POLITECNICO
MILANO 1863

School of Architecture, Urban Planning and Construction Engineering

MSc Management of Buil Environment

A.Y. 2019-2020

Impact of Technology in the Real Estate sector

Analysis of Blockchain and Smart Contracts implementation

Candidate: Stefano Magnani
927660

Supervisor: Prof. Gianandrea Ciaramella

Content

Figures and tables

Abstract

This work aims at analyzing how the Real Estate sector is being affected by the implementation of innovative technologies.

The studied available literature shows how Big Data and digitalization are having a huge impact in many working sectors, and it is interesting to analyze whether they can become relevant in Real Estate companies to manage their assets.

The overview of this trend is allowed by the analysis of PropTech companies' development with all the categorizations related to it.

The operational part stands in the description of the Blockchain technology and its application in Real Estate, and, in the end, by the implementation of Smart Contract models to make smarter how transactions are executed.

The analyzed papers about the theme present some examples of implementation of those systems for the management of Real Estate assets. On this basis, it is possible to hypothesize a Smart Contract model that can be used for the management of the rent of an office building's spaces.

1. Introduction

The goal of this work is to analyze two distant words, the technological and the real estate one.

The push for this kind of work comes from the impact of the innovative technologies in the world and how they are changing the lives of people in many aspects.

The first step of the work is done to have an overview of Big Data. This term is changing the world having a huge impact on different sectors.

Digitalization is another revolution that has characterized the world in the last years.

The analysis of papers such as Munawar's one allows understanding of where data come from and what can be its potentiality.

The connection point between technologies and real estate is firstly studied with PropTech. Thanks to the work made by the JRC center of Politecnico di Milano (Bellintani, 2019), it is possible to understand the PropTech phenomenon and how the real estate sector is changing.

To have a proper contextualization of the theme, there is a geographical view of the PropTech companies' development with a focus on the Italian situation.

The built environment undertakes the scenarios described in the following chapters. Indeed, they are identified three sub-sectors of PropTech. They are Smart Real Estate, Sharing Economy, and Real Estate FinTech.

The literature available has been used to analyze deeper those three areas, where the use of technologies is improving the performance of Real Estate companies.

In the Sharing Economy and Real Estate FinTech chapters, it is possible to understand how technology is changing the Real Estate sector and how the way of thinking about the space and its modality of rent is evolving.

The deepening of these aspects is always accompanied by an overview of the evolution of Italian companies in the Proptech sub-categories.

The work made by Shaw allows having an interpretation of the new Real Estate sector as a Platform Real Estate one.

In this area, it is possible to introduce the part related to the operational aspect of the theme.

Blockchain technology is the one used in the sector to try to change the transactions of real estate assets. The most important advantages are described in the chapter.

The application of Blockchain technology in the Real Estate market is analyzed through the papers collected about the theme.

In the same way, smart contract technology is the one that if implemented can modify the current way of executing the transactions.
The overview of this topic with the comprehension of the advantages of the system and its areas of application makes it possible to hypothesize a smart contract model. The goal is to think about a method to make smarter the process of renting spaces. It can be a revolutionary approach for companies too that can optimize the assets' management.

2. Big Data

Nowadays there is an abnormal amount of data that comes from telephones, credit cards used for purchases, from television to storage necessary for computer applications, from intelligent infrastructures in cities. Data can also be collected from sensors mounted on buildings and public and private means of transport.
The data is generated with such an increasing flow that all the information accumulated over the last two years has exceeded the order of Zettabytes (10^{21} bytes).
The term "Big Data" refers to a huge, varied, and complex volume of data that cannot be analyzed by traditional software and so to what can be done with all the amount of information, that is, to algorithms capable of dealing with so many variables in a short time and with few computational resources.
The large volume of datasets is one of the keys to this phenomenon along with its sharing, creation, and removal in seconds. Also, the variations that can be registered increase their complexity.
A contemporary presence of trends has permitted the rise of big data, they are:

- Computation power, which grows exponentially concerning the relative cost.
- The network generated between computers and digital devices makes it easy to transfer and share data.
- New technologies, such as sensors, have made data machine-readable, so each data is uniquely identifiable and interconnected with other databases.
- Data storage has expanded but being cheaper.

The technology available today and the processing capabilities are the fundamental keys that make data management possible thanks to the speed in storing and analyzing data. The real revolution related to the world of Big Data is the possibility to use all the information collected to process, analyze, and find objective feedback on various issues.
Until recently a scientist to analyze an amount of data took a long time and would have used mainframe computers worth over 2 million dollars. Today, with a simple algorithm, that same information can be processed within a few hours, perhaps using a simple laptop to access the analysis platform.

Big Data presuppose new abilities to link information available together and to provide a new visual approach to data, proposing interpretation patterns and models hitherto unimaginable.

Big Data is strongly related to Information Technology, which represents the starting point from which to start with the tools such as cloud computing, search algorithms, and so on. But this world is not only associated with IT, in fact, but data is also very useful in most business markets, and no sector in which there are marketing and information to be analyzed can be excluded by the Big Data revolution. Some of the sectors that are involved can be for example cars, medicine, commerce, astronomy, biology, pharmaceutical chemistry, finance, and gaming.
The businesses that have a large amount of data available can more easily proceed towards their goals and take advantage over their competitors in the market if they have the skills to use and manage the data.
Among the advantages there is the possibility to attract new customers, addressing at the same time better the needs of the existing ones. Customers are motivated to use the business systems due to the personalization of the experience.
At the same time, available information must be arranged correctly in every other field, isolating meaningful results from the large datasets thanks to the necessary tools and technologies.

Many definitions can be used to describe the concept of Big Data, but they have three common characteristics:

- Massive data volume
- Processing speed
- Data coverage

Speed and analysis are the keys that can motivate the use of Big Data in Real Estate Management and these attributes are known as "Big Data Analytics". This term refers to a complex process that comprises the identification of data sources and many issues such as data repository, cleaning, extraction, validation, mining, and visualizations. (Munawar H. S., 2020)
It is possible to identify different stages:

1) Identification and determination of the sources and then the collection of data that are pertinent to the problem domain;
2) Storing of data in a database or data repository;

3) Data cleaning with the elimination of redundant, irrelevant, empty, or corrupt data objects from the data previously collected. This operation is useful to reduce the complexity and the size of data;
4) Extraction of data from different or unidentified formats and then transformation into a common one. Through this step data can be read and used by analytics engine reducing the total amount;
5) Application of validation rules, specific to the business case, to data to verify the relevance and the need of these data through an aggregation function;
6) Data mining techniques are used to establish hidden and unique patterns to make important business decisions;
7) Visualization of data in a graphical form where the results of the analysis are displayed. This method makes data easier to be understood by the viewers.

However, Big Data analytics presents several problems related to data discrepancy, redundancy, integrity, security. Moreover, must be considered problems such as space, processing time, organization, and visualization of them (Munawar H. S., 2020).

2.1 Seven Vs

Big Data was initially characterized by the so-called three Vs of data, which are Variety, Volume, and Velocity.

Through new studies that permitted understanding better the topic, the amount of Vs reached the number of seven, since Value, Veracity, Variability, and Veracity have been added.

Variety refers to the collection of data from different sources, they can be images, audio, videos, and numbers.

Data can be divided into:

- Structured data, which are present in spreadsheets in tabular form.
- Unstructured data, which are random like text, images, and audio and are difficult to be sort.

Variety is a characteristic not only related to data itself but also to multiple ways of using and analyzing data. This first V implies more chances of errors and affects the data integrity. To address this, it was proposed the concept of data lakes to manage Big Data, which provides a schema less-repository for raw data with a common access interface.

"Such data lakes can be integrated with urban big data for smarter real estate management, where, just like the human and non-human resources of smart real estate, urban big data also emerge as an important strategic resource for the development of intelligent cities and strategic directions" (Munawar H. S., 2020). They can be analyzed through IoT and artificial technology to intelligently administer smart real estate.

Volume is defined as *"The generation of data every second in a huge amount collected from different sources"* (Munawar H. S., 2020).
Currently, there is an increase in the volume of data generated from gigabytes to petabytes and according to the study conducted by Munawar 20 zettabytes of data are expected to be created by the end of 2020.
The big volume of data comprises text, images, audio, social media, research, and reports, and they are collected from different documents from social media, satellite images, web servers, and audio broadcasts.
In the Real Estate sector some companies are using big data applications for handling a large volume of data. In China, Fantasia Group is benefitting from using an e-commerce platform that combines commercial tenants with customers through an app on cell phones (Munawar H. S., 2020).
Velocity stands for the speed of data generation and processing and it is defined as the rate at which data are created and changed along with the speed of transfer (Munawar H. S., 2020). One of the main advantages related to Big Data is the real-time collection of streaming data from websites; data are created at an unparalleled rate by sensors and digital devices and so they can be handled only by real-time analytics.
In the Real Estate sector, it was proposed a big data-assisted customer analysis and advertising architecture which can create a faster rate of advertising processing, approaching millions of users in single clicks.

Value refers to the hidden value from larger datasets. This concept is strictly related to the importance which the amount of data collected has because the company expects to generate some value out of it since a lot of time and resources are spent in the analysis. Moreover, an investment in big Data techniques is risky if it cannot be generated value, for example, raw data are meaningless for a business if they are not processed into some useful information.

In the Real Estate sector, Big Data can generate neighborhood value as it has happened in some African cities as explained by Munawar causing an improvement in mobility and access to a job.

Veracity is the term used to define the inaccuracy or trustworthiness of data. It is a significant aspect of Big Data because the use of uncertain or unreliable data can have negative consequences on the business and so sophisticated software and analytics are required.

Variability is referred to the different ways in which the same information can be interpreted and consequently can be used. For example, in the Smart Real Estate sector, a company has introduced a system based on big data generated by heart rate variability in different patients to recommend places where these people can live with the highest wellness condition (Munawar H. S., 2020).

The last V stands for Visualization that is related to the interpretation of patterns and trends in the database. A major role is assumed in this case by Artificial Intelligence, which is used for the visualization itself and the forecasts of the movements.
Visualization is important to attract new customers and keep the existing ones motivated to use the system.

2.2 Big Data Analytics

Big Data Analytics refers to the extraction of useful hidden information from fast-moving and diverse raw data through efficient processes. It includes a large amount of data, which can be structured or unstructured and several tools and techniques are related to this analysis such as text, audio, video, and social media analytics.
This process is also associated with the combination of data and technology that extracts useful data and gains insight from it, which is not possible through the traditional technologies of data extraction (Munawar H. S., 2020).
Currently, this method is the most used for processing raw data because of its potential to analyze large amounts of data.
Recently many organizations wanted to invest in big data analytics for improving their performance, this is since using big data for company decision-making gained much attention. Moreover, many retail companies are extensively using big data capabilities to enhance relationships with customers.

The process of making informed decisions becomes smart with the use of automatic data analytics while previously they were taken by the judgment of decision-makers.

Big Data Analytics can be defined by three main features:

- Information itself
- Analytics presentation
- Results presentation

This tool, if used, can increase value and market shares in different sectors such as e-government, businesses, and healthcare. It is used for improving the life's quality and reducing the operational cost in the healthcare industry (Munawar H. S., 2020); in the business and supply chain management area the improvement of business monitoring, the management of the supply chain, and the rise of industrial automation are the benefits which can be gained by the big data analytics use.

Data management and analytics are the two processes that can be individuated in the information extraction from big data.
The first process is about the technologies that are required for acquiring and analyzing data, while the second process is for the extraction of meaningful information from the data amount.

2.3 Sources of data

Data can be stored from various sources such as sensors, apps, Geographic Information System, images, videos, and they are stored in a platform which make them indexable. The collection may be in real-time or at irregular intervals. The different sources reported below are analyzed with the impact on cities and the Real Estate sector (Barkham, 2018).

2.3.1 Administrative

The actual trend is the digitalization and compilation of existing administrative data to improve transparency and accountability moving toward a culture of open data (Barkham, 2018).
The impacts can be the reduction of long-term operating costs and the increase of productivity across the city. For example, in New York City, the open data platform

has a specific code for each building and all the codes can be linked with real estate transactions, leases, and capital expenditures (Barkham, 2018).
Moreover, many cities are deleting paper processes to use only online ones. This can increase the involvement of the community, for example, voting for the allocation of capital to realize projects in the city.
The potential of these data portals that focus on citizen engagement and transparency is to save cities money through more efficient operations with a lower risk of fraud.

2.3.2 Sensors

Sensors are the most used source for collecting urban big data. Many inputs, such as light, temperature, air quality, and movement of people in the area can be measured through sensors placed in buildings.
Sensors can provide real-time information that is useful for monitoring safety measures and creating automated systems to raise productivity and quality of the services (Barkham, 2018).
For example, in New York City, fiber optic sensors monitor the cracks and temperature fluctuations on the Brooklyn Bridge. The information collected is useful for structural engineers to understand when the vaults will need to be replaced (Barkham, 2018). The great advantage, in this case, is the minimization of costs associated with the inspections besides avoiding catastrophic events.

2.3.3 Apps

Software on smartphones is nowadays distributed to use existing information and produce new datasets. They can be an advantage for citizens.
For example, in Boston, the Mayor's Office of New Urban Mechanics has developed a crowdsourcing mobile app that helps residents improve their neighborhood streets by inputting road conditions while they drive (Barkham, 2018).

