international and technical barriers and facilitated a lot of new business opportunities. Real estate investment players should think globally by combining the right technology with the right people for reaching more diversification, lower risk and higher profit.

The Dutch real estate market started already to consider the value of technology and big data, as many tools, data bases and platforms are found already and some of them were reviewed in this report. The next step should be integrating the available tools and innovations to the real estate investment business.

•Generally speaking, the real estate investment business will be more competitive and complicated with all the growing trends. Investors should integrate the demand and users' preferences in their model and think in real estate as more than bricks. Real estate investment players should also leverage technology and big data for reaching better and faster investment decisions.

5.2. Phase two:

In general, the discussions between professionals in the validation sessions helped a lot in validating and improving the outcome of this research. Gathering the main findings of the first analysis of phase one (first round of interviews) in one presentation (Appendix.J.) was essential for reaching concrete conclusions and outcome. The main challenges and benefits of adapting big data, acquisition criteria (indicators) and their availability, required data, analysis and techniques for automation, the developed real estate investment decision making model and flowchart were validated and approved by professionals by adding minor comments for further improvement. The final model and flowchart were shown before in fig.4.44. and 4.46.

Experience and gut feeling will always remain important part of the process but will be less, which means that the whole investment decision making process cannot be completely automated, but there will always be a need for human intervention in running the model, validating the data, interpreting the analysis and making the final decisions as shown in fig.4.47.

Although many firms started in deploying (big) data analytics, the real estate market and the mindset are still traditional and many people, especially advisors, see a big risk in sharing more data, as it will result in losing their potential and competitive position in the market. Accordingly, the developed automated decision making model and flowchart are noticed to be more supported by investors and banks than advisors. Advisors think that their role will be diminishing due to sharing more data and automation, although technology might open new jobs and roles for many people within the industry, thus there might be change in their role and not actually disappearance. In fact, automation will not take away our jobs but people should adapt their skills to the market demand. As illustrated by the economist David Autor (2017) that in the last 45 years since the introduction of the automated teller machine, the number of human bank tellers employed in the United States has roughly doubled but with different tasks such as solving problems and introducing new products rather than the routine cash handing tasks. There are two main reasons behind this paradox: human genius & creativity and human greed (people will never be satisfied and there will be always new work to do). Therefore, people within the industry should consider more the coming trends and their impact on their organizations and jobs to adapt themselves to the rapid technological change and be ready for the coming challenge.

In fact, automation opens new possibilities allowing us to come up with new ideas, products and services that opens up new opportunities and fields. In that sense, technology is main driver in increasing the role of human expertise and creativity.

The remaining question is whether we need to solve the transparency problem or lack of information by building different data bases and tools which are not transparent and available for everyone. Big data solutions could also be deployed internally in each firm with integrating some available data solutions and tools from the market rather than transforming the entire real estate market to be transparent, and this is for keeping the fun risky part that attract many people to the real estate game. This solution might increase the gap between big investment firms who afford to invest in those solutions and small investment firms. But in all cases, there will be competition because the solution is not only about having the data but what to do with this data and how to interpret it for achieving the right decision.

To sum up, adapting this smart model will benefit the industry allowing investors to focus more on the outcome rather than the process which saves a lot of time and helping in achieving more informed decisions based on more accurate and realistic arguments. To illustrate, having this real time overview allows investors to optimize their returns, selecting the right time and opportunity to reach better invest and risk-diversification based on wider range of data, information and analysis.

5.3. Research limitation and further recommendations:

This study revealed a lot of possibilities of big data analytics and smart tools that can improve the real estate investment decision making process by reviewing literature, real cases and tools and interviewing professionals. However, it has some limitations and challenges that have been noticed through the whole process.

The difficulties and challenges of carrying out this research could be stated in the following points. The main point to be figured out is the need of huge amount of data and statistics to be collected and analyzed for more efficiency and accuracy, especially in determining the impact of different indicators and features on the rent level of the office property. The conducted research method by giving professionals a score-card to rank and adding some indicators is really good in drawing a holistic general overview about different categories but it is not accurate enough to rely on in the valuation process. Therefore, a further quantitative study should be conducted on different data sets for higher accuracy.

Second limitation is the difficulty of managing the big size of population whom needed to make the results more reliable and the difficulties of approaching more investors to participate as many parties were not willing to participate. However, the research incorporated different and many other market players for better interpretation. Additionally, a big challenge was trying to arrange all the conducted interviews with different parties in that limited time, especially during the expert panel. A further recommendation is to combine more experts in one session as their discussions are so constructive and give more insights.

Third, a big challenge was translating all collected open answers from the interviews and finding a well-structured way to analyze them into concrete findings that could help in answering the main questions of this research trying to improve the performance of the real estate market which is a general challenge of qualitative studies. In case of repeating the same research, answers could be also analyzed in different ways which might be reason for creating and drawing additional insights.

Finally, the available time and budget are considered as major constraints to the whole research processes. Thus, the interviews investigated the four mentioned themes and it was more explorative general study to show different possibilities within the market and further focused researches and studies are needed in order to improve the proposed solution of this study according to different aspects and perspectives. This research is concluded by the general model for real estate investment decision making process and a further technical researches are required to convert it to a real dashboards which can be directly used. Moreover, it was focused on the Dutch office market and should be also adapted and validated in other markets.

As addressed at the beginning of this research that Block chain technology has many benefits especially for achieving more accuracy and reliability, further study focused on blockchain is necessary in order to check how can we tackle some of the mentioned challenges of big data.

Generally speaking, I recommend the whole market to be more transparent especially in sharing data, insights and information, and they should be more willing to participate in more studies, due to the fact that technology is the future and those studies will be also beneficial to them.

Finally, automation is coming anyway and will never completely replace human, thus a general recommendation is to change the current mind-set, trying to accept it, leverage and adapt to it by defining the different potentials of having it instead of fighting it, in order to be the future.

6. CONCLUSION:

The real estate market is a chief component of the world economic wealth which is also regarded as a complex and imperfect market based on the lack of different required information, that leads to less informed and unreliable decisions. The daily vast availability of data and smart tools, in the IoT and big data era, raised a striking question about how to make use of big data and those smart tools for achieving more informed real estate investment decisions in such a complex and fast changing context. Accordingly, the purpose of this research is to find out whether deploying big data analytics and different tools is beneficial for the real estate investment management and how to leverage them for making more informed real estate investment decisions based on data rather than guessed work in less time. Therefore, the following hypothesis is developed for this research:

'Big data and smart tools enhance the investment decision making process of office property for institutional real estate investors by reaching more accurate and informed decisions based on data and reliable analysis.'

In order to answer the main question and validate the developed hypothesis, this research is structured to start with reviewing literature about the main principles of the real estate investment management and related methods, techniques and approaches for assessing the real estate investment decision making process, besides investigating the current characteristics of the Dutch office market. Followed by reviewing literature about different hot topics, methods, tools and approaches of big data trying to find out how to bridge both areas. The operational part is mainly based on interviews with professionals and Delphi Expert Panel, in addition to reviewing some cases, reports, current tools and trials in the market and scorecards.

Real estate investment decision making process in practice followed the described models in theory starting from defining general strategy, goals and KPI's, collecting required data, micro, meso and macro analysis, scenario planning until making the final decision. But, the real estate market is still traditional market as professionals still follow the traditional methods and approaches in valuation and different analysis, besides basing their final investment selection on a lot of assumptions and gut feeling, despite the fact that there are many innovative tools and methods within the market that can open up more opportunities, but the current mind set is not ready enough for fully adapting and trusting in proposed innovative tools, methods and approaches.

The daily growing availability of data and different smart tools in a combination with globalization and technology, transformed the real estate market to be more complicated and competitive. Therefore, investors should mainly shift their role and business model to be predictive and pro-active instead of the current re-active role.

After building a general overview about the real estate investment decision making process, it was important to check which indicators, data and information are needed for the decision making process and to check whether this information is available or not. When it comes to investment decision (acquisition or disposition), the financial performance of the product is the most important indicator as the main purpose of investment is making profit. Respondents acclaimed that comparable transactions, net rental income, market values and other financial indicators are not available in the market. The required information were clustered in different data bases; the first one includes building, economic and contractual features, the second one is the location features, those two data bases will be used to estimate the rent level. The third data base contains the comparable transactional to validate the estimated rent then a fourth one is more for capturing the emotional side and future-proofing value of the building. Additionally, a real time data is needed for monitoring the asset performance in the operation phase. Another striking finding is the expected significant shift by professionals in some indicators such as, sustainability, building quality, materials, energy use, ventilation, health & well-being, charisma of the surroundings, location and building amenities, etc. But the more interesting finding is that those important data and information are not available or easily accessible. Therefore, adapting different tools and techniques is essential for improving the decision making process.

Professionals mentioned a lot of benefits of adapting (big)data methods and tools to the real estate investment management such as, faster, better, instant and more accurate decisions, better-real time analysis, better insights and arguments, more informed decisions, better future prediction, less risks, etc. however, many challenges were mentioned like, data availability and accuracy, complexity, mindset and the willingness of people to share and cooperate, the required money and time to invest, people skills and required technology, etc.

However, professionals approved that the decision making process cannot be fully automated and there will always be need for human intervention, experience and gut feeling. This human intervention will be more for starting the model by asking the right question and designing the required decision criteria, validating the data, interpreting the analysis and making the final decisions.