2.3.4 GIS and User Behavior

The data, which are obtained from social media or urban patterns studied via GIS, are used to improve the quality of life, and provide solutions to possible urban problems.
For example, MIT Media Lab collaborated with the Andorra government to apply data science to understand the dynamics of tourism, commerce, mobility, and

transportation systems. Data collected from cell phones, social media, bank transactions, and transportation allow predicting tourist behavior and routes to develop in Andorra a targeted tourist attraction recommendation system (Barkham, 2018).

2.4 Data Analytics Process

The main characteristics of big data analytics are the ability to handle a huge volume of data and the availability of tools for storage and analysis (Munawar H. S., 2020).
The main analytic processes are:

- Data collection
- Data filtering
- Data cleaning
- Data visualizations

The analysis starts with data collection and acquisition. Data can be acquired through different tools and techniques from the web, Excel, and other databases (Munawar H. S., 2020).
Then some tools filter out useful information from data to extract structured data from unstructured data.
The third procedure is the removal of errors and imperfections of data through cleaning tools, this is because these defects can affect the results and the analysis itself.
In the end, visualization techniques are applied to extract meaningful information from raw data through several tools and techniques, which change depending on the kind of data and the visual outcome. Most of the tools use data mining and artificial intelligence technique for analysis and visualization.
An artificial intelligence tool is machine learning, which is used for the extraction of knowledge from the amount of data. This data analytics technique uses computational methods for teaching computers to learn information from the data resulting very efficient (Munawar H. S., 2020). However, as the size of data grows, the traditional machine learning methods are quite inefficient in the extraction of useful information from the dataset.
Thus, some advanced methods are being developed to face the growing demand for data processing and solve efficiently the different problems that can arise. For example, a representation learning method has been developed and nowadays deep

learning methods with higher processing power and advanced graphic processors are used (Munawar H. S., 2020).
The use of distributed learning shares data among different workstations, making a much faster analysis process.
Active learning is used to solve the problems that arise by obtaining labels from the data since it is expensive and time-consuming. This produces a subset of applications from the data to form labels. It reduces the cost of obtaining labeled data, ensuring high accuracy of the process (Munawar H. S., 2020).

The analysis of big data has been facilitated by the achievements made in machine learning, but there are still some challenges to be faced.
Challenges are about different aspects of big data such as volume, value, velocity, variety, and in particular uncertainty and incompleteness.

2.5 Big Data challenges

Some issues and challenges are posed by Big Data use. They are (Munawar H. S., 2020):

- *Security and privacy*; it is difficult to store and manage massive amounts of data using traditional methods. Often customers' and organizations' personal information is collected, without their knowledge, by firms, to increase their business but there can be serious consequences if this information is accessed by hackers. Moreover, people's behavior is constantly recorded in many ways like social media, IoT, GPS, and credit cards. In some cases, data are deleted after a period.
- *Heterogeneity and Incompleteness*; they can arise because data are collected from different sources that vary greatly and because the malfunctioning of any sensor or fault in the system can make the collection of data incomplete.
- *Fault tolerance*; it sets the range for any failure to recover lost data without time and cost waste, in fact, a failure during the process may require restarting it from scratch.
- *Storage*, technologies nowadays switch from hard disk drivers to cloud computing to generate data at a high speed.

2.6 Big Data application

The Real Estate and Property Management industry have recently introduced the use of big data in various forms such as visualization of properties, virtual and augmented realities, four-dimensional advertisements, stakeholder management, online customer management, and the use of technologies like artificial intelligence and robotics that are transforming this sector into Smart Real Estate (Munawar H. S., 2020).

Among the companies utilizing big data in Real estate in China, there are some successfully started using big data to address the needs of stakeholders such as property information, buyer demand, transaction data, buyer personal information, and historical transaction information (Munawar H. S., 2020). The author analyses the different types of big data implementation according to the various stakeholders, from customers to government authorities.

Agencies and sellers of properties own software and tools that can generate big data to give personalized suggestions to the buyers or users of the service, who can make better and informed decisions. However, a centralized validation system operated by the government is important to protect the privacy of the users and to verify the information provided to the buyers. The goal of this operation is to favor trust between sellers and buyers and avoid regrets related to incomplete decisions.

Regulators and legislators are beginning to develop strategies to ensure consumers' protection against the strong growth of big data brokers who mislead the consumers to exploit their interests. In Figure 1 reported below it has been hypothesized an intermediary organization to check agents and brokers manipulating data.

The goal is to create a *"win-win situation in smart real estate. Specifically, this system can help smart real estate managers, and sellers to attract more customers toward the properties with the use of immersive visualizations, thus improving the business and sales. While the customers can make better and regret-free decisions based on high-quality, transparent, and immersive information, thus raising their satisfaction levels. At the same time, the government and regulatory authorities take advantage of providing better citizen services, ensuring the safety and privacy of citizens, and detecting frauds"* (Munawar H. S., 2020).

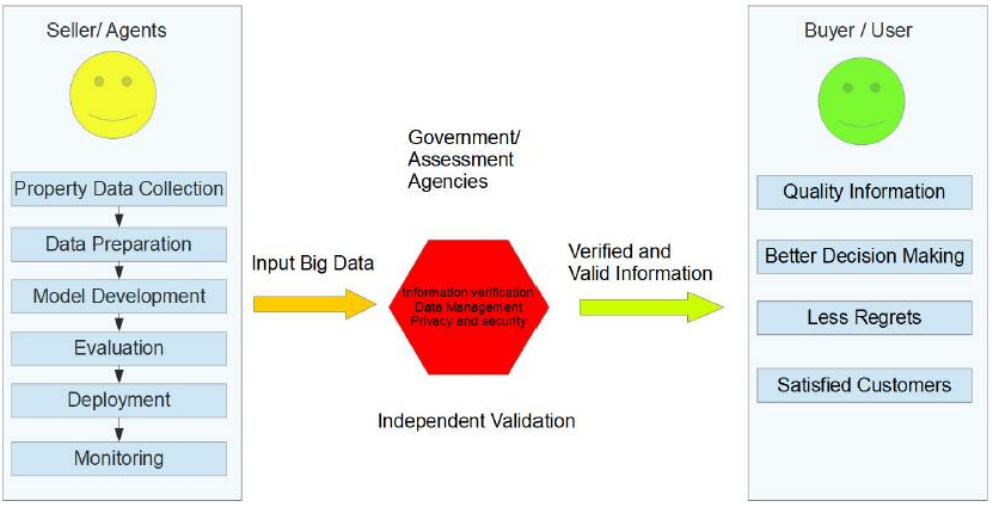


Figure 1. A conceptual model for big data utilization in real estate transactions (Munawar H. S., 2020)

There can be an integration of smart real estate and disaster management fields. Smart big data from real estate can be useful for the disaster risk management team to be ready to respond to disasters. As such, "*the data received from building occupants coupled with data from building integration, maintenance, and facility management can be shared with the disaster management teams who can integrate with the central systems to better respond to disasters or emergencies*" (Munawar H. S., 2020).

Big Data thus frees Real Estate organizations, agents, and professionals to focus on their core roles and leave the analysis to technology. This is achieved through "data-centricity", which places better, reliable, more accessible, and relevant data at the core of decision making to boost productivity (Ullah, 2018).
The use of Big Data in the Real Estate sector can be an improvement from the time saving, the sales speed point of view, and can increase the consumer accessibility to improve decision making ability and empower the Real Estate owners to analyze and understand trends in the market and overcome inefficiencies.

In the U.S. there are cities as Los Angeles, Boston, Chicago; New York, and New Orleans that are advanced in the use of big data overcoming financial, human, and technological constraints.
They have created integrated data platforms that allow to understand better the city communities and make easier decisions for the improvement of public services.

Big Data use implies that cities can become more productive, more attractive to highly skilled workers, and raise the quality of life, potentially increasing the real estate values (Barkham, 2018).
The potential for the development of smart cities is particularly strong in emerging countries with necessary educational, financial, and political assets (Barkham, 2018). Interventions that focus on improvements in relatively poor neighborhoods of the cities can have an impact on the real estate valuations within cities themselves. Moreover, these improvements may be associated with rent and price convergence.
Many smart city interventions such as the use of sensors, statistics about traffic and pedestrian flows are likely to be more successful in densely urbanized areas and may be too dispersed and consequently inefficient in the suburbs to justify the related cost. This can cause higher residential and retail rents in denser locations.

3. PropTech

The world of PropTech represents a digital disruption (Braesemann, 2020) of the Real Estate industry and is about information provision, transactions and management, and control; three activities that have been significantly facilitated by the technological boom.
The core business of Real Estate is still space-based, but the PropTech boom is related to the fact that all the information around a building can be digitalized and the Real Estate processes can be datafied.
The network of property technologies is strictly related to the generation of value from the use of digital data. It is the core of the innovation and allows buying, selling, and renting real estate assets to become smarter processes than life-long investment decisions or long-term leases agreement.
The Real Estate market is becoming digitalized, shaped by winner-takes-all dynamics, and a more competitive market, generating a higher return on investment. In this sector, characteristics of datafied markets, such as data protection or competition for market share, are becoming increasingly important.

This movement was born in the US and UK around the 1980s with the key driver of change represented by the introduction of personal computers, which supported the

first spreadsheets applications. It contrasts with the traditional perspective of real estate.

The revolution was the growing data availability and transformation of portfolio management systems, which became computerized and technologically based. However, this globalization trend was limited by the high costs of storing, processing, and transmitting digital data.

It is possible to identify the first stage of PropTech during the period 1980 to 2000. The second stage kept the focus of the first one on the residential market sector because it is characterized by the huge availability of public information, such as prices and rents. It started in the 2000s when online platforms could create and use internet-based business models (Braesemann, 2020).

Zoopla was one of the first firms to apply a platform business model. People who want to sell a property were incentivized to provide precise information about it, while buyers' research could be shaped by applying some filters on the website according to their preferences.

One of the first important innovations allowed by the digital market was the possibility for renters and sellers to use platforms with large user bases. This was an advantage for buyers too, who could analyze many choice possibilities.

Users can switch from one digital platform to another going further to the geographical separation. In fact, before the digital era, real estate agents served only their local market.

Companies understood the advantages that were related to the expansion of the user base. They started to offer key services for free because adding one additional unit of an online service implied zero marginal costs.

Firms faced only fixed expenses to create a server infrastructure, have an adequate data center for storage, and have a good team of software engineers and qualified employees.

Digital business models were allowed by Information Technology. They collect, aggregate, and process information, which is the service that adds value for users (Braesemann, 2020). Moreover, sellers' and buyers' search tools are used to generating value and can be used to train automated valuation models.

A platform can decide to sell data to other firms to expand its database. If it is larger than competitors' one, it indicates that the automated valuation model of the company is better than the others available in the market. Moreover, a larger

database will indicate better accuracy of the model and consumers will be incentivized to use it.

Data use represented a revolution in the sector because it is a non-rival good, which means that it can be used for different purposes and in different combinations but without losing value. Thus, firms can transfer data from one market to another to gain competitive advantages in different sectors. The amount of traffic-related data in a specific market determines the richness of the firm.

For example, Google has become the reference in navigation services thank to its website extensions, such as Maps, Earth and Streetview. The firm offers those services for free to users, who provide their data in return, which becomes a source of competitive advantage in the autonomous vehicles' market.

Moreover, the ease of information processing and the accelerated globalization allow newcomers, such as start-ups, to enter the market.

The second stage, identified as PropTech 2.0 (Baum, 2017) is during its great development phase. Its growth has been facilitated by e-commerce, social networking, and the open-source software world.

The actual Proptech world shows a global connection among real estate agents, property developers, financial advisers, investment lawyers, and IT professionals.

The author identifies three key PropTech aspects: *"PropTech increases the sheer amount of recorded information, about land, housing, and property. Second, data digitization has specific effects, such as the emergence of digital data as assets with a value in and of themselves"* and *"PropTech brings new actors, products, and services into housing and real estate sectors"* (Baum, 2017).

The change in companies' approach has been inspired by other sectors. For example, the revolution in e-commerce done by Amazon has made it possible to think about selling real estate assets via an e-commerce platform sing customer feedback. Moreover, websites that collect data about real estate services have been inspired by open-source software that has allowed cheap access to expensive technologies.

The foundation of the PropTech 2.0 revolution has been by the FinTech industry, which includes online payment systems, crowdfunding equity, and online exchanges. Anyway, PropTech is not considered as a subset of FinTech, because the latter one does not include the sharing economy, in which there is a peer-to-peer services exchange between sellers and buyers.

Baum identifies three sub-sectors of PropTech:

- Smart Real Estate
- Sharing Economy
- Real Estate FinTech

It is possible to identify a fourth one, relative to the Professional services. They include automated technological solutions used to manage assets, marketing, and consulting.

Figure 2 reported below shows the most significant technologies that are used in PropTech. Each of them is represented by a dot, while the size of the dots corresponds to the funding invested in the technologies.
Different technologies are associated with them if firms tend to use them together. If the technologies are often used together, the line which connects them is darker.
According to the author is possible to identify six tech clusters (Braesemann, 2020). The core of the network is the cluster of Data Analytics which is connected to the one of Smart Real Estate.
The core cluster is also connected to one of the technologies such as augmented reality and 3D modeling.
The business processes cluster is weakly connected to the others while ConTech and Real Estate FinTech clusters, which contain Crowdfunding, Peer to Peer, Blockchain, and Cryptocurrency, are completely detached.
In the network, the more central technologies, which represent the core, are those that have been successfully introduced in the real estate market. It is important to underline that the technologies that are placed at the periphery of the network have not less potential for development than the others and they too can be combined with the other clusters.

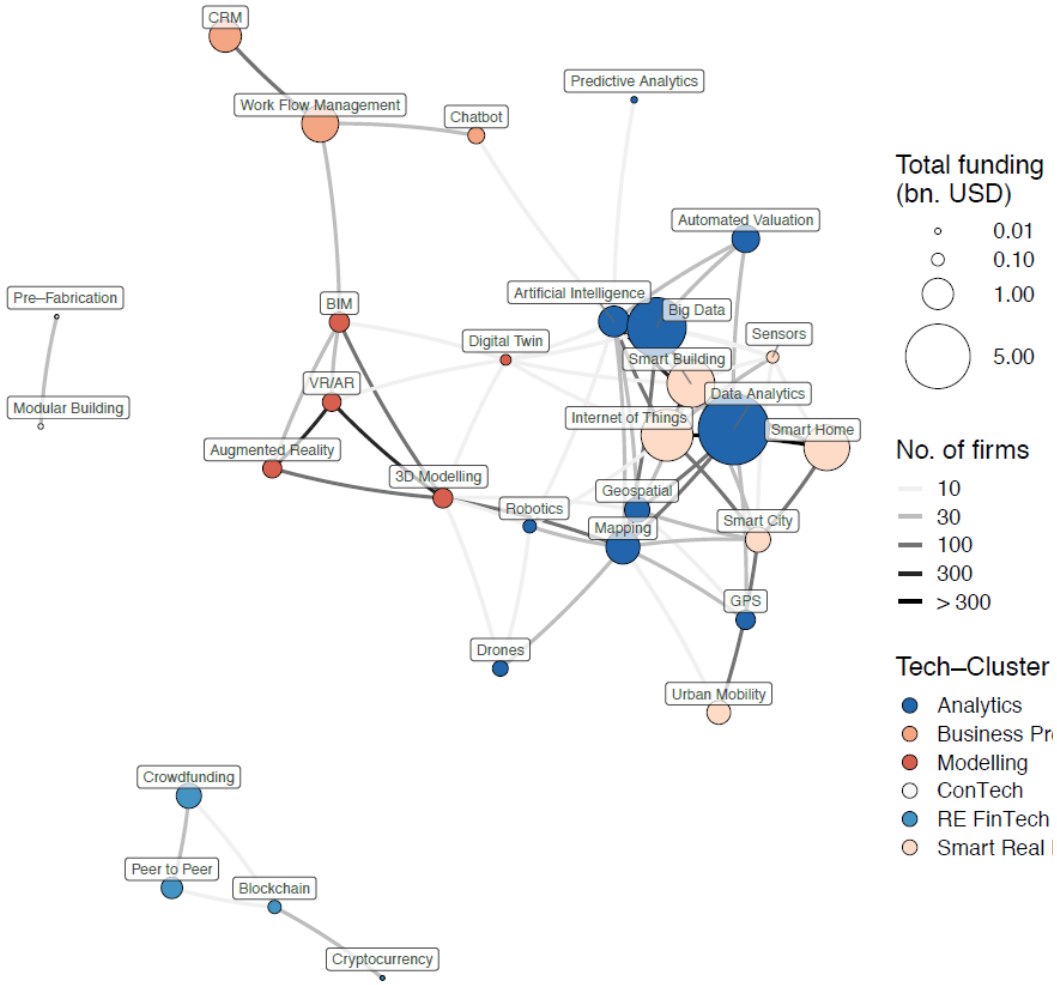


Figure 2. Property Technology network (Braesemann, 2020)

The economic importance of the different technology groups is represented by the venture capital funding, which has been obtained by every cluster.

It can be confirmed by the graph reported below (Figure 3), which shows the frequency of technical terms that have been used in 2016 about PropTech.

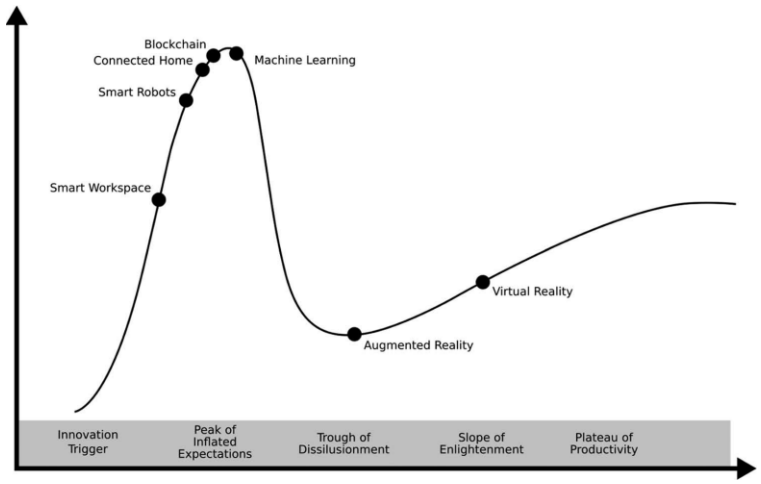


Figure 3. Analysis of the frequency of technological terms about PropTech (Shaw, 2018)

Figure 4 reported below shows the average funding per firm in millions of US dollars. Technologies are represented by the dots, while each dot size stands for how much firms use a technology.

The results obtained confirm what emerged in Figure 2. The two largest clusters are also those who obtain the highest capital funding per firm; 5,7 million dollars per Smart Real Estate firm and 6.2 million dollars per Data Analytics firm.

Within each cluster, there is high volatility. The technologies able to collect the highest amount of funding are (Braesemann, 2020):

- "Smart Building", "Smart Home" and "Internet of Things" in the Smart Real Estate cluster
- "Data Analytics" and "Big Data" in the Analytics cluster.

It can be concluded that the most relevant technologies in the PropTech market are those that can produce digital data and generate value from it, while in comparison to those technologies other ones like Cryptocurrency remain peripheral and do not seem to be ready to have an impact on the market.

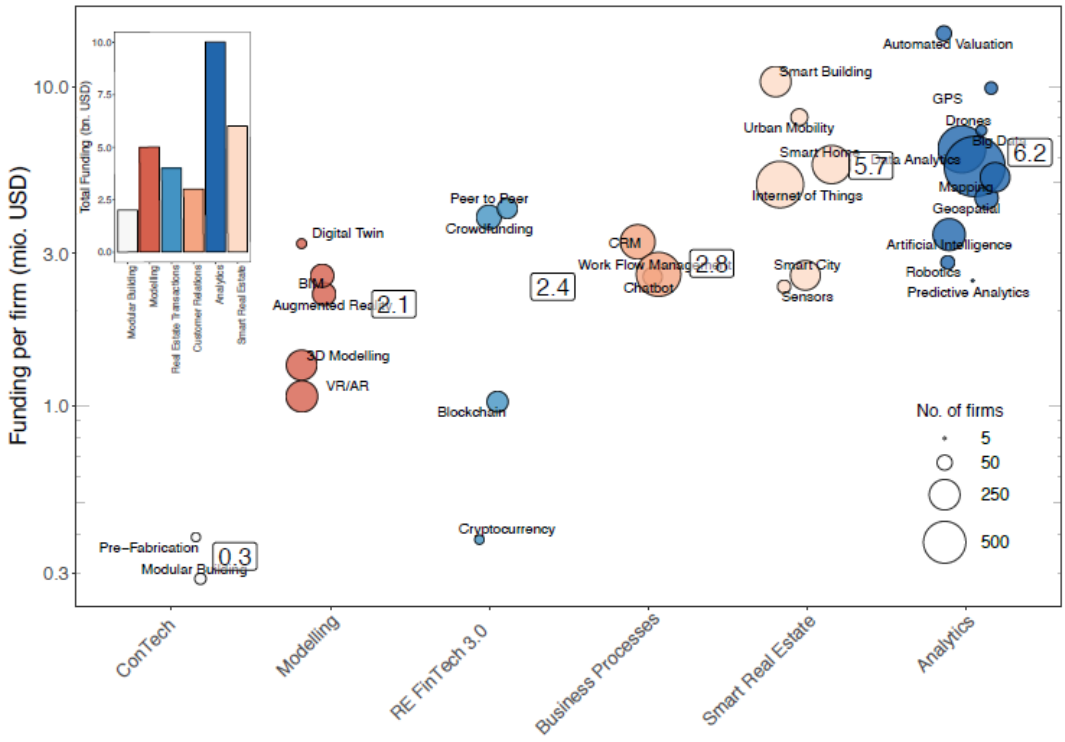


Figure 4. Size and funding per Property Technology cluster (Braesemann, 2020)

PropTech is focused on a limited number of technologies that can be applied to allow the development of the Real Estate market and solve problems arising in the sector. The most promising technologies are Data Analytics, Big Data, and sensor technologies. Thus, users and owners of Real Estate must become aware of the value of the data generated in buying, renting, or selling assets.

The growth of PropTech from a market point of view is confirmed by an analysis of the funding received by companies belonging to the sector.

It can be seen by the graph reported below (Figure 5) that the amount of funding received in the first two quarters of 2019 is about 9,3 billion. It is equal to half of the total amount obtained in the previous year and registers an increase of 40% of 2018's first two-quarters amount.

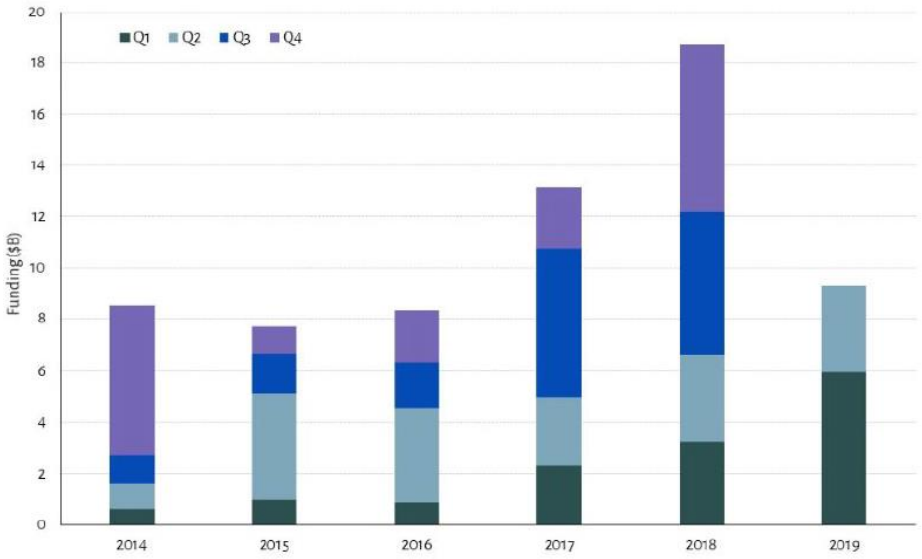


Figure 5. Funding received by PropTech firms at a global level in billions of dollars (Bellintani, 2019)

3.1 PropTech geography

Figure 6 reported below shows the global distribution of PropTech all over the world. In particular, the dots represent the firms, and their size stands for the funding each firm has obtained.

As it is possible to see from the map, the Proptech industry hotspots are in western Europe, in California, on the US east coast, and in Asian metropolitan areas such as Shanghai, Seoul, and Singapore.

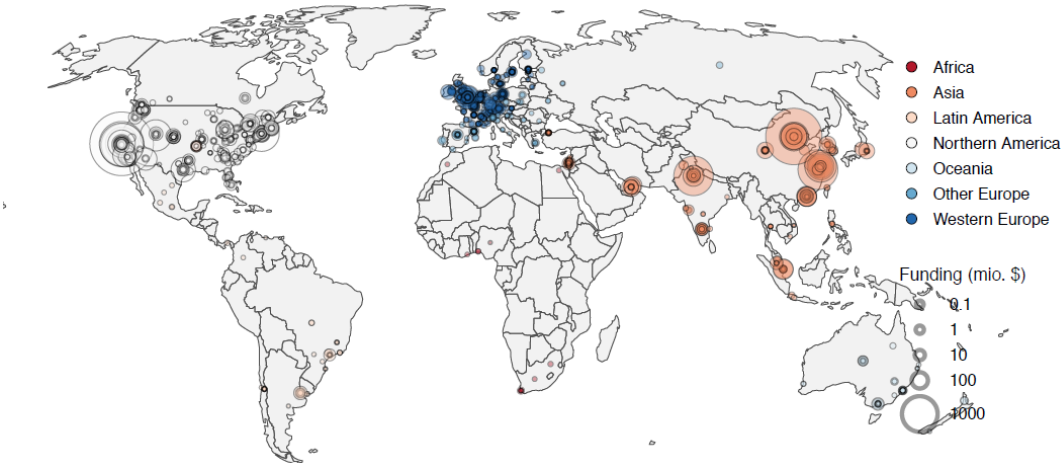


Figure 6. Global distribution of PropTech firms (Braesemann, 2020)

A deeper analysis is allowed by Figure 7 where it is shown the number of PropTech firms per one million population per country, grouped into larger geographical areas.