Despite the fact that all professionals approved strongly many benefits of deploying big data analytics and smart tools to the real estate investment management, transparency remains a big question in the industry. A lot of professionals see big data, automation and transparency as a big risk to their business and jobs, explaining that if there will be automation and transparency, their competitive positions and potentials within the market will be diminishing and there will not be competition within the market. On the contrary side, automation and technology opens new possibilities allowing us to come up with new ideas, products and services that opens up new opportunities, fields, new jobs and roles for many people within the industry. In addition, the solution for the current problems of the real estate market won't be solved by only having more data and information, it is more about interpreting those information for making good decisions, in other words there will be always a need for creative human thinking and it is more about humanizing technology and technifying man. Thus, automation will not take away our jobs but it will change our roles and create new different roles which is the main reason behind the paradox of increasing automation and employment power at the same time. In fact, individuals and firms should adapt themselves to the rapid technological change and be ready for the coming challenge.

In short, professionals and investors should believe that technology, automation and data are the future and they should adapt their business models and future growth to that.

Finally, technology, user satisfaction and flexibility are major trends in the office market which were main reason for emerging the concept of 'space as a service' and encouraged a big move in the real estate market towards high-quality assets with high quality services. Consequently, contracts are expected to be shorter and more flexible with higher operational cost and less cost per sq.m. that affects the real estate potential of having a stable predictable cashflow. Those trends and their impact should be also taken into account in the decision making process and the valuation process by defining new ways of valuation, assessing the associated risks and the future business model.

Based on the main findings and analysis of this research, an integrated real estate decision making model and flowchart that integrate technology and automation with human were developed and validated by professionals in the validation sessions.

To sum up, the developed integrated (technology + human) real estate investment model and flowchart in this report will benefit the industry allowing investors to focus more on the outcome rather than the process which helping them to achieve more informed decisions in less time based on more reliable arguments. To illustrate, having this real time overview allows investors to optimize their returns, selecting the right time and opportunity to invest and reach better risk-diversification based on the wider range of data, information and analysis.

This research is limited to the Dutch office market which has different characteristics than other markets or different uses. More studies in different markets and uses are recommended for validating the final findings and models, in addition to further improvements. The time is always a limitation to any explorative study due to the 'not enough' human nature and the vast availability of smart tools and innovations in different disciplines and industries.

7. REFLECTION:

During my study at TU Delft, I was exposed to many and different interesting disciplines, but I have noticed that my passion always goes to finance, real estate investment and portfolio management, and this was through different courses like: Asset Management, Finance & Economics, Real Estate Management, Land Valuation, etc. This passion and interest were the main drivers to choose my thesis topic about real estate investment. Additionally, another interest into innovation in the data and IOT era was increasing day after day, especially after attending the BIG Data Expo in Utrecht (Sep., 2017). Accordingly, I tried to bridge both hot topics during my research which I enjoyed and was always eager to gain more knowledge and do more analysis in both areas.

This part contains my personal reflection about the graduation project in terms of process, planning and outcome for my mentors and following students who are willing to conduct their research within those areas.

At the beginning of my research, it was clear which area I wanted to research but the exact scope and topic was not that clear. Thus, I started to read the most famous books, articles, and blogs about the topic, because in the MBE master track, we did not go into depth in those topics, however, many courses like finance, economy and management were extremely helpful for making me understanding the financial dilemma of real estate and being able to absorb extra knowledge in that domain. Additionally, having Philip Koppels at the early stages as an expert mentor in the real estate investment and the academic research field was a great potential, as he proposed as well some books, previous work and theses, which gave me more insights and helped me to figure out my main research topic and related subtopics.

The held feedback sessions between me and my mentors were a good guidance for me through the whole process in terms of keeping me on track, motivated and excited to go further and further. The most interesting thing is that all the feedback sessions were more like discussion sessions and my both mentors were open enough to listen and discuss my logic and argument behind each topic or phase. The combination between two different perspectives and backgrounds broadened my vision and the way of my analysis from different insights, which I hardly recommend for other researchers.

The selected methods for my research, interviews with experts and professionals, surveys, presentations, expos and the Delphi Expert Panel, were really suitable for such an explorative study. At the beginning, I thought that all my sample would be investors and advisors but lately I realized the importance of involving data companies in real estate and some companies who represent the end-user in order to be able to connect and compare supply perspective to demand perspective, as shown from the results and future trends that there is a new shift to the soft and social aspects in the real estate world.

The main challenge of the whole process was finding the right people to interview and the right materials to review. Arranging and analysing all the conducted interviews in this limited time was big challenge. Another difficulty was finding the right analytical methods to translate all these semi-structured interviews which mainly contains open questions and answers into tangible answers and conclusions that could help in improving the real estate investment domain. Moreover, joining Royal HaskoningDHV as a graduation company was really helpful in connecting me to different cases and contacts from different companies to interview, especially that they are really interested in innovation and smart solutions in different domains in real estate. Another limitation was of course the limited time of the research. Although this research was intensive and I spent a lot of time and effort in it, I was always passionate to explore more and more.

Through the whole process, I gained a lot of extremely valuable information and knowledge in both areas real estate investment and big data & innovation, first through the literature review and later through the interviews, cases and reports, which helped me to draw concrete conclusions for improving the real estate investment process in the Dutch office market. The results don't only include current situations but also future expectations within the next 10 years. To sum up, exposing to such a process answered a lot of personal questions in both area and filled up different gaps which I consider as a good preparation for my professional future as well.

Finally, this research topic is currently hot phenomenon and many companies already started working on improving the whole decision process and to be transformed into data-driven organization. Accordingly, I would recommend further academic studies and researches in order to cope with the rapid changing and complex world. Personally, I hope to continue working on the research concept within my coming professional life because I do believe that this topic is extremely important and could change the way we think in real estate in general and real estate investment in specific.

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9. APPENDIX:

A . The semi-structured interview script:

I. Introduction:

First of all, we would like to welcome and thank you for participating in this research.

This research is part of the Management in the Built Environment master track at TU Delft University with the cooperation of Royal HaskoningDHV engineering company.

The research aims to leverage big data and innovative smart tools for reaching more informed real estate investment decisions.

The purpose of this interview is to acquire insights into the investment decision making process, applied acquisition decision criteria and the impact of big data and current smart tools on the real estate investment domain for achieving more informed decisions.

The interview takes approximatively 60 min and consists of open questions and scorecard for the acquisition decision criteria. The collected data from this survey will be confidential and cited strictly to you or to anonymous in the results (according to your preference).

By the end of the interview, you could leave any further comments or questions regarding this interview.

II.QUESTIONS:

A. Investment decisions: (15 Min)

1- First of all, can you tell me more about your professional background?
2- Can you walk me through your daily routine in the office? What does your job entail?
3- The shown investment decision making models examples are found in theory. Can you describe the acquisition (investment) process in practice within your firm through the last three transactions? How do you make an acquisition decision for an office property? (by ordering the proposed flashcards).

Normative Framework

Source: Parker (2010)
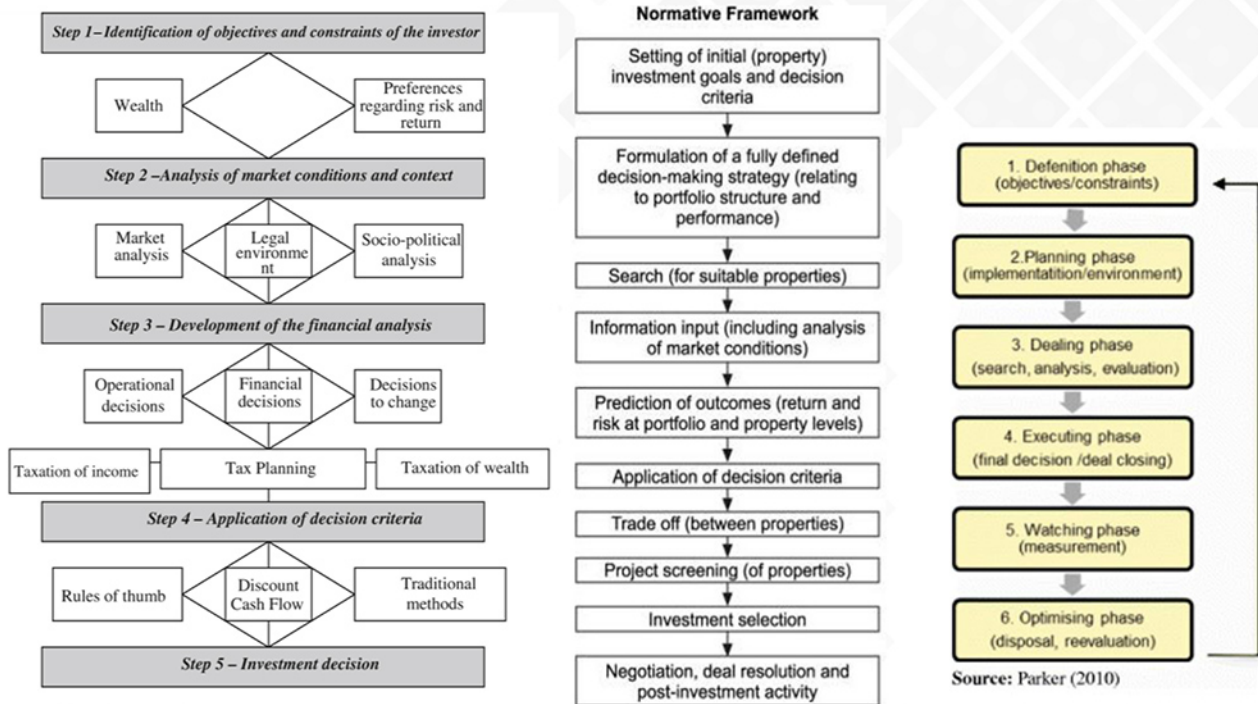
4- In the last three transactions, did you follow the traditional way of valuation or there were some innovative and smart tools? Explain.