The graph highlights the gap in the development of this industry between the economies of western Europe, Oceania, and North America and the ones of Global South developing countries.

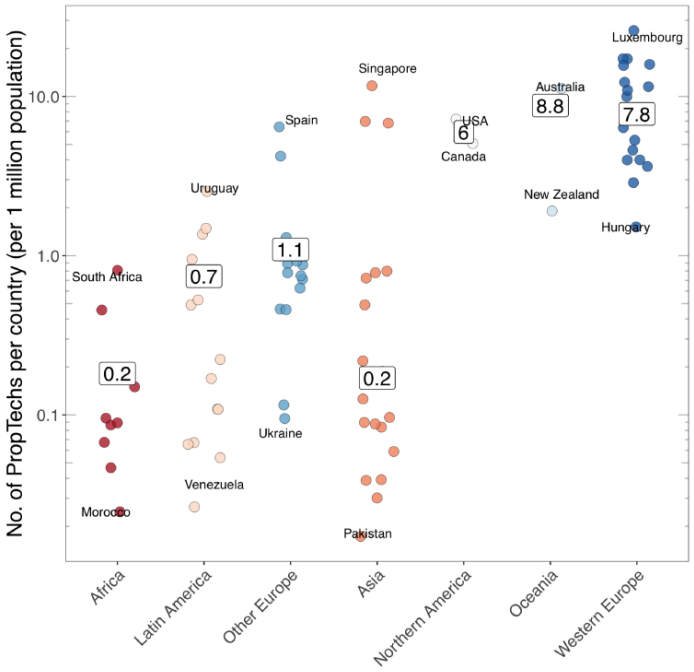


Figure 7. Number of PropTech firms per country, per one million population (Braesemann, 2020)

Figure 6 shows that PropTech firms that have the highest funding amounts are concentrated in some specific geographical areas. This aspect is confirmed by the following Figure 8, where it is shown the average funding per PropTech firms in millions of US dollars.

Data about the funding per firm varies on a global level. For example, as it is shown by the graph, the Chinese PropTech industry registers 85 million dollars of funding per firm, which is substantially higher than the Asian average of 28 million. The impact of countries like Vietnam, which registers an average of 100.000 dollars funding per firm, lowers the average.

In Europe too is possible to see a scenario like the Asian one. In fact, Portugal and Ireland have average funding of more than 5 million dollars per firm, while Romania and Latvia's average funding per firm is about 100.000 dollars.

They are also areas in which the average funding is similar between different countries. The graph shows that funding is high overall in Oceania and Northern America countries, while it is low overall African ones.

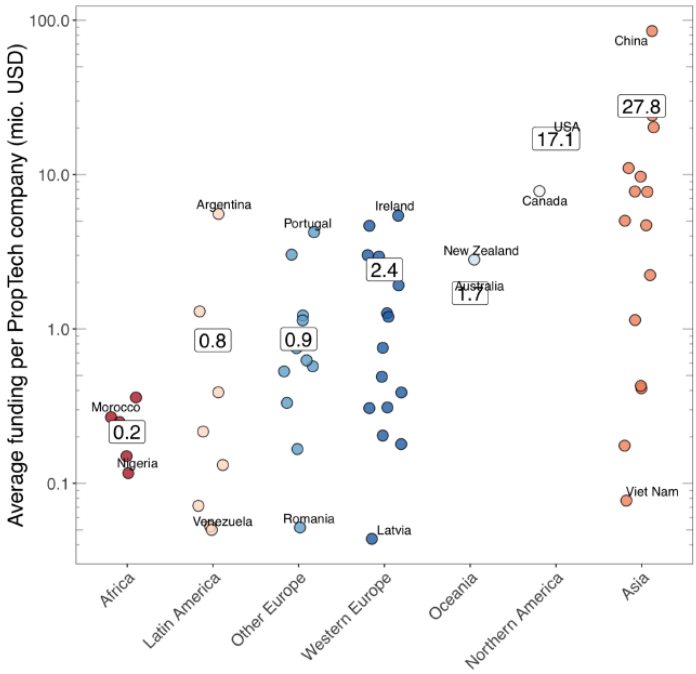


Figure 8. Average funding per PropTech firm (Braesemann, 2020)

Even if the Chinese and Indian PropTech sectors are smaller than western Europe and North America ones, a lot of funding is invested in these economies.

Further analysis, represented in Figure 9 below, is made about the relationship between the number of PropTech firms per country and the GDP per capita. The results obtained from the study allows to stand that the higher the country's income is, the larger is the PropTech sector.

However, the size of the PropTech sector varies as it is represented by the widespread in the figure.

It is important to notice that the low-income countries are also the ones with huge development potential. Firms can grow and offer PropTech services to solve the most relevant problems of their country's real estate market.

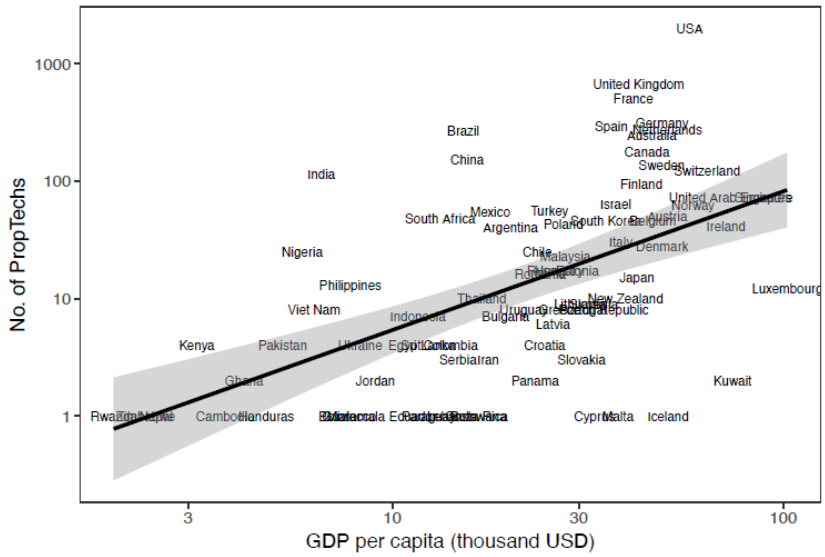


Figure 9. Relationship between the size of the Proptech sector of a country and its GDP per capita (Braesemann, 2020)

PropTech sectors from high-income countries benefit from being in an innovative ecosystem that attracts more venture capital funding and gives them a better chance to be competitive in the market. At the same time, small markets too can develop relatively large PropTech ecosystems.

3.1.1 PropTech development in Europe

The study developed by JRC PropTech, a partnership of medium-long term between a group of companies and Politecnico di Milano, has registered the presence of 3.219 companies operating in the Proptech sector. In the following table, they have listed the most active countries in the sector, which assume the role of promoters of events related to Real Estate digitalization.

Countries	*Number of PropTech companies*
United Kingdom	805, most in London
Germany	238
Spain	305
Finland	136, highest number of companies per million of population
Switzerland	More than 200

Table 1. Number of PropTech companies per country (Bellintani, 2019)

It can be useful to see in the following Figure 10, the distribution of the UK PropTech companies according to a classification based on the life cycle of a building.

The results obtained show that the highest percentage of PropTech companies operates in the management of the asset, while the other phases such as "Sell", "Buy", "Rent" and "Build", register a similar distribution of companies between 15% and 20%.

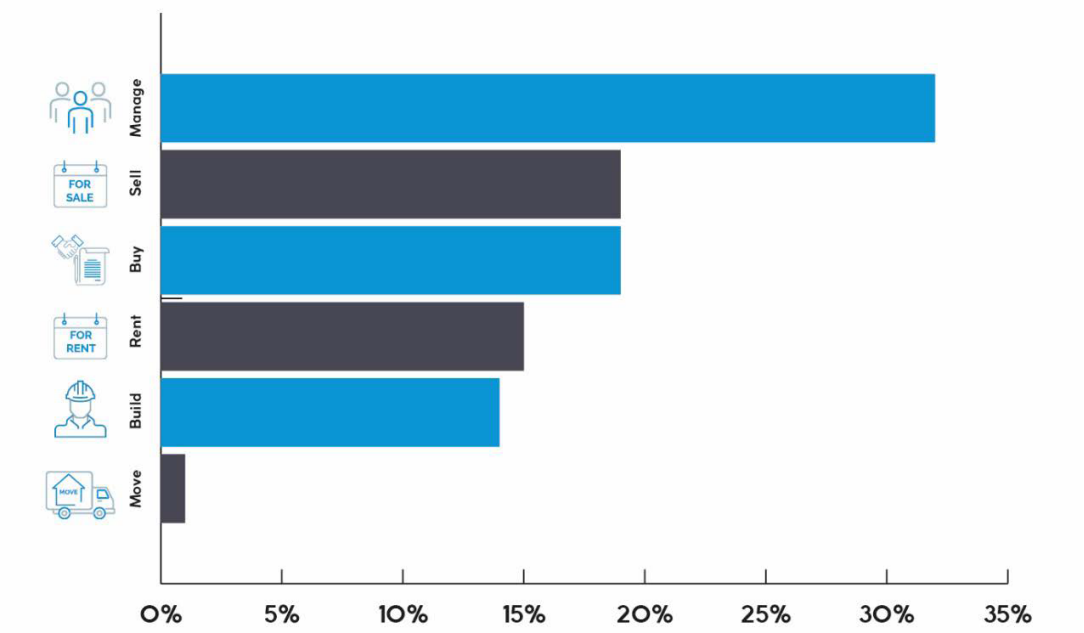


Figure 10. Classification of PropTech companies in the UK (Bellintani, 2019)

3.1.2 Italian scenario

The development of the PropTech sector in Italy is late concerning the other European countries, which have already been mentioned. The sector has registered a huge growth in the last two years as it is possible to see in the graph reported in Figure 11 below.

The amount of PropTech companies in Italy is 108, of which 35 have been founded during 2018 and 2019.

The graph shows that from 2010 there has been a positive trend in the creation of PropTech companies in Italy.

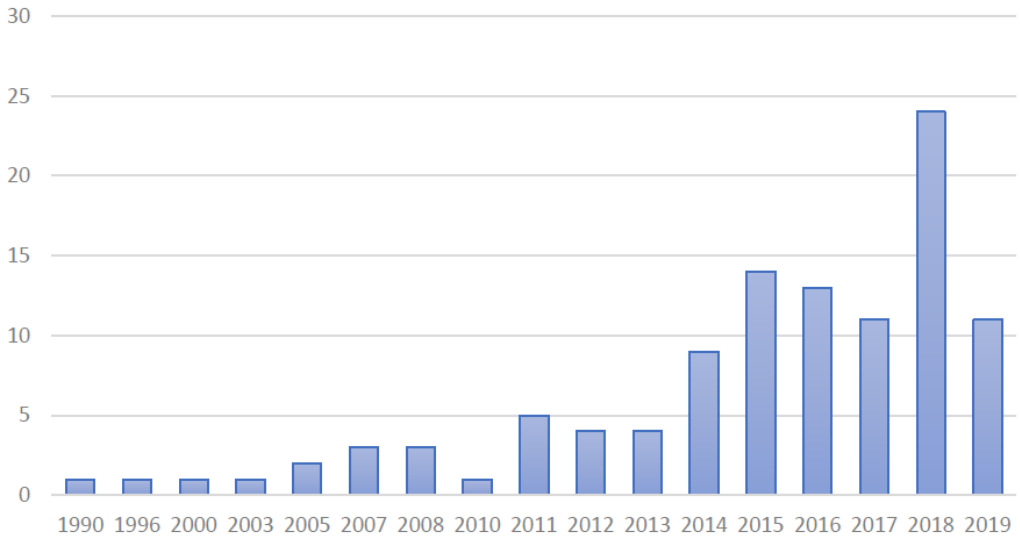


Figure 11. Development of PropTech sector companies in Italy, according to their foundation year (Bellintani, 2019)

All the 108 PropTech companies act in Italy, even if 12% of them have been started abroad, and then the founders have decided to come back to Italy and work in their native country too.

In the graph reported below (Figure 12) it has been analyzed the distribution of the firms in the Italian territory.

It has emerged that about 70% of the Proptech companies originated in cities in northern Italy, while a similar percentage of firms originated abroad and in the center of Italy. Only 5% of companies were founded in the south of Italy.

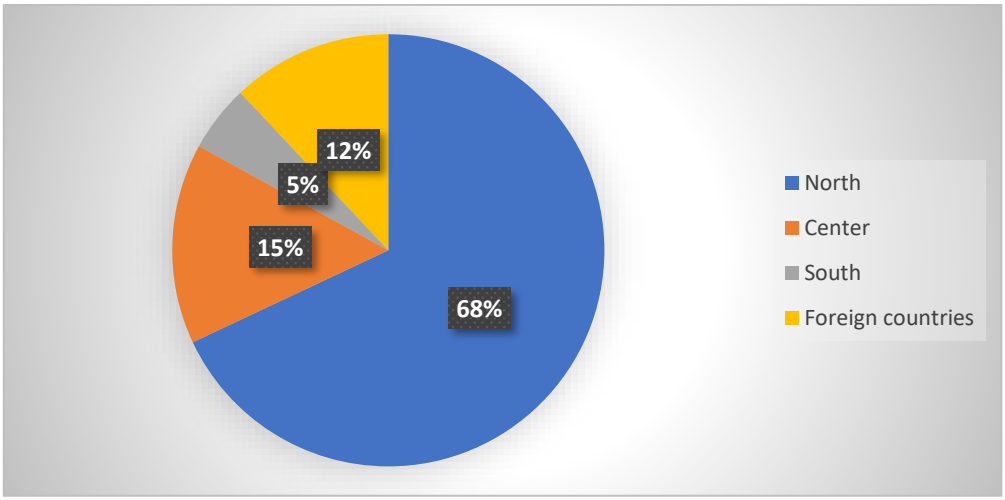


Figure 12. Geographical distribution of Italian Proptech companies (Bellintani, 2019)

The two graphs reported below show the importance of Milan in the Italian PropTech context.

Figure 13 reports the percentage of Proptech firms located in Milan with respect to the total Italian amount.

It is possible to see the high impact of Milan in the Italian scenario, in fact about half of the Italian PropTech companies are in Milan.

A deep analysis is shown in Figure 14, where it is visible the great relevance of Milan in the northern Italy distribution of PropTech firms.

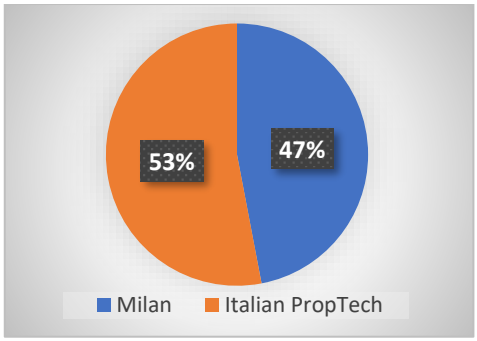


Figure 13. Milan and the rest of Italy distribution (Bellintani, 2019)

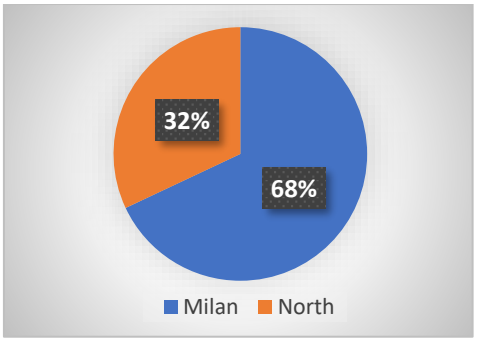


Figure 14. Incidence of Milan on northern Italy (Bellintani, 2019)

According to the JRC report, it is possible to divide the Italian firms according to the PropTech sub-sector they belong to (Bellintani, 2019).

To 2019, the division of firms among the sub-sectors resulted to be homogeneous. Figure 15 shows that the highest percentage of companies belong to the Real Estate FinTech sector, while the lowest one to the Smart Real Estate. The remaining half of the firms are equally divided between Sharing Economy and Professional services sectors.

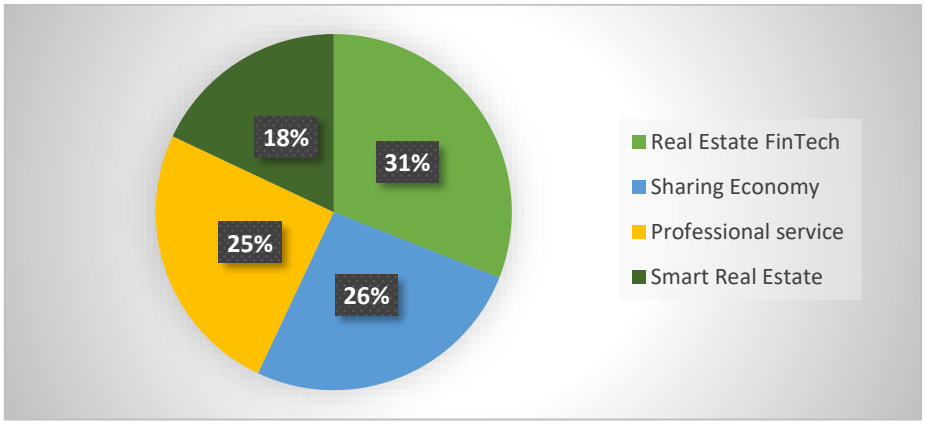


Figure 15. Categorization of Italian PropTech firms (Bellintani, 2019)

Though, it is significant to analyze the development of the firms in the last two years, when most of them have been introduced in the market.

In Table 2 reported below, it is possible to observe how the distribution of firms has changed between 2018 and 2019.

Data about 2018 shows a more relevant incidence of the Sharing Economy sector compared to 2019. The other important difference within the two years is the growth of the Smart Real Estate sector in 2019, which was very lacking in 2018 with the lowest percentage, equal to 12%.

	Year	
PropTech sub-sector	2018	2019
Real Estate FinTech	30%	31%
Sharing Economy	32%	26%
Professional Service	26%	25%
Smart Real Estate	12%	18%

Table 2. Distribution of PropTech firms into the sub-categories (Bellintani, 2019)

The graph reported below (Figure 16) shows the growth rates of the Proptech sub-sectors in Italy in the two years 2018-2019.

Real Estate FinTech and Professional Service dots are closed to the 0% of growth, confirming what is reported in the table previously explained.

The two most significant situations are those about Smart Real Estate and Real Estate FinTech.

The former has registered an increase of the sector about 50%, while the latter a decrease of about -20%. They can be indicative of a trend that can characterize the market in the next years, especially for SRE which can have exponential growth in the market.

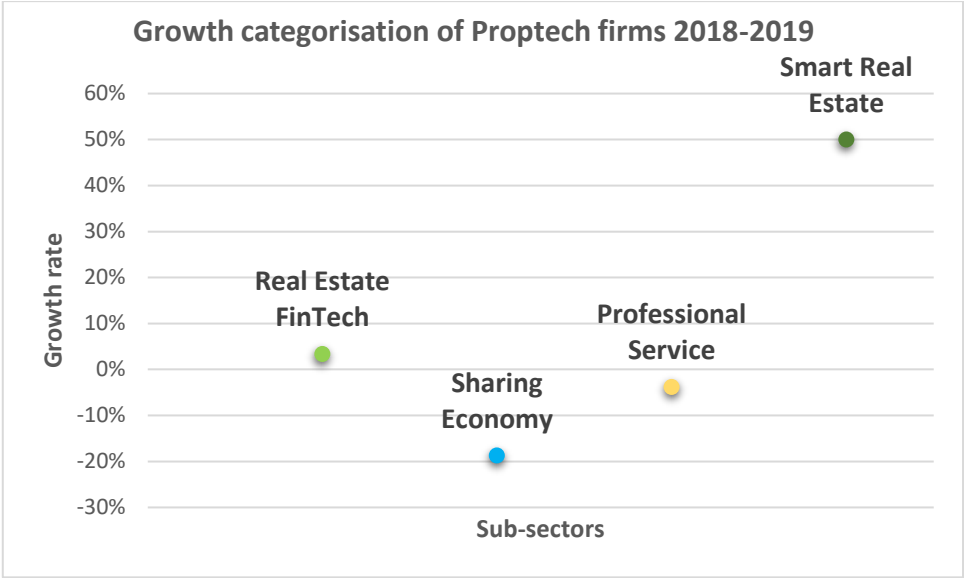


Figure 16. Growth of the PropTech sub-categories in the two years 2018-2019 (Author's elaboration)

4. Smart Real Estate

As it is defined by Baum *"Smart Real Estate describes technology-based platforms which facilitate the operation and management of real estate assets. The assets can be single property units or entire cities. The platforms may simply provide information about building or urban center performance, or they may directly facilitate or control building services. This sector supports real estate assets, property, and facilities management"* (Baum, 2017).

Innovative technologies are the main indicator of the concept of smartness and can be used both in smart cities and in the real estate sector.

A city can be defined as smart if the last disruptive technologies are implemented. They include drones, IoT, clouds, software, big data, 3D scanning, wearable technologies, virtual and augmented realities, artificial intelligence, and robotics.

In a smart city, the use of electronic data and technologically advanced sensors are allowing to manage the assets and resources in a new and more efficient way (Ullah, 2018).

Real Estate is smart for its innovative nature and its capability to adopt innovative technologies, even if they can become more complex over time. Thus, smart cities need smarter management to succeed (Ullah, 2018).

There is not a proper definition of smart real estate and smart cities. They are characterized by different parameters. Ullah identifies, as key components (Ullah, 2018):

- User-centeredness
- Sustainability, which can be a reason of interest for global industries.
- Innovative technologies such as virtual showcases, crowdfunding, AI, smart homes, online marketplaces, and smartphone apps.

They represent the core of smart real estate management, which is not only constrained to infrastructure but also asset management.

Based on this analysis the Smart Real Estate is defined as *"A property or land that uses various electronic sensors to collect and supply data to consumers, agents, and real estate managers that can be used to manage assets and resources efficiently. The key features are user-centeredness, sustainability, and the use of innovative and disruptive technologies in such a way as to attain holistic benefits that are otherwise not attainable"* (Ullah, 2018).

An example of this trend can be Airbnb, which raised $10 billion in 2014 and gained greater market capital than some important hotel firms (Ullah, 2018).

Smart Real Estate is a novelty in the market, but the starting point is always based on stakeholders and their relationships. Two main protagonists are identified (Ullah, 2018):

- *Consumers*; they can be buyers, renters, users, or sellers of real estate and are the beneficiaries of the transaction process;
- *Agents and associations*; they are real estate managers, developers, and private investors who provide services to consumers in exchange for revenue.

Technologies in the search process assume an important role from the moment in which a consumer looks for a property.

The buyer-sellers interaction is represented in Figure 17 reported below, where it is shown a property search from the moment in which a seller uploads an asset's detail to present it. Then a potential consumer searches, views, and selects a property.

Online platforms are based on the use of disruptive technologies, including smartphones and websites, which provide useful information for consumers. For example, new prices in any neighborhood can be predicted or can be given to consumers' information about safety, crime rates, or ease of travel of a specific neighborhood.

All this knowledge is important because it can avoid consumer regrets that can arise when the information provided by the seller is not exhaustive.

In the second phase of the process, the administration of the website can approve or reject the information that has been uploaded. In the case of rejection, the owner must intervene modifying property details or uploading missing parts, while, in the case of approval the property becomes visible online to the consumers.

The different requirements of consumers can be met with the use of filters on the website which allows generating a shortlist of the available properties.

Consumers can provide feedback or demand some information; in the last case, the demand is firstly verified by the administrator and then is sent to the property owner and vice versa before the finalization of the deal (Ullah, 2018).

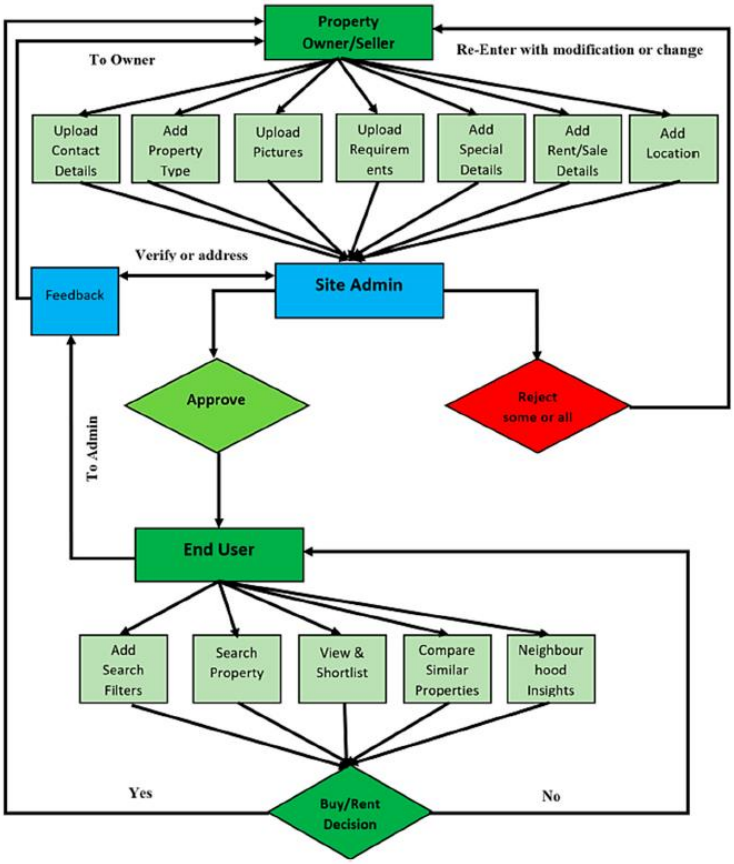


Figure 17. Process of online rent or buy (Ullah, 2018)

The first analysis can be implemented if, besides consumers and associations, two more stakeholders are considered. They are the government or regulatory authority and complementary industries. The latter ones consider all the industries like banks and law firms that receive money in exchange for the services they provide to make easier the processes of buying or selling of the property for consumers.

In the Figure 18 reported below it is shown the interaction among the stakeholders, putting the consumer at the core of the process.

Associations and industries provide services to consumers in exchange for revenues, at the same time industries provide services to associations in exchange for revenues.