5- What is the average time horizon for investment process in years?

6- Can you show me the last two transactions as examples?

B. Investment decision making Criteria: (10 Min)

1- Which acquisition criteria (indicators) are currently used for office buildings within your firm?

2- Which acquisition criteria could be included or excluded for the office building in ten years?

3- Is the required data available and easily accessible? Explain.

4- How big is the role of experience and gut feeling within the decision making process? Who is making the final decision?

5- What do you think about the concept 'the office as a service'? and how could it affect the office market?

C. Big data and smart tools: (20 Min)

1. In your opinion, what can be the competitive benefits of adapting big data to the real estate investment decision making process?

2. Can you explain the steps to be followed to deploy big data solutions to the real estate investment process?

3. Does the available data allows more informed decisions? Is it accurate, reliable, relevant and current?

4. How can you assure the accuracy of collected data?

5. What are the challenges of adapting big data to an investment firm?

6. Do you think that the current mindset and culture will accept and trust in big data analytics and machines (Automated valuation process)?
7. What are your expectations about the workspace in 10 years? And what is the impact on the office market?
8. What are the most likely future trend that can affect the office market? (the most predictable trends are shown in the flashcards)

Future trends
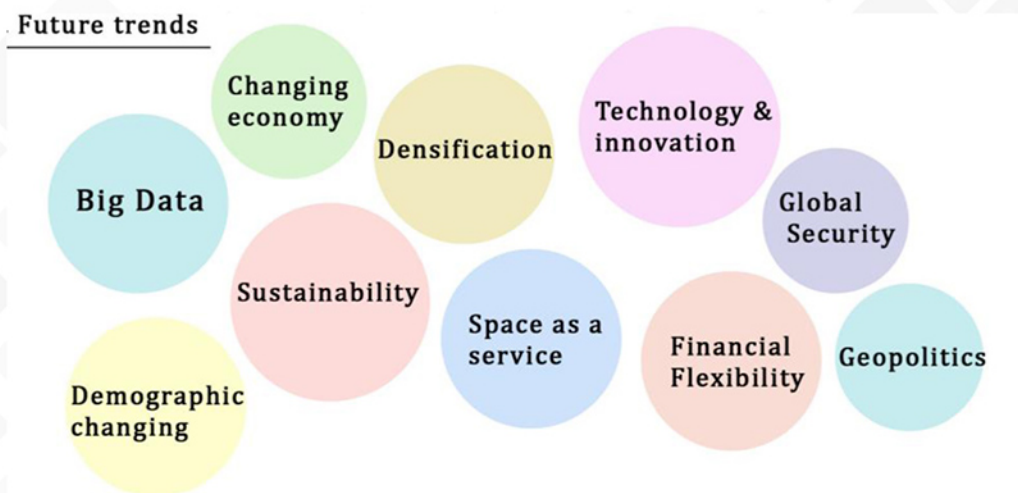
9. The current vast availability of data can tackle and solve the problem of the real estate market. In your opinion, do you think that big data should solve the problem of transparency or only the lack of information for specific entities? (Shall the real estate market become transparent?)
10. In your opinion, how can we leverage the social media in determining the end user preference? Does this have an impact on the financial performance of the building? Explain.

11. Did you adapt big data techniques to your firm?

If yes:
  a. Which techniques and tools are used for data collecting and analysis?
  b. How do you transform unstructured data into structured data?
  c. Which techniques and tools are used for data visualization?
  d. Do they alter your decision making model? Explain.

12. If the valuation and decision making process is automated, what will be in your opinion the new role of appraisals or investment managers?

D. Could you fill the attached scorecard for acquisition criteria (indicators) for determining their impact on the rent level (15 Min).
E. Other unprepared questions: (Min)

III. CONTACT SUMMARY SHEET:

Lastly, we would like to ask you about some personal information that will help us to categorize the answers, make it possible to contact you if we have some further questions and send you the draft report of this research for further comments and the final results.

Name of interviewee: _____

Company: _____

Current position: _____

Phone number: _____

E-mail address: _____

Nationality: _____

Date and time of interview: _____

Name of interviewer: _____

Thank you for your appreciated time.

B. The score-card:

Acquisition criteria (Indicators) for office spaces

1- Economic Features

Indicators (Criteria)	Impact on Rent (Currently)				Impact on Rent (In 10 years)				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
1- Vacancy rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2- Gross Domestic Product (GDP)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3- Absorption rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4- Office stock	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5- Office supply	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6- Office employement rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7- Annual interest rate	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8- Annual depreciation rate of the building	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Suggested additional Features (indicators)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

2- Location Features

Indicators (Criteria)	Impact on Rent (Currently)				Impact on Rent (In 10 years)				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
1- Distance to CBD	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2- Distance to the Randstad area	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3- Distance to public transportation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4- Distance to high ways (Road infrastructure)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5- Distance from Airports	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6- Charisma of surroundings & Environmental amenities (level of urbanization)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7- Parking fees	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8- Number of parking places	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Suggested additional Features (indicators)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

3- Building Features

Indicators (Criteria)	Impact on Rent (Currently)				Impact on Rent (In 10 years)				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
1- The building size (Total area)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
2- Building materials and its Quality.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3- Building Design	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4- Building Age	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5- Building condition (Structure)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6- Building compatibility with the surroundings	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7- Total Floar area	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8- Number of floors	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9- LFA/GFA ratio	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10- The percentage of comman space	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
11- The percentage of unused space	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
12- Number of elevators	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
13- Ceiling height	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
14- Availability of external view	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
15- Architectural quality	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
16- Privacy	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
17- Charisma of the entrance	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
18- Flexibility	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
19- Lighting	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
20- Building amenities and services	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
21- Communication technology	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
22- Sustainability label and certificates	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
23- Energy usage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
24- water usage	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
25- Waste production	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
26- Heating, cooling, ventilation	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Suggested additional Features (indicators)

4- Contract Features

Indicators (Criteria)	Impact on Rent (Currently)					Impact on Rent (In 10 years)					Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective		Very Effective	Fairly Effective	Not very Effective	Not at all Effective				
1- Contract Period (Years)	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐
2- Duration of rent free period	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐
Suggested additional Features (indicators)												
	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐		☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐

C. Analysis of Theme 1 (interviews' open questions):

1. Investors and Advisors (supply-side):

Interview/keyword	Theme 1 Process in practice	Decision making Excluded/added steps from theory	process Average investment time horizon	Traditional methods	Innovative methods
Interview 1	1- set general investment strategy/ setting of initial goals and decision criteria 2- Market analysis/ application of decision criteria 3- Source product 4- property research 5- Collecting data & information/ define risk preference vs return 6- Financial analysis 7- Trade-off between properties 8- Business Plan 9- Investment decision - Consulting client is along the whole process	Excluded: - Socio-political analysis - Define Detailed strategy - Set investor constraints Added: -Source Product -Business plan		- The valuation (appraising) process is outsourced.	- Smart rental contract (blockchain). - Torch: tool that connects the rental payments to the smart contracts for the data consistency.
Interview 2	1- Define risk preference vs return 2- Set general investment strategy/ Set investor constraints 3- Collecting data & information 4- Market analysis 5- application of decision criteria 6- Source product 7- property research/ financial analysis 8- Trade-off between properties 9- (Risk/ return analysis match)/ Consulting client 10- Investment selection	Excluded: - Socio-political analysis - define risk preference vs return (given by investors) Added: - Source Product - Risk/ return analysis match.	- Opportunistic investors: 2-3 years - Institutional investors/ pension funds: 5-10 years - Insurance companies: longer periods.	- For the financial analysis: comparable transactions. - Net present Value	- Working on a whole project based on big data and innovative ways to get the KPI's but still confidential.
Interview 3	1- Consulting clients (transaction) 2- Define risk preference vs return 3- set general investment strategy/ setting of initial goals and decision criteria 4- Set investor constraints/ Socio-political analysis 5- Define detailed strategy 6- Source product 7- Collecting data & information/	Added: - Consulting client (transaction) - Source Product - Business plan	Depending on the asset: Core assets: 10 to 15 years. Value add: 2-5 years "the higher the risk the shorter the holding period	- Depending on the complexity: - Cash flows (NPV) - Hardcore yields - Comparable transactions	- 'Not to the extend that we would like to but we are working on that' - Building own data base, project with big data