The role of government and regulatory authorities is to protect consumers against unethical practices and misbehavior by associations and industries. In return, consumers pay taxes to regulatory authorities.

The government also supports industries and associations in the form of loans and protection in return for taxes.

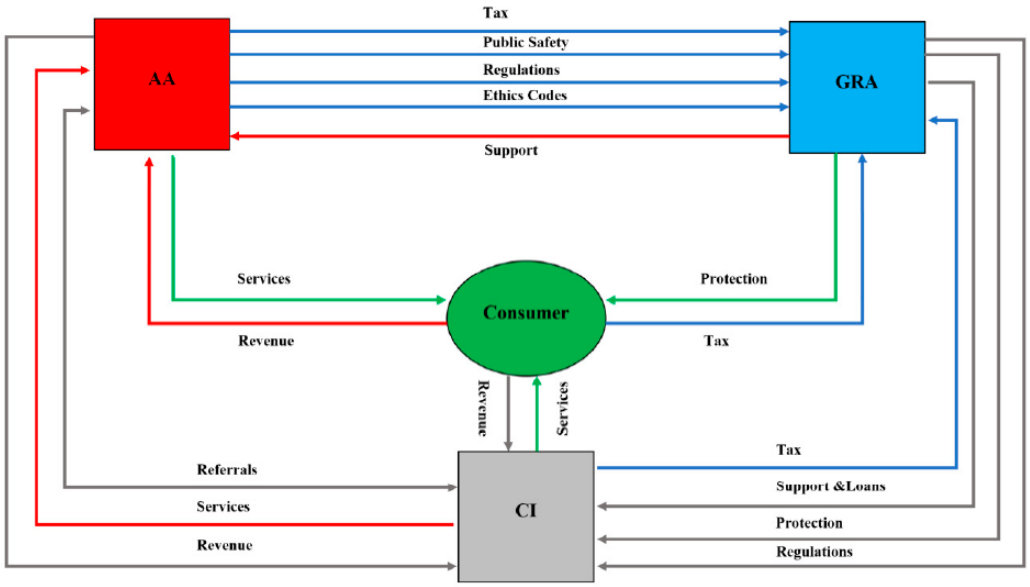


Figure 18. Key stakeholders' interactions; AA: agents and associations; GRA: government and regulatory authorities; CI: complementary industries (Ullah, 2018)

In the Figure 19 reported below, they have been highlighted the needs of the stakeholders, which are distinguished between basic and secondary needs.

The basic need for a consumer is to buy or sell a property; while a secondary need is, for example, living in a desirable neighborhood that provides desired facilities. Preferences vary according to the consumers' needs which can range from travel time to the workplace to having a low crime rate.

The basic need identified for government and regulatory authorities is providing the protection of citizens in return for taxes. The secondary needs are the formulation of codes and regulations, the economic growth of the state, and political support.

The basic need for associations is profit, which is generated by the services provided to consumers, which include ensuring the main goal of negotiation so that sellers and

buyers are matched according to their availability and demands (Ullah, 2018). Secondary needs include networking, support from the government, and associations. The two-way process of referral between industries and associations is particularly relevant because it helps both stakeholders to increase their business and profit, which is their basic need.

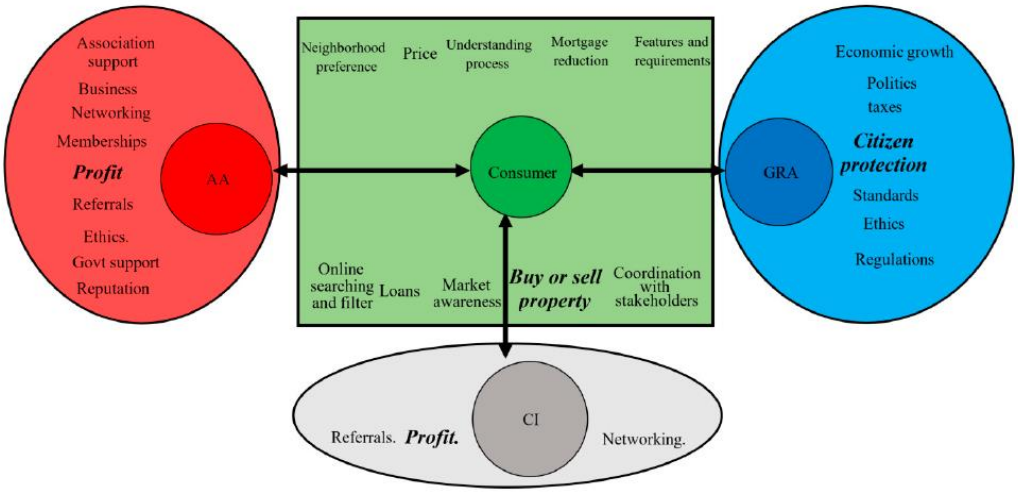


Figure 19. Basic and secondary needs of key real estate stakeholders (Ullah, 2018)

Technology is not the only important factor, but the dissemination mechanism very significant too. A poor dissemination tool can restrict the availability of the technology to the consumers and result in financial losses.

In this era, many of the market leaders in real estate have a functional and accessible website system, which is the most powerful platform for sharing information with users. The ease of use for a consumer is obtained through videos, 3D images, virtual tours, interactive maps, and neighborhood information.

Technology itself can be categorized into two sub-parts that are detection and storage, while dissemination can be divided into control and output. Big data are associated with storage technologies (Ullah, 2018).

Their relationship is properly shown in Figure 20 reported below. The process begins with the data collection, which is possible using tools and gadgets in the house. Big data and IoT-based algorithms are used to extract useful data from the whole set, then information is stored on servers and passed through ethics checks and government regulations before it becomes reliable to consumers (Ullah, 2018).

All the stakeholders involved in the process have control over the information and this aspect has the additional benefit of increasing between them and the consumers.

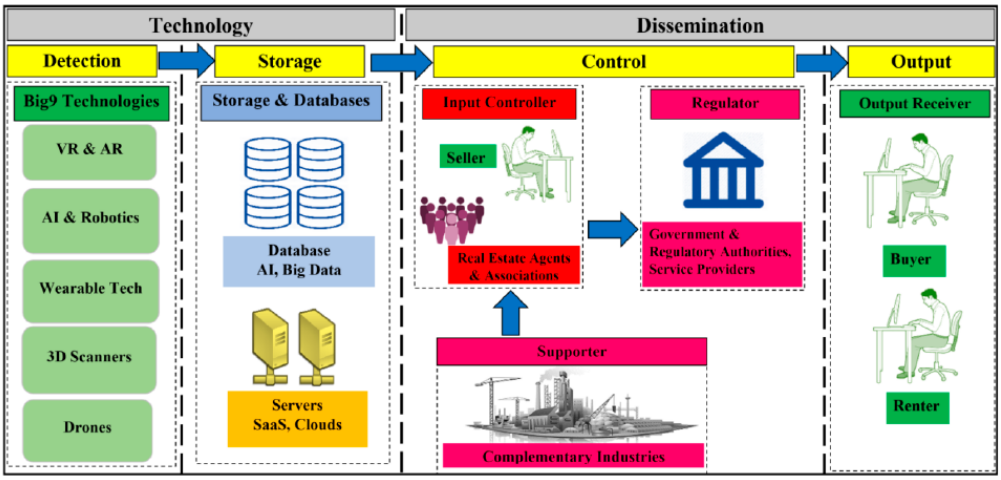


Figure 20. Process of information detection and dissemination (Ullah, 2018)

Big data directly affects associations, consumers, government, and industries. Consumers, thanks to statistics, become more market-aware and tend to make more decisions about buying or renting (Ullah, 2018). Lack of information disappears.
It is possible to identify three main processes through which big data affects stakeholders: buying, selling, and facilitating.

Smart Real Estate must be considered in its infancy phase because most of the existing residential buildings were built without any integration of technologies (Feth, 2018). However, some factors can make possible development and a shift to the SRE reality.
The first is the use of clean and renewable energy, which represents a great growth opportunity for companies with innovative ideas to increase efficiency.
The second factor is the trend of private tenants becoming more open to new technologies. With actual devices, they can optimize and control, for example, energy consumption.
In the future, it will be possible with the help of Smart real Estate to optimize entire neighborhoods, including schools and hospitals. It is related to the innovative idea of Smart City (4.2.2).

4.1 User-centeredness

This first issue of SRE is related to customer satisfaction, customer value and they are important factors that can add value to organizations. They can introduce new disruptive technologies to attract new customers and satisfy the needs of the existing

ones, overall obtaining an improvement of the business. Key domains of user-centeredness in SRE include changes in lifestyle, technology, and space.
Customer satisfaction is the main aim of smart technologies which can be physical, functional, and psychological. Functional comfort is about consumers' needs and their interaction with the environment thanks to a better design of space and technology (Ullah, 2018).

4.2 Sustainability

Sustainability in Smart Real Estate can be associated to price, reliability, technology, and environmental effects. It can be nonsense, but eco-certified real estate assets and buildings are often overpriced and so not sustainable.
As it is described by Ullah *"Sustainability in SRE can be achieved by assessing the energy and the environmental efficiency of buildings, performing sustainability-related risk assessments, and using locale-specific tools for effective implementation"* (Ullah, 2018).

4.2.1 Smart Buildings

Nowadays delivering sustainable assets represents a minimum standard and a requirement to be competitive in the market.
Smart Buildings can combine and integrate two main purposes:

- Provide space for residents.
- Increase efficiency through the integration of new technologies.

Buildings are expected to be efficient from both cost and functional aspects to satisfy users and investors. This means that building service inputs, such as air, water, and power, and outputs, such as emissions, must be managed with the goal of ensuring good health and well-being level for tenants and the building itself (Baum, 2017). Moreover, it has consequences from the market point of view.
Since the moment in which building energy efficiency and relative costs have been included in the real estate decision process, landlords have an input to produce energy-efficient buildings.
Investors can have the advantage of gaining better returns because a lower energy cost of the building can be used to negotiate higher rents.
Monitoring of the energy use through control devices combined with the transmission of data between the user of the asset and its supplier becomes very important to

reduce the amount of energy used. In fact, should be created a system able to pass the benefits of energy-saving to market participants (Baum, 2017).
It can be concluded that the core of Smart Building Technology includes:

- The development of intelligent leases
- An efficient energy's supply.
- The monitoring of energy consumption

With smart buildings, it is possible to see a shift of property management to the owner or manager of the property itself.
All the values measured in a smart building can be read off in real-time via PCs, tablets, and smartphones improving the awareness of users about their consumption and allowing them to control the building infrastructure more efficiently (Feth, 2018).
IoT allows to measure and control the objects remotely. For example, the heating system can be switched off through a mobile phone app.
Moreover, many of the biggest consumer technology companies are moving into the smart home market. Their goal is to deliver new building automation and energy management systems able to improve comfort, environmental quality, and to ensure requirements related to sustainability (Baum, 2017).
The first one was Google, with the acquisition of Nest, a producer of thermostats and sensors.
Two years later, Apple launched a smart home ecosystem called Apple Home. It is a part of its IOS 10 system. Apple aimed to become a competitor in this market, which was dominated by Amazon Alexa's technology.
Other firms, such as Siemens, are transforming their configuration, passing from the supply of goods in the mechanical sector into the development of automotive and intelligent home systems.

4.2.2 Smart Cities

The concept of "Smart City" refers to a complex development vision where the assets are managed through communication and information technology and IoT solutions. The services included are various and can be schools, transportation systems, libraries, hospitals water-supply networks, power plants, and waste management.
A smart city is built to improve the whole life's quality with innovative urban informatics and technologies to make services efficient and meet the needs of the citizens.

Data can be collected from devices and by sensors that are integrated with systems that can monitor real-time events (Baum, 2017).

4.3 Innovative technologies

Smartness as a concept is strictly connected to the adoption of technological innovation. Advantages of SRE and smart cities are related to the improvement of everyday life and the innovation can translate ideas into services or goods, creating value or meeting consumer demands (Ullah, 2018).

The four contexts in which innovation can arise are political, social, environmental, and technological; while the key aspects of the Real Estate sector include digital technologies and their adoption, virtual showcasing, crowdfunding, AI, and smart homes.

The adaptive nature of SRE distinguishes it from traditional real estate and the management of SRE creates a make-or-break situation because properly managed SRE can result in greater financial and business benefits while bad management can degenerate into huge financial losses.

Real estate technology can be defined as a *"combination of online platforms and software tools that are used by stakeholders such as investors, brokers, real estate lenders, property owners, managers, and consumers*" (Ullah, 2018).

Information from disruptive technologies can avoid regrets and make consumers able to make better decisions if it is available for the users.

Recently the real estate company OpenDoor Labs introduced a particular model for buying and selling homes, which is based on the owner that can directly buy the home, improving it with the installation of the latest technologies and listing it to the market as soon as possible (Ullah, 2018). The company has two advantages:

- A gain from the appreciation in the property price
- Protection from losses by taking a fee from the homeowner that is based on the asset's estimated value.

The benefits for the seller are a faster sale and lower transaction costs.

Moreover, thanks to the business model proposed by the company, consumers are more satisfied because of a higher amount of information available.

4.3.1 Hi-Tech Buildings

The origin of hi-tech buildings goes back to the 1980s when they were a mix of offices and industrial buildings forming a science park.