	Process	Excluded / Added	Time horizon	Methods	Tools
Interview 4	Market analysis/ property research 8- Business plan 9- Financial analysis 10- Application of decision criteria 11- Trade-off between properties 12- Investment selection 1- Define risk preference vs return/ set general/ Define detailed strategy 2- Collecting data & information/ Sourcing capital 3- Market analysis/ Socio-political analysis 4- Setting of initial goals and decision criteria/ Set investor constraints 5- Source product 6- Property research/ Application of decision criteria/ Financial analysis 7- Trade-off between properties 8- Investment selection * Collecting data & information is along the whole process	Excluded: - Consulting client Added: - Sourcing capital - Source Product	5 to 7 years But if the market go up faster, it will be less - Institutional investors: 10 years or even longer	- Traditional excel model DCF, GIY, comparable	- Data 360: a map with all the office buildings of the Netherlands and all the data is visualized on this map (building year, rent, lease ending, tenants, ...)
Interview 5	1- Set general investment strategy 2- Setting of initial goals and decision criteria 3- Set investor constraints/ Consulting client 4- Define detailed strategy/ Define risk preference vs return 5- Trade-off between properties/ Market analysis/ Socio-political analysis/ Business plan 6- Application of decision criteria/ Property research/ Financial analysis 7- investment selection/ Consulting client	Added: - Business plan	Long term investments (20 years) – Core properties	- Traditional ways (Excel,... etc.) Financial analysis: DCF	- Ready platform to collect and store the data. - Expanding more models and analysis.
Interview 6	1- Setting of initial goals and decision criteria 2- Set investor constraints/ Define	Excluded: - Socio-political analysis	- Opportunistic buyers: as soon as possible	- Traditional	

	Process steps	Added / Excluded	Investment horizon	Valuation & tools
Interview 7	risk preference vs return/ set general investment strategy 3- Collecting data & information/ Market analysis 4- Application of decision criteria 5- Define detailed strategy/ Sourcing capital/ sourcing debt. 6- Sourcing product/Consulting client/ Trade-off between properties 7- Property research/ Business plan 8- Financial analysis 9- investment selection 1- Set general investment strategy 2- Collecting data/ market analysis 3- Financial analysis/ Define risk preference vs return 4- Set investors constraints 5- Application of decision criteria 6- Consulting client- investment manager 7- Trade-off between properties 8- Investment selection	Added: - Source debt - Sourcing capital - Source Product - Business plan Excluded: - Setting of initial goals and decision criteria - Define detailed strategy - Socio-political analysis	- Core or Core plus: 5,10, 15 years - Pension fund: longer - Average of 5 year- - For big tenants in Amsterdam, we have 10 years. - Flexible spaces, half year contracts.	- Cash flow modeling - (NPV) - traditional valuation models - Using Geophy platform for getting the data
Interview 8	1- Set general investment strategy 2- Sourcing capital 3-Set investors constraints/ Setting of initial goals and decision criteria 4- Define detailed strategy/ Define risk preference vs return 5- Market analysis 6- Collecting data & information/ Property research/ application of decision criteria 7- Financial analysis/ debt sourcing/ business plan. 8- Investment selection 9- Consulting clients/ managements. - Trade off between properties depends on how many products. - Source product is alongside the second half of the	Excluded: - Socio-political analysis Added: - Sourcing Capital - Sourcing debt - Business plan - Sourcing product		- Cash flow modeling - (NPV) - traditional valuation models - Using Geophy and vastgoed data.

	process.				
Interview 9	1- Setting of initial goals and decision criteria 2- Property search 3- Set general investment strategy/ Define detailed strategy/ Set investors constraints 4- Market analysis/ financial analysis 5- Collecting data & information/ Application of Decision criteria. 6- Define risk preference vs return 7- Trade-off between properties 8- Consulting clients/ managements. 9- Investment selection	Excluded: -Socio-political analysis		- Cash Flow diagrams - Comparable transactions	- Call center department which collects data about the tenants around the Netherlands. - Building a huge data base of 14.000 buildings within the Netherlands
Interview 10	1- Consulting clients/ managements. 2- Set general investment strategy 3- Setting of initial goals and decision criteria / Define risk preference vs return 4- Socio-political analysis/ Collecting data & information/ Market analysis 5- Property research 6- Application of decision criteria 7- Financial analysis 8- Trade-off between properties 9- Investment selection 10- Consulting clients/ managements. (transaction)	Excluded: -Set investors constraints - Define detailed strategy		- Cash Flow diagrams - Comparable transactions	- Call center department which collects data about the tenants around the Netherlands. - Building a huge data base of 14.000 buildings within the Netherlands

D. Analysis of Theme 2 (interviews' open questions):

1. Investors and Advisors (supply-side):

Interview/keyword	Current Criteria (KPI's)	Acquisition — Added criteria in 10 years	Criteria — Excluded criteria in 10 years	'office market' — Data availability	Gut feeling & emotions
Interview 1	Location, Location, Location, Market value, rental level, maintenance cost, quality.	- Sustainability - Social connections - Building passports 'digital unique file for each building contains all building aspects '		Not all data is available	
Interview 2	Market rent, Vacancy rate, Office take-up	- Sustainability - Flexibility	Parking especially in good locations	Not available 'Not publicly available'	Not that much in the process. Only in trading off between very similar properties (irrational) I think 50%, 50%
Interview 3	Location, quality, rental income, cash-on-cash	- Portfolio diversification - Sustainability - Building services and amenities (laundry service, restaurant, coffee bar, parcel delivery, etc)		No sufficient data on transactions, actual preference of tenants.	
Interview 4	- Location - Demographic figures (Employment rate,...) - Demand	- Less office space (Flexibility) -Sustainability		No, not always , especially comparable transactions	It is pretty important, if it is not okay, they will not invest.
Interview 5	- Location: geographic focus on the big cities - Size: big assets - Sustainability - Transport hub location -	- Space as a service concept: operation will be more important - Soft and social aspects will be more important - Sustainability, user satisfaction		No, the market is quiet transparent in terms of each deal which is done and kind of listed somewhere but the details of all the deals are not available.	20% of the decision criteria, because it is always about the part that you cannot answer
Interview 6	- Getting your hand on a product	- Sustainable location - Sustainability - Possibility of transformation		Yea, I think so.	Very large especially for opportunistic buyers
Interview 7	Demand (occupancy/vacancy rate), accessibility by public transportation.	Mostly the same	Mostly the same	Not available specially for small companies. (local market features	It is not only about Automation, but also experience

Interview 8	Location (distance to transportation hubs), vacancy rate, price, sustainability.	- Sustainability - Health and well being - Air quality	we got it from big companies like CBRE) ,Building characteristics as well, but we use Geophy. The data is mostly available (Geophy, vastgoeddata, land registry, cadaster,....) But transaction and rental level data are not available.	90 % automated and 10 % has to be done by people.
Interview 9	IRR, Location,..	- Contracts flexibility - Notice period - Sustainability	Not all data is available	There is a lot of experience in the valuation process (Human check)
Interview 10	Added value for the property, vacancy, the quality of the building environment,	- Political factors (Brexit) - Polices - Sustainability	Not everything is available or accessible.	Less than 50%

2. Big data & real estate (innovation side):

Interview/keyword	Theme 2	Acquisition		Criteria	'office market'	
	Current Criteria (KPI's)	Added criteria in 10 years	Excluded criteria in 10 years	Data availability	Gut feeling & emotions
Interview 1	The value of the building, location, building characteristics, public transport, vacancy rate, what kind of tenants (public or private tenant,...), contextual criteria (surroundings, external factors)	- corporate and green - New ownership structures (flexible contracts)		It is out there but not clean nor ready to be used.	- No gut feeling at all - The valuation process in our firm is based 100% on data
Interview 2	Location, Building features, surroundings,	- Everything should be included		- General demographic numbers are available but on the lower level is not that easy.	- No gut feeling at all - The valuation process in our firm is based 100% on data
Interview 3					
Interview 4					
Interview 5					

3. End-users (demand-side):

Interview/keyword	Theme 2	Acquisition	Criteria	'office market'	
	Current Criteria (KPI's)	Added criteria in 10 years	Excluded criteria in 10 years	Data availability	Gut feeling & emotions
Interview 1	- Health and well-being - Sustainability - Flexible office space and contract (adaptability) - Inspiring work spaces and meeting spaces				
Interview 2	-Location - Local government plan and demand - it depends also on the organization (specific location, criteria, etc.)			- Not always.	- Important especially in complex real estate - You have to base it on good data and arguments
Interview 3					

E. Analysis of Theme 3 (interviews' open questions):

1. Investors and Advisors (supply-side):

Theme 3 Interview/keyword	Benefits to real estate investment	Main Challenges	Big Data & Smart tools Data 'Accurate, relevant,	Data accuracy assurance	Mind-set Acceptance
Interview 1	- lower risk. - Better data. - It will be cheaper to buy a building (Lower transaction cost). - Easier system.	- The mindset of investors (the willingness to share). - Moral issues. (Privacy)	Not accurate enough	- Manual input -Blockchain - Torch tool	- People will adapt to it but Dutch people are pretty critical on that.
Interview 2	- Making better decisions 'I think the people in the industry should make use of big data'	- It takes a lot of time and resources to deploy it. - Difficult to reach transparency (sharing) 'it should be phased by regulations'	Not Accurate (data companies lack market experience)	- Data providers should have market experience	- It is coming any way
Interview 3	- More accurate, comparable market insights -Adapting faster to user preference change - Provide insights on the general trends in the market - giving you the opportunity to approach potential investors whom you never seen before	- Getting accurate data - The quality of the data	Not accurate	- Should be in the input side, new input systems should be defined.	Almost, older people needs around 10 to 15 years to go but our generation is ready.
Interview 4	- Visualizing facts - easier and better overview to give a decision	- the ability of checking and controlling the process - needs a lot of money and effort	I wouldn't say 100% but almost accurate	- hard because it is not public	More and more but not entirely (a bit behind compare to other industries)
Interview 5	- Act quicker than competitors - better future prediction: predictive analytics - More details, more precise	- Data availability and quality. - Security, safety and privacy - People skills	No	- use multiple data sources on top of each other's. - Automation - Blockchain	Yea, I think so
Interview 6	- Quicker and easier decisions. - better overview.	- The lack of information on some factors like: incentives, under table deals and emotions.	Yes.		
Interview 7	- Easier to get required data and information for valuation and	- A lot of money and time to invest, suitable more for big firms.	Yes.		The automated process is coming

	investment decision process. - More accurate assumptions (Vacancy rate, take-up, rental level, tenants behavior and intendency etc.)		Not at all. But it gives certain idea about the market.	It doesn't need to be 100% accurate, they are just indicators.	anyway.
Interview 8	- Reducing risks. - The decision making process could be a way faster. - It could help in providing a better KPI's and detailed strategy. - It would massively increase the speed of gathering data and being able to actually process the entire investment decision which saves weeks of work.	- Privacy - Technology - Willingness of people to cooperate			Within our company, yes. In general, I am not sure yet if they are ready for this open cultures.
Interview 9	- More transparency - Better data and information.	- The willingness of some people to share - The data base will never be complete - The quality and accuracy of data	Not accurate	Manual input	yes
Interview 10	- Provide more data and information - Better knowledge of prices - More accurate and faster decisions	- the market will be at the same level (no competition)	Not accurate enough	- Blockchain - we compare both data bases for the buildings that we build ourselves and the one from the call center.	- yes
Interview 11	- More data = more knowledge = making better decisions	-Make if functional and easy in use.	- 95% reliable and accurate through vastgoeddata.nl	-Standardization & random checks	- without data you are nothing more than a person with an opinion.

Interview/keyword	Theme 3 Social Media	Big Data & Smart tools Techniques for collecting and processing data	Techniques for analyzing and visualizing data	100% Automation (agree/disagree)	The new role of appraisals
Interview 1	Predicting the needs of your potential renters better	Manually or by connecting data bases through Api's			
Interview 2	Using Facebook to derive some information, but we are not nearly there yet.	Own transaction database.		No, you can automate most of it but there are always less tangible factors	- Advisors will be needed, it is not about the data but what to do with the information or data.
Interview 3	- Tracking what people do and where they go. - How much leased space, locations, user-preference	- Support agency department: provide input on estimated renal value and other requirements. (own database) - From external and internal sources. Partly automated.		Yes, I am with this	What will never change is matching sellers to buyers and that is why specialists are needed. Now it is more consulting level, it will be more data driven.
Interview 4		- Manually (transaction data base)		That is good but we cannot only use data, we need also people who can understand it and work with it	
Interview 5		- API's Open data sources and buying data sets		Yes, but not now may be in 20-30 years	Checking whether the data is valid, asking the right question and thinking of new questions
Interview 6	Marketing tool (acquisition, leasing ......)	- Traditional		No, for the emotional side of investors.	Grabbing the emotional part and experience of the decision process
Interview 7		- Geophy platform - CBRE and big firms		I am not against it because you can not	There will not be role anymore although there is

Interview	Recommendation	Data sources	Quote	Key point
		- Cadaster	stop it, it is coming any way. But in our firm, we use big data in getting the information, but we like to determine the values and cashflow modeling ourselves.	always a need of experience
Interview 8		- Geophy platform - CBRE and big firms - Cadaster	You cannot fully automate it	Matching demand with supply
Interview 9	- Better marketing 'Not really important'	- Own data base of 14.000 buildings in the Netherlands. - Call center department for gathering information from tenants - Retrieving data is manual	No, you will always need a human check and experience	Check and experience
Interview 10		- Own data base of 14.000 buildings in the Netherlands. - Call center department for gathering information from tenants	No 'I cannot fully trust machines'	The market is also about seeing the opportunities which needs a human touch (not only numbers)
Interview 11	- A survey with the end-user is more recommended	- Uses Vastgoeddata.nl	- Human final check is needed	- Final checks and making the decisions instead of collecting data

2. Big data & real estate (innovation side):

Theme 3		Big Data & Smart tools			
Interview/keyword	Benefits to real estate investment	Main Challenges	Data 'Accurate, relevant,	Data accuracy assurance	Mind-set Acceptance
Interview 1	More accurate, instant (faster) decisions, and accessible value (informed)	- Explaining it to people	Yes 'the data is there'	-Manual check - checking the confidence of the model	- Most big companies consider adapting it.
Interview 2	- Better informed decisions. - Faster decisions.		- Data is there but not publicly available	- Small mistakes doesn't affect very large sets	- yes.
Interview 3					
Interview 4	- Better arguments for decisions - Faster decisions - Getting more insights in different markets	- Data accuracy and availability - 'Getting the correct data and information'	- Accuracy is a big challenge	- Comparing different data sets - Manual check and calling tenants - Location specialist	- yes, but slow
Interview 5	- Being able to benchmark between assets - Better future expectations especially about the building use - Making better decisions at the right moment - Better overview on the portfolio	- Mind set of people 'real estate and government are away behind' - Data doesn't talk to each others	- Not really accurate or current	- Internal input for the data. - Putting the data together based on bottom-up approach (sensors, object managers)	- People think it is far away

Theme 3		Big Data & Smart tools			
Interview/keyword	Social Media	Techniques for collecting and processing data	Techniques for analyzing and visualizing data	100% Automation (agree/disagree)	The new role of appraisals
Interview 1	- Good marketing tool - expecting the preference of the end-user	- Mostly from Excel sheets, and csv format, - the data merged by using python language - stored in own semantic core data base	- QGIS - Mad-box	- Yes, we are working on that.	- Appraisals are used for many reasons 'it depends'
Interview 2	- Using Facebook events and venues to measure vibrancy within specific area.	- Manually - Using API's - Scrapping structured websites	- Spatial programming. - A lot of statistics and analytics	- Yes	
Interview 3					
Interview 4	- Tough one for the office market 'no possibilities at the moment'.	- Using API's - Manually (rental transactions)	- Web interfaces - New user interfaces - Elastic search engine	- It is better for the market but it is not our goal.	
Interview 5		- Manually - Connecting API's to different data bases	- Our own developed GRIP® application, GRIP dashboards and other web based applications	- No, small part will remain non-automated	- Grabbing the emotion side of property valuation and future possible uses of the building.

3. End-users (demand-side):

Theme 3 — Big Data & Smart tools

Interview/keyword	Benefits to real estate investment	Main Challenges	Data 'Accurate, relevant,	Data accuracy assurance	Mind-set Acceptance
Interview 1	- Getting more real-time data on the building performance - Optimizing the usage of a building in serving the users - Optimizing the maintenance	- Privacy - Convincing real estate owners to invest in big data			- Only the frontrunners, others doesn't contact the end-users.
Interview 2	- Better valuation	- Data availability on specific real estate - Mixed-use/ complex real estate	- Not always accurate, because some data is based on national level (not exact data)	- Personal check - transparency behind the source of the data	- Some parts are more than ready, but others still not - Government: we can accept it for some normal real estate but not for complex
Interview 3					

Theme 3 — Big Data & Smart tools

Interview/keyword	Social Media	Techniques for collecting and processing data	Techniques for analyzing and visualizing data	100% Automation (agree/disagree)	The new role of appraisals
Interview 1					
Interview 2				- But there should be a personal touch 'data should follow emotions'	- Finishing touch - Capturing the emotional part (human)
Interview 3					

F. Analysis of Theme 4 (interviews' open questions):

1. Investors and Advisors (supply-side):

Theme 4	Future trends & scenarios	
Interview/keyword	The workspace in 10 years	
Interview 1	Two possibilities: 1- People are working at home and more online meetings (more virtual). 2- More flexible spaces with more social amenities. It will be more than a place to work but rather a social being	
Interview 2	- Flexible offices/ space as a service. - Co-working environment (Agility). Higher risk for investors. (financing: higher margin and lower LTV).	
Interview 3	- It will be different and may be more virtual but we will still doing things in Excel and PowerPoint - Work space will be with less desks and more leisure - More green and healthy 'making your work space more fun than just a place'	
Interview 4	- Flexible office space - less face-to-face meetings	
Interview 5	- There will still be a need for an office building, because need human interaction, not only for productivity but also as human being, - Mixed use (all type of uses blurred in one building)	
Interview 6	- Mix between everything (open floors, cells, silent spaces,….) - The new way of working does not work because it doesn't suit each company nor person.	
Interview 7	- Flexible offices with short term contract - Space as a service.	
Interview 10	- Flexible office spaces - The physical office space will remain.	
Interview 11	- More people are working for some days at home & IT makes it possible to be more efficient in the use of workspace - Demand of office building would be decreasing - New building combined with residential and other commercial buildings (mixed use) - More quality in new office building with the goal to increase the productivity of the users and efficiency in operating costs	