Nowadays this concept refers to buildings that include the use of technology-based platforms, as in the case of smart ones. They can be data centers, specialized logistics like online distribution hubs, Amazon lockers, or co-working spaces designed for tech companies.

Data centers are on the rise globally, it has been estimated that traffic within data centers will quintuple by 2020 (Baum, 2017).

Facebook is probably the most data-hungry of the five big tech companies. In 2010 it built its data center in Oregon and since this moment it has realized three other data centers; two in the US (North Carolina and Iowa) and one in Sweden (Figure 21).

To support its business growth after the acquisition platforms such as Instagram, WhatsApp, and Messenger, Facebook has started the construction of other four centers; two in the US, one in Ireland, and one in Denmark.

It has been estimated that *"Facebook has commissioned a new build averaging a million square feet every year in the last seven years*" (Baum, 2017).

An additive issue talking about data centers is the connectivity. About that, Facebook has announced partnerships to help to build a trans-oceanic cable from the US between the East Coast and Europe. In the same way, a cable will be built to connect the West Coast to Asia.

Figure 21. The Facebook data center in Lulea, Sweden (DataCenter Knowledge, s.d.)

A lot of property companies are specializing in data centers.

For example, Digital Realty, a spin-off of CBRE Global Investors, has a portfolio that includes 198 buildings in 14 countries across 5 continents. Another company is Equinix, which manages 145 data centers in 40 markets on five continents.

The energy supply for data centers is another growing business. The goal is to develop systems providing to the customers the needed energy services at a lower cost.
It is important to meet sustainability targets, with the use of renewable energy.

4.4 Italian scenario

The sector of Smart Real Estate, according to the JRC study, includes 19 firms. They, as shown by the graph reported below (Figure 22), can be divided into three sub-categories:

- Facility & Property
- Smart Building & IoT
- Virtual and Augmented Reality Service

The IoT sector is the one with the highest number of firms, equal to 10. The second sub-category is the one that offers virtual or augmented reality solutions that allow to visit or furnish properties without being inside them.
In the end, there is only one company belonging to the Facility and Property category, focused on the operative efficiency of firms.

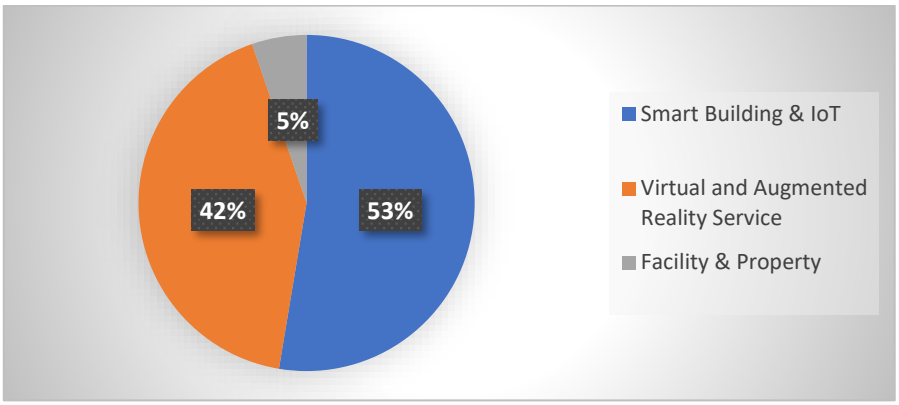


Figure 22. Smart Real Estate sub-categories division (Bellintani, 2019)

5. Sharing Economy

The concept of sharing economy, which started in the 2000s, is based on the philosophy that space and capital goods are better shared.
It had an impact after the global financial crisis of 2008 when there was a search for new business formats. In fact, the crisis, due to job loss and financial austerity, had an impact on the way consumers access, buy, and use products and services.
Two main business and social problems have been resolved and improved by the sharing economy:

1) The increasing relevance of collaboration and access economy
2) The accessibility of goods and services

Collaboration, in the sharing economy, refers to the share or exchange through peer-to-peer based platforms of intangible assets such as skills and innovation.

There was an impact on several companies, which redefined their business model.
The best-known examples of these firms are Airbnb, WeWork, Uber, Lyft, and Zipcar.
These companies share assets such as cars, houses, and offices.
Real estate is one of the most impacted industries by this revolution, including residential, retail, office space, and storage.
Figure 23 shows some significant statistics about some industry's key players.

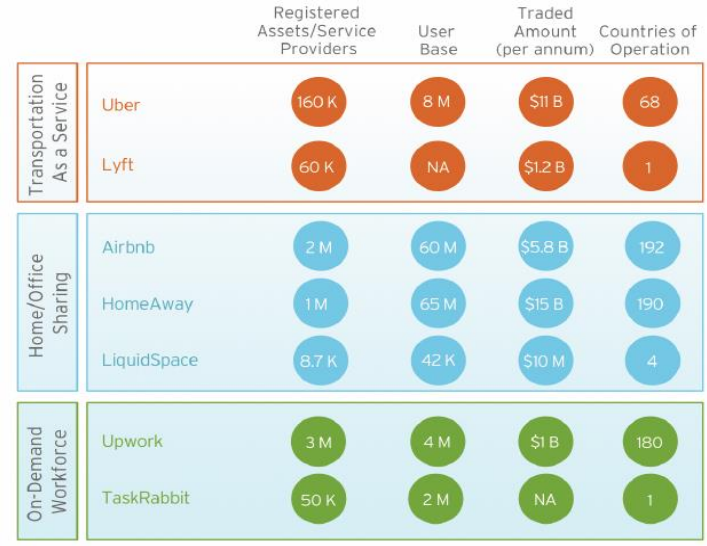


Figure 23. Sharing economy (Feth, 2018)

The revolution stands in the fact that more consumers are paying for temporary access and temporary ownership, instead of traditional ones.

The most important changes related to the sharing economy are reported in Table 3 below.

Sectors	*Changes*
Technological	o Companies have been facilitated to aggregate supply and demand via the internet. o The access of consumers and producers to marketplaces has been revolutionized. o Internet billing systems allowed the foundation of e-commerce.
Economic	o Consumption behaviour of people has been changed by austerity and crisis. o Introduction of more efficient rental models due to high prices.
Political	o Increase of political instability. o Replacement of institutions by global businesses.
Social	o The concept of ownership has been questioned. o It is no longer recognized the security guaranteed by the ownership.

Table 3. Impact of sharing economy in different sectors (Baum, 2017)

5.1 Shared Economy and Real Estate

The Real Estate sector is one of the most affected by the impact of the sharing economy. It is growing fast and is very attractive to start-ups and other innovative companies. It is possible to share spaces such as houses, rooms in houses, office buildings, restaurants, car parking, and shops via technical platforms.

Real estate is a capital-intensive investment whose prices have risen in recent years (Feth, 2018).

The prevalence of renting the spaces over the ownership of them is because purchasing houses in densified urban centres is very expensive. People are forced into the shared housing by the widening gap between rich and poor and the discrepancy between housing supply and demand.

For example, house prices in London have increased by 60% since 2008, despite over 30.000 new city apartments have been built.

The demand is growing for the rented sector creating a supply shortage. Many business start-ups are beginning to operate in the p2p (peer to peer) rental market.

According to Baum *"The shortage can be corrected by employing the sharply increasing number of spare bedrooms in the increasingly under-utilized owner-occupied sector: 8.2 million households in England have one or more bedrooms than they need"* (Baum, 2017).

The best-known firm in this sector is, for sure, Airbnb. It was launched in 2008, during the financial crisis. The crisis was related to the growth on the supply side that, for years, has been significantly lower than the growth on the demand side.
The founders, Brian Chesky and Joe Gebbia, in the occasion of the organization of an industrial design conference in the town where they lived, exploit the opportunity to make extra money. They hosted boarders who were coming to the conference but did not want to pay for expensive hotels.
After the creation of a website, they bought the necessary stuff and played host to three people during the conference's weekend.
Airbnb began almost by accident but in few years became an international phenomenon. Nowadays, it operates in 57.000 cities in 192 countries.
In 2015, it was identified a total number of 550.000 Airbnb listings in the US. Another research has shown that over 2,8 million room nights were booked between September 2014 and August 2015; consequently, it has been estimated that there has been a loss for hotels of over $ 450 million in direct revenue per year to Airbnb (Baum, 2017).
Figure 24 shows that the company has more than 2,3 million house listings and a market capitalization exceeding $ 30 billion.

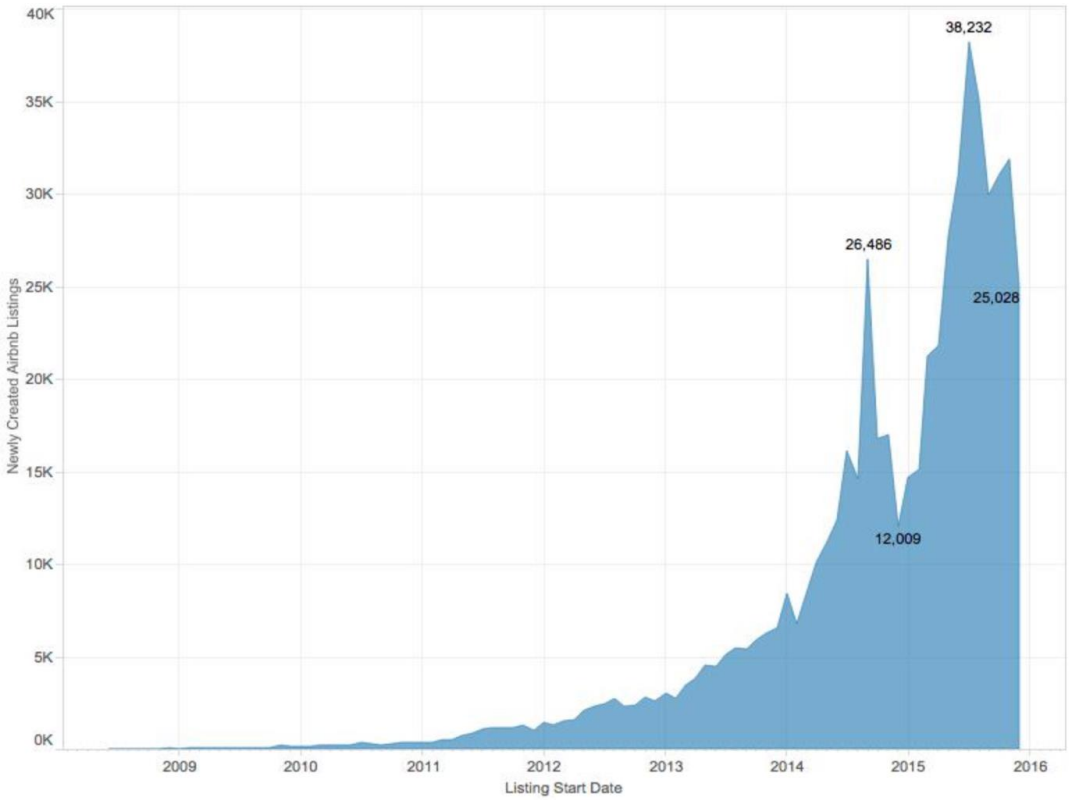


Figure 24. Growth in Airbnb listings in the period 2009-2016 (Baum, 2017)

The conditions which explain the success of Airbnb refer to the PropTech principles and can be summarized in the graph reported below (Figure 25).

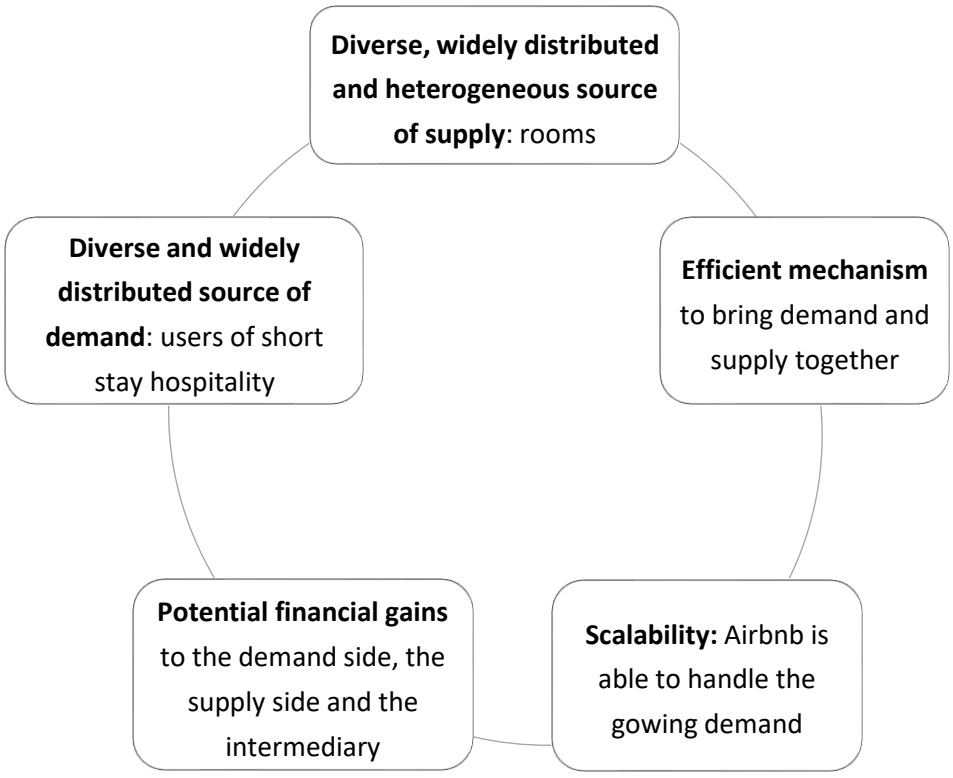


Figure 25. Conditions for shared economy service (Baum, 2017)

The efficient mechanism that it is possible to recognize in Airbnb is the combination of a website and a brand. The value of the brand is a very important factor in the automatic and low-cost generation of volume (Baum, 2017).