G. Decision making models by interviewees (flash-cards):
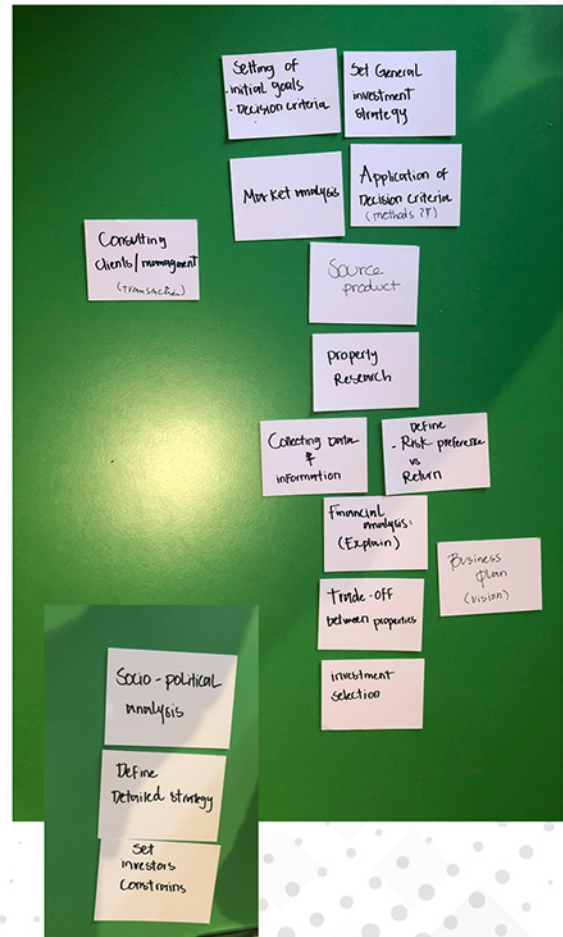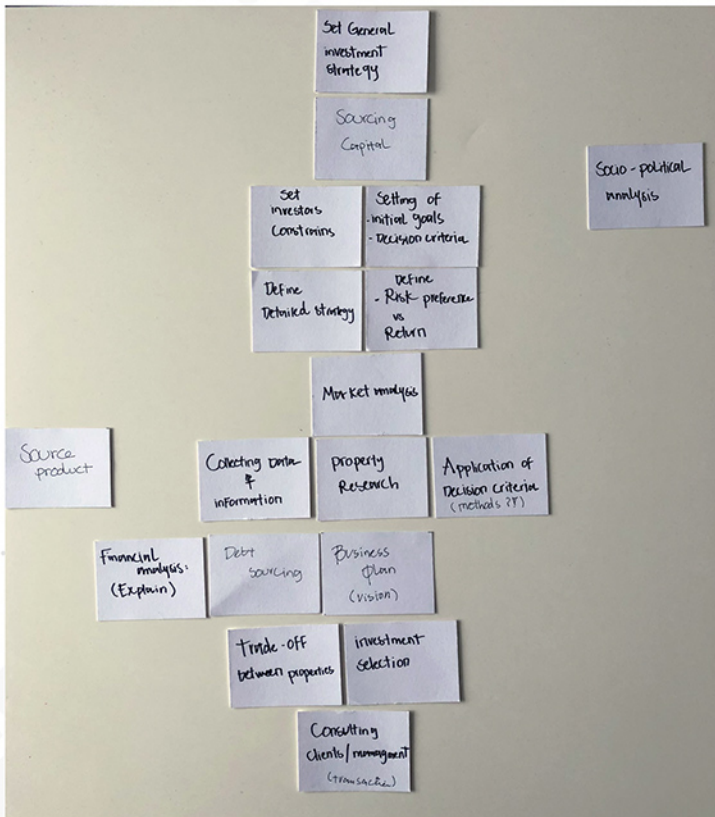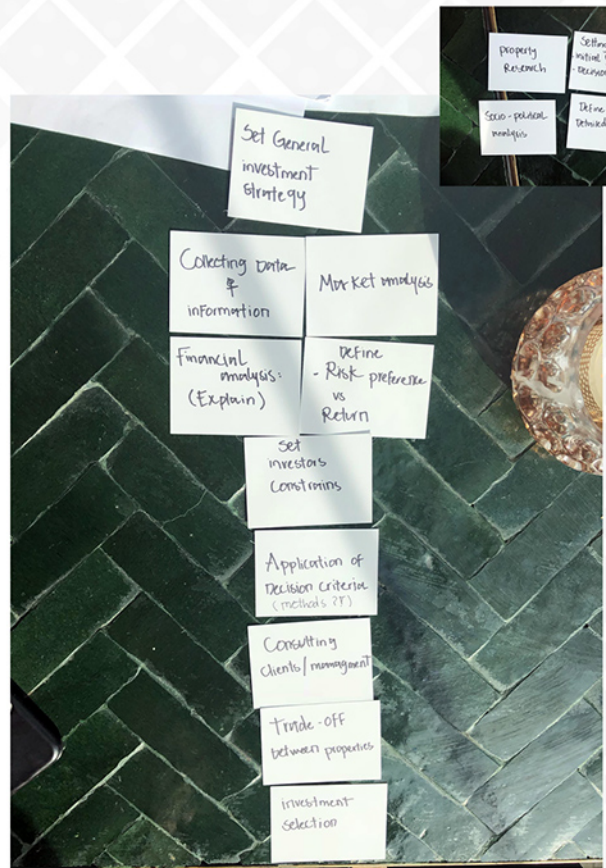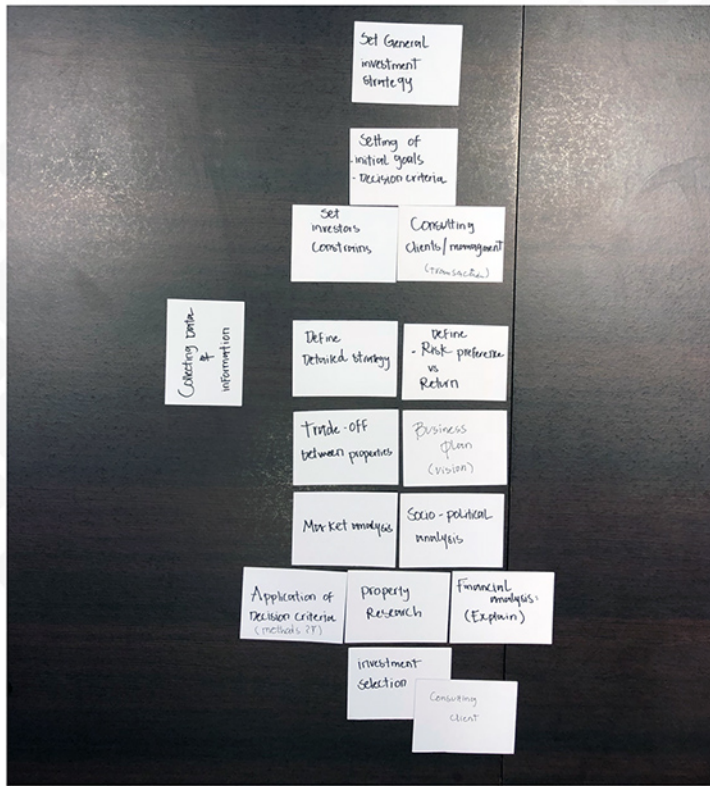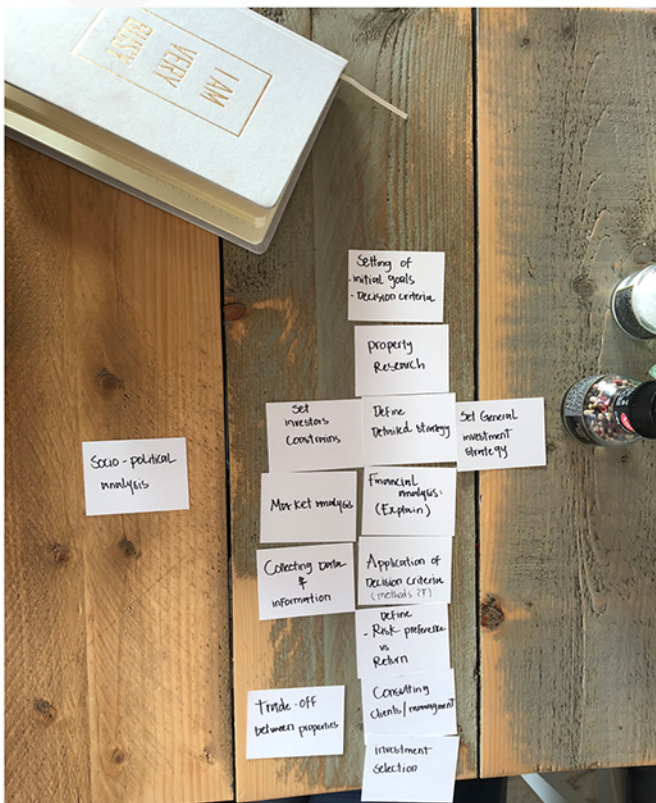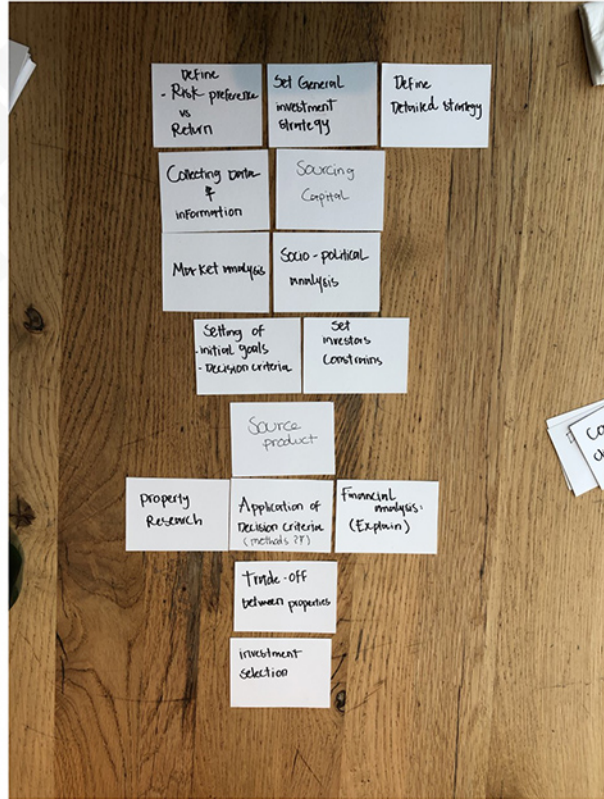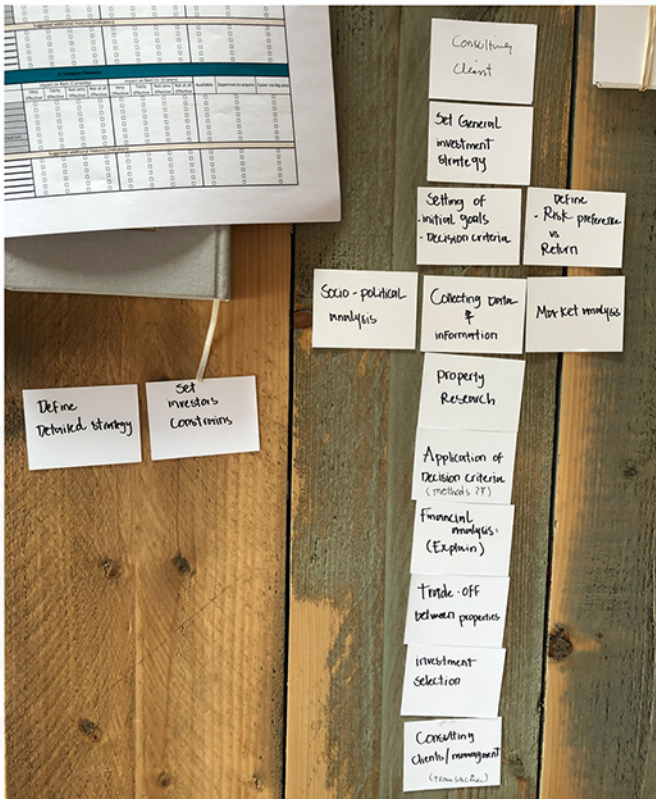
H. Future trends- predictability/impact matrix (flash-cards):
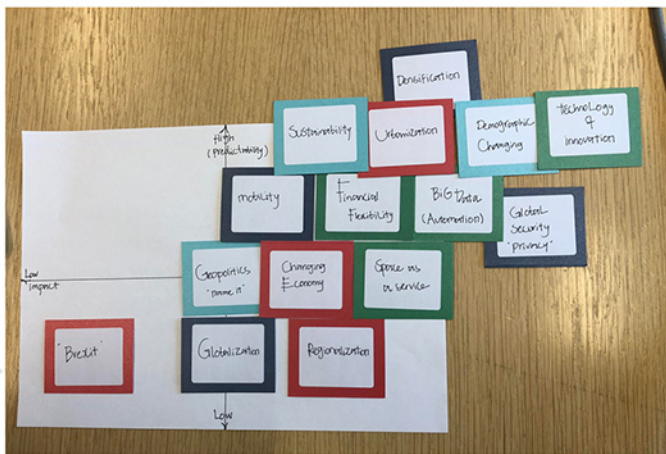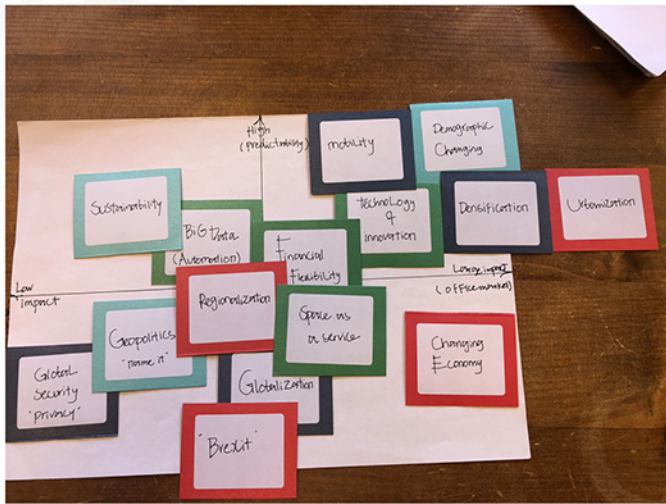
I. Score-cards' results (by interviewees):

Acqusition criteria for office spaces

1- Economic Features

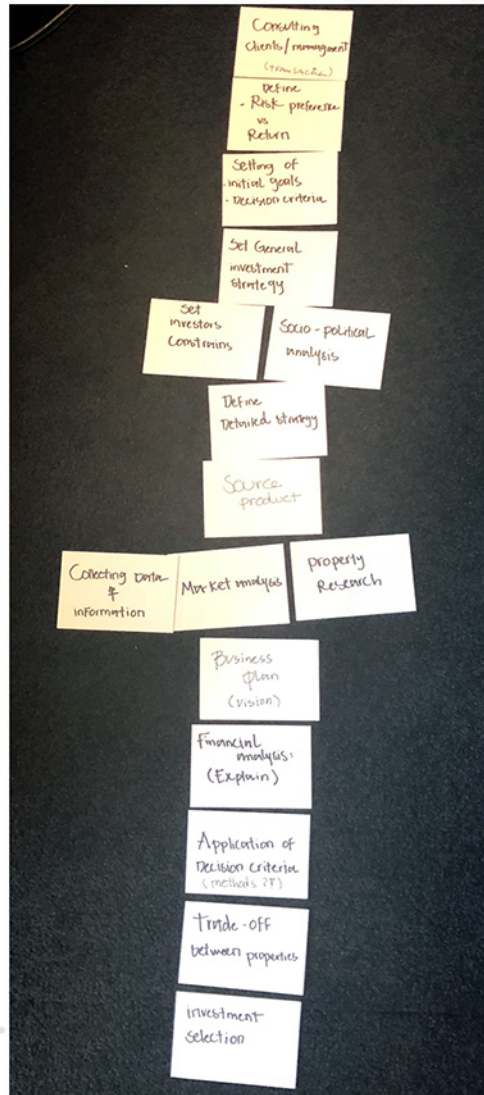| Indicator/ impact on return	Currently				In 10 years				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
1- Vacancy rate	9	6			10	5			6	6	9
2- Gross Domestic Product (GDP)	2	6	5	2	2	5	7	1	16		1
3- Absorption rate	5	9	1		4	9	1	1	5	6	10
4- Office stock	4	9	2		4	9	2		8	3	9
5- Office supply	9	6			8	6	1		8	4	8
6- Office employement rate	3	7	3	2	2	11	1	1	14	1	3
7- Annual interest rate	2	3	7	3	2	6	6	1	13	1	3
8- Annual depreciation rate of the building	1	3	9	2		5	8	2	5	7	3
Suggested additional Features (indicators)											

2- Location Features

Indicator/ impact on return	Currently				In 10 years				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
1- Distance to CBD	11	4	7	3	12	2	1	1	15		1
2- Distance to the Randstad area	11	2	2		11	4			15		1
3- Distance to public transportation	11	4	3		10	5			14		2
4- Distance to high ways (Road infrastructure)	7	5	3	1	5	7	3		14		2
5- Distance from Airports	2	7	5	1	4	7	4		15		1
6- Charisma of suuroundings & Environmental amenities (level of urbanization)	2	11	1	1	8	5	1	1	6	2	7
7- Parking fees	1	3	8	3		4	8	3	9	1	6
8- Number of parking places	3	7	5		3	4	6	2	8	2	6
Suggested additional Features (indicators)											

3- Building Features

Indicator/ impact on return	Currently				In 10 years				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
1- The building size (Total area)	4	1	7	3	4	2	6	3	10	3	5
2- Building materials and its Quality.	3	10	2		10	3	2		4	8	5
3- Building Design	1	11	3		4	8	3		6	5	5
4- Building Age	2	9	4		4	8	3		14	1	2
5- Building condition (Structure)	6	7	2		7	6	2		4	8	5
6- Building compatibility with the surroundings	1	9	5		2	8	5		9	5	2
7- Total Floar area	8	5	2		8	5	2		9	3	4
8- Number of floors	2	6	6	1	3	5	6	1	10	2	5
9- LFA/GFA ratio	4	8	2	1	4	9	1	1	4	7	6
10- The percentage of comman space	3	7	5		4	8	3		4	7	6
11- The percentage of unused space	1	7	5	2		8	5	2	4	9	4

Indicator/ impact on return	Currently				In 10 years				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
12- Number of elevators		5	9	1		6	7	2	5	5	6
13- Ceiling height	1	10	4		2	9	4		4	6	7
14- Availability of external view	3	9	3		3	9	3		8	4	5
15- Architectural quality	2	9	4		3	9	3		6	4	6
16- Privacy	1	6	7	1	1	5	8	1	6	5	6
17- Charisma of the entrance	3	10	2		4	9	2		7	5	5
18- Flexibility	6	9			9	6			5	6	7
19- Lighting	1	8	4	2	3	8	4		4	5	6
20- Building amenities and services	2	9	4		6	8	1		5	4	7
21- Communication technology	2	8	3	2	7	4	2	2	3	6	8
22- Sustainability label and certificates	3	6	5	1	9	5	1		9	3	5
23- Energy usage	3	7	5		9	4			3	5	9
24- water usage	3	5	5	2	9	4	1	1	3	5	9
25- Waste production	2	6	6	1	8	5	2		3	5	9
26- Heating, cooling, ventilation	4	8	3		8	7			4	4	8
Suggested additional Features (indicators)											
27- Building layout (Single/ multi)	1				1			1			1
28- Renovation date	1					1		1			
29- Art			1			1					1
30- Health	1					1					1
31- Data-systems(measure, analyze & optimize)		1			1			1			1

4- Contract Features

Indicator/ impact on return	Currently				In 10 years				Available	Expensive to acquire	Easier via big data
	Very Effective	Fairly Effective	Not very Effective	Not at all Effective	Very Effective	Fairly Effective	Not very Effective	Not at all Effective			
1- Contract Period (Years)	9	2	3	1	8	2		3	6	6	8
2- Duration of rent free period	9	4		2	8	5		2	3	10	6
Suggested additional Features (indicators)											
Policies			1			1					
Notice period		1				1					
Fitout contribution (investment contribution)	2				2						
break options (flex.)	1				1						

J . The validation session script:

I. Introduction:

First of all, we would like to welcome and thank you for participating in this research.