In the table reported below (Figure 26), they are reported data about the top 10 US cities. They are interesting the overall results reported in the last two rows.
It can be noticed that there is a relevant difference in the ratio of Airbnb units/Hotel rooms between the top 10 US cities and the whole country. In the first case, the ratio is equal to 9,9% while in the second it is equal to 3,4%. The incidence of Airbnb in the market is significant because illustrates the self-reinforcing nature of densification. An urban concentration and data richness are necessary to create value.
If local data becomes richer, more people will be attracted to that location, further driving concentration (Baum, 2017).
It is possible to see that the highest ratio of Airbnb units per Hotel rooms is in the most populated city of the US, New York. At the same time, Los Angeles, which is the second classified in the ratio ranking, is the second American city for the population. The remaining eight cities of the top ten are characterized by ratios close to the wage of 9,9%. The exceptions are San Francisco, with a percentage of 12,1%, and Chicago and Washington DC, whit the lowest ratios about 4%.
Big cities make the sharing economy more successful, while it is almost absent in rural areas. This is the case of car-sharing services too, as Uber.

MARKET	ACTIVE AIRBNB UNITS	ACTIVE AIRBNB BEDROOMS	BEDROOMS PER UNIT	HOTEL ROOMS	AIRBNB UNITS/HOTEL ROOMS
New York	22,876	27,965	1.2	117,367	19.5%
Los Angeles	13,023	17,967	1.4	98,166	13.3%
San Francisco	6,428	8,790	1.4	51,561	12.5%
Miami	5,199	7,368	1.4	51,498	10.1%
Chicago	4,626	6,153	1.3	111,408	4.2%
Washington DC	4,443	5,784	1.3	107,776	4.1%
Boston	4,147	5,566	1.3	52,119	8.0%
Seattle	4,044	5,601	1.4	42,455	9.5%
San Diego	4,016	6,290	1.6	60,754	6.6%
Austin	3,357	6,024	1.8	33,877	9.9%
Top 10 U.S	72,159	97,508	1.4	726,981	9.9%
Overall U.S.	173,057	277,256	1.6	5,031,645	3.4%

Figure 26. Analysis of Airbnb units and hotel rooms in the US (Baum, 2017)

Airbnb cannot be considered the only important change in the hospitality market. The advent of customer feedback, one of the innovations introduced by Amazon, has driven some businesses such as Trivago, Booking, and Trip Advisor.

They have exploited the hotel chain website as a revenue source, offering much more choices.

5.2 Sharing of workspaces and co-working

They have been identified two kinds of spaces:

- First places, they are the homes.
- Second places, they are the workplaces.

It has been identified also a third space, different from the two explained above. For example, they have been included in this category environments such as cafes, clubs, public libraries, or parks.

According to a study conducted in 2016, in this year the average worker time spent in the third places is about 25%.

As it is represented in Figure 25, real estate sharing platforms respect the conditions. In this case, the source of demand is the office-type workers, and the source of supply is the workrooms.

The concept of co-working is based on the sharing of workspaces among workers with different backgrounds to encourage knowledge-sharing, innovation, and users' experience.

The growth of tech industries and the work's changes have increased the demand for co-working spaces. For example, the market share of office space in central London has increased from 1% to 14% over 2000-2016.
In the graph below (Figure 27), they are reported the three main drivers which explain the development and growth of co-working.

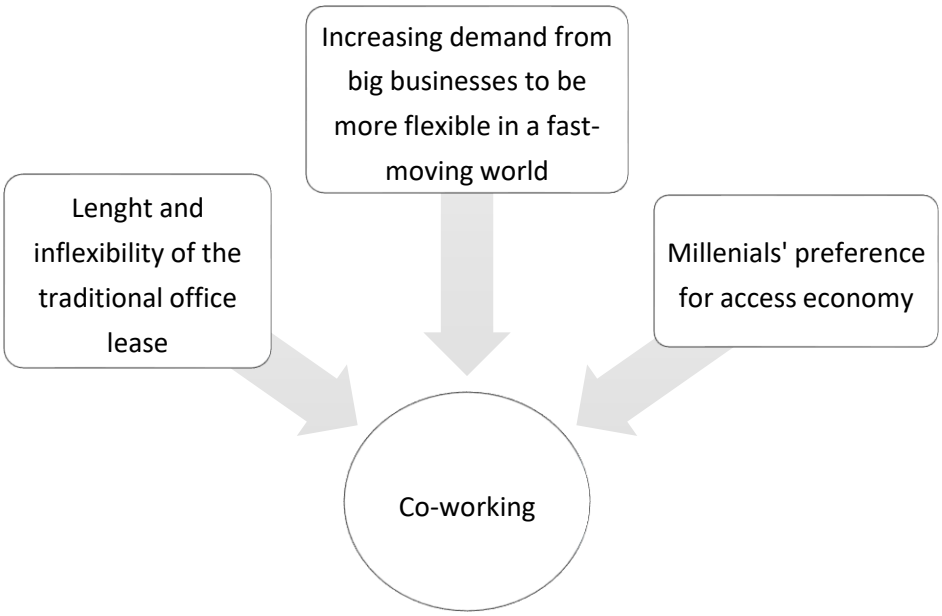


Figure 27. Co-working drivers (Baum, 2017)

One of the first firms in the co-working sector was Regus. It was launched in 1989 and now operates 4.000 business centres supplying a flexible number of spaces on short leases or licenses across 120 countries (Baum, 2017).
They can be identified two co-working models:

1) A Tech firm is simply an intermediary or broker of shorter-term workspace.
2) Operator model, in which the capital asset is controlled directly or indirectly by the business.

The first model is based on Airbnb, Booking, and Uber concepts. They are firms that rely on customers' feedback.
The second model refers to firms that act as renters of spaces rather than intermediaries between users and operators.
WeWork, a start-up founded in New York, is one of the firms which can be included in this model. It is the global leading shared office provider and opened the larger shared space in the UK, in London, with the capacity to house 3.000 members. Its valuation reached $16 billion in 2016 (Baum, 2017).
It manages about 10 million square meters of offices.

The clients of WeWork are diversified among different industries.
Passing from a revenue model from a lease length arbitrage into a management fee collection model for the services they offer including in some markets design, branding, and software is the biggest change made by the company (Baum, 2017). It may continue to evolve as a management company.

China can be considered the most emerging market in the sector.
The Central Government has predicted that this market will grow by over 40% annually and will represent an amazing opportunity for all the shared economy enterprises.

5.3 Italian scenario

The sector of the Sharing Economy, in Italy, includes 28 Proptech firms, which can be divided into six sub-categories (Figure 28).
The categories are:

- Short Term Rental and Hospitality
- Management
- Community Life
- Workspace and Co-working
- Event space
- Marketing

The Short-Term Rental and Hospitality category is the one with the highest number of firms, equal to 10.
They are more than double the average number of other categories' firms.
The second larger sectors are Management and Community Life. The former includes five firms, which deal with the management of short-term rentals and related services. The latter includes five firms too, which deal with solutions to help the growth and development of neighbourhoods.
The third place is occupied by Workspace and Co-working area, in which it is possible to find four firms that survey platforms and networks about the sharing of workspaces.
The smallest firms belong to the Event space and Marketing categories. The former includes two firms, which are focused on the reality of the environment and offer spaces for temporary events. The latter category includes only one firm which offers support to individuals or institutions in the search for student accommodation.

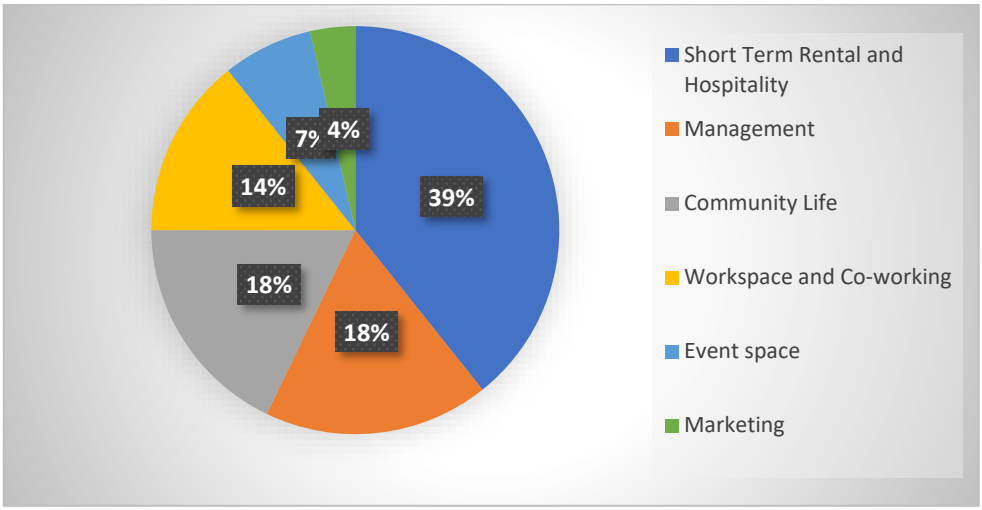


Figure 28. Sharing Economy sub-categories division (Bellintani, 2019)

6. Real Estate FinTech

As it is defined by Baum "*Real Estate FinTech describes technology-based platforms which facilitate the trading of real estate asset ownership. The assets can be buildings, shares or funds, debt, or equity; ownership can be freehold or leasehold. The platforms may simply provide information for prospective buyers and sellers, or they may more directly facilitate or effect transactions of asset ownership or leases with a negative or positive capital value."* (Baum, 2017).

Real Estate FinTech is concerned with the support and realization of transactions. It is about trading in real estate, while classic FinTech deals with trading in financial products.

The conditions that make a shared economy proposal attractive to the investors (Figure 25) can be applied in the Real Estate Fintech sector. Many activities are focused on the residential sector that is larger than the commercial one.

The conditions have some differences compared to the other sectors (Baum, 2017):

1) *The diverse, widely distributed source of demand* in the FinTech sector is homebuyers, home renters and buyers, and users of commercial and non-residential real estate assets.
2) *The diverse, widely distributed, and heterogeneous source of supply* is the same global real estate asset base.

3) There is *no efficient mechanism* for bringing supply and demand together, instead of which there are many brokers who guard information.
4) *Potential financial gains* to the demand side, the supply side, and an intermediary
5) *Scalability*, which is based on the huge global real estate asset base.

The revolution of technology in the Real Estate sector is related to the chance of make consumers take any decisions about selling, buying, or renting thanks to information about market demand and supply. Generally, the home buying and selling process will be shorter.

The ease of renting spaces can be an incentive for consumers to purchase larger homes.

Real Estate FinTech is related to the use of artificial intelligence and machine learning. The former is intelligence related to machines; an intelligent agent is *"a device that takes actions that maximize its chance of success in achieving a specific goal*" (Baum, 2017). The latter is a *"kind of artificial intelligence that provides computers with the ability to learn without being programmed*" (Baum, 2017). In fact, machine learning focuses on the development of computer programs, which can change according to the different data they are exposed to.

Program actions, in this case, are adjusted automatically.

Properties, nowadays, are searchable online through individual brokers' websites. However, they are not interested in sharing publicly available knowledge about the market.

The trend is to make information available to everyone, stopping its asymmetric distribution.

Online real estate agents are acquiring market share with a reduction in the number of estate agents. Tech-enabled information providers, such as Zoopla, Zillow, and Trulia, were founded. They initially dealt with residential sales and then moved into the lettings' area.

For example, Zillow, an American group born in 2006, offers consumers the chance to be informed about property listings through its website without exploiting the services of a real estate agent.

Nevertheless, providers are helping to break up the asymmetric information situation in the real estate sector (Feth, 2018).

According to the analyses carried out, the global real estate market is worth some USD 217 trillion, 75% of which is locked up in homeownership. Annual buying and selling of real estate in 2007 were approximately about USD 683 billion and rose to around USD 900 billion in 2015. This represents an annual trading volume of about 0.3–0.4% of the total property stock (Feth, 2018).
The global real estate portfolio, even if it is illiquid, represents more than half of all established assets.

In a market calculation, it has been estimated that the market volume is about USD 40–50 billion. It is currently shared by advisors, real estate experts, lawyers, and accountants (Feth, 2018).
Feth claims that *"If the real estate FinTech sector would be able to make real estate trading just 10% more efficient, the consequence would be another USD 4–5 billion in potential returns*" (Feth, 2018). It highlights the huge potential for the RE FinTech industry and any firms that will enter the sector.
According to a forecast by Catella (Feth, 2018), the annual volume of transactions on the European residential property market is currently already growing at more than 5%. It increased from € 37 billion in 2016 to € 