This research is part of the Management in the Built Environment master track at TU Delft University with the cooperation of Royal HaskoningDHV engineering company.

The research aims to leverage big data and innovative smart tools for reaching more informed real estate investment decisions.

The purpose of this session is to validate some of the main findings of the results of phase one (first held interview with you) in combination to the theoretical framework.

The session takes approximatively 30 min and consists of general presentation followed by few open questions.

II.PRESENTATION (5-10 mins):

The session will start by presenting and explaining some findings, the presentation slides are shown in the next page.

III.QUESTIONS :

A. Open questions: (15 Min)

1- Do you generally agree with the main findings in the presentation? If not, Explain.
2- What is missing in the main challenges and benefits of adapting (big) data and smart tool to the real estate investment management?
3- What is missing in the decision making model and the flowchart?
4- In your opinion, where can human experience and gut-feeling be involved in the shown automated process?
5- What can be the main challenges and opportunities of adapting the explained process and analytics within your firm?
6- Do you consider deploying this outcome within your firm?
7- Where do you see your role within this process?

B. Other unprepared questions: (5 Min)

FROM DATA TO VALUE
in real estate investment management

Hoda Hassan
(Validation session – May, 2018)

Content

- Research questions
- Benefits & Challenges of (Big) data
- What we need?!
- Real estate investment decision making model
- Real estate investment decision making flow-chart

Research questions

- How to make use of (big) data for achieving more informed real estate investment decisions?

sub-questions:
- Which acquisition criteria are affecting the real estate investment decisions for institutional investors?; and what type of data is required and available?
- How could (big) data tackle the current problems in the real estate industry?
- What are the main challenges for applying big data to the real estate industry?
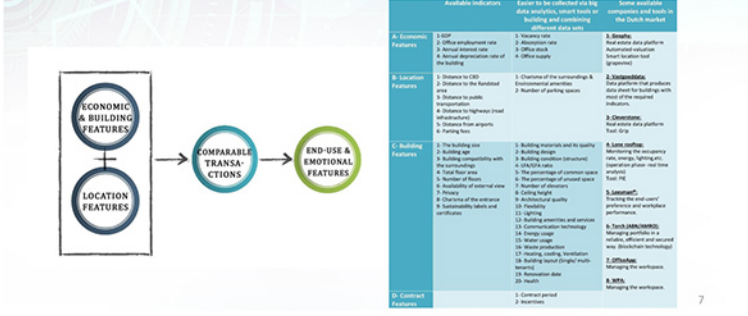- What are the opportunities of using big data and predictive analytics in real-estate investment decisions?

Benefits & challenges of (Big) data

BENIFITS OF BIG DATA: Better, faster, cheaper decisions; Reducing risks; Adapting faster to user's preferences; Approach potential investors; better knowledge of prices & the market; Better future expectations; More transparency (better data)

CHALLENGES OF BIG DATA: Data accuracy and quality; Privacy and moral issues; No competition (the market will be the same); Alot of money, time, resources and technology to invest; Current mindset (willingness of people to share & cooperate); Knowledge & skills of people

What we need!

The future depends on:

EXPERIENCE — DATA — TECHNOLOGY

What we need!

01 REQUIRED DATA:
- Meta data
- Historical data
- Transactional data
- Real time/ time series data

02 DATA SOURCES:
A- Internal data sources: Internal data bases; Sensors and machine generated; Manual human data
B- External data sources: External data bases by data providers; Social media / web.

03 ANALYSIS TYPE:
- Exploratory
- Summarization
- Estimation
- Prediction

04 ANALYSIS METHODS:
- Analytics
- Predictive analytics
- Real time analysis
- Location based analysis
- Statistical & mathematical analysis
- Social networks/web analysis
- End-user's preference and satisfaction surveys

What we need!

ECONOMIC & BUILDING FEATURES + LOCATION FEATURES → COMPARABLE TRANSACTIONS → END-USE & EMOTIONAL FEATURES
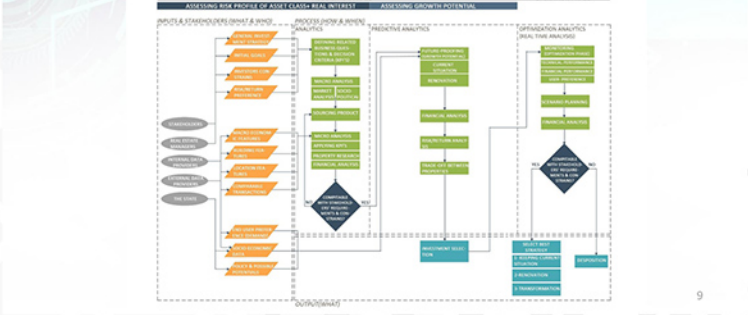
Decision making model

Decision making flowchart

What do you think?!

Should you start to humanize technology and technify man?!

K . Analysis of phase two (validation sessions):

Phase 2 — Session no./keyword	Validation sessions				
	General validation (agree/disagree)	Acquisition indicators	Missed benefits of big data	Missed challenges of big data	
Session 1 (Advisors)	- Generally agreed	- Distance to amenities (bars, restaurants, cafes, etc.) is missed (available) - Amount of amenities			
Session 2 (Advisors)	- Generally agreed	- Lease size (available) - Special contract clauses (not available) such as break option, the right to sublease, etc.			
Session 3 (Investors)	- Generally agreed but: Sourcing capital and debt can be better highlighted in a whole circle around the process and to be changed to (sourcing & optimizing capital structure)	- Special clauses is so important - No. of parking spaces is more related to the building features rather than location features.		- Challenges are connected and related	
Session 4 (Advisors)	- Generally agreed but: There should be a decision making block with a yes or no before the investment selection. - there are more different options than keeping the current situation and renovation, thus it is better to be called Asset management plan (renovation, small investment, transformation, extra sq.m, marketing, leasing renewal or optimization, etc)				
Session 5 (Investors)	- Generally agreed but: There should be a decision making block with a yes or no before the investment selection.				
Session 6 (Advisors)	Generally agreed	- Number of parking is available - Total floor area & no. of floors are not available			

Phase 2	Validation sessions				
Session no./keyword	Required human interventions in process	Specific own role in the process	Challenges of adapting the developed process 'flowchart'	Opportunities of adapting the developed process 'flowchart'	Expected changes in the job role
Session 1 (Advisors)	- Defining related business question - The compatibility checks. - Sourcing the product - Acquisition decision and final decision.	- Sourcing the product - External data providers - Decision of acquisition and disposition	- Collecting the data	- Faster actions - Better position in the market	- Smaller and may be not needed
Session 2 (Advisors)	- Always in data checking - Defining related business question - The compatibility checks. - Future proofing - Sourcing the product - Acquisition decision and final decision.	- As advisors: starting from defining related business question till risk/return analysis	- Mind set of people - Missing some good opportunities (potential properties)	-	- less but it will be needed
Session 3 (Investors)	- Defining related business question - The compatibility checks. - Sourcing the product (can be partially automated) - Acquisition decision and final decision. - Future-proofing (scenario planning) - Financial analysis	- Through the whole process	- Less people will be needed for the industry in case of lots of my	- Working more efficiently - don't miss aspects - less human error	
Session 4 (Advisors)	- Defining related business question - The compatibility checks. - Acquisition decision and final decision. - all analyses - Future-proofing (scenario planning)	- Everywhere except the final decisions	- You always need checks (will not be never fully automated)	- Safes time (you lose the middle management part) - less human work	- will be more data-driven and you have to provide more data to your customers instead of just your gut feeling

Session 5 (Investors)	- Socio-political analysis - Sourcing product - Future-proofing (scenario planning) - Trade-off - Acquisition decision and final decision. - The compatibility checks. - Monitoring user preference	- The firm is doing everything - Personal roles: - Macro analysis - Micro analysis - Scenario planning - Acquisition and disposition decisions (partially)	Same as mentioned before - Skilled people	- More focused on the outcome + the main mentioned benefits	- less than we hope
Session 6 (Advisors)	- Defining related business question - The compatibility checks. - Acquisition decision and final decision. - all analyses - Future-proofing (scenario planning)	- Mainly in the analysis part	- The know-how - Making time in the daily business to create those automated elements in the process. - People need to be data-minded	- Saving time - Better decisions	- My job is already changing by creating and deploying some automation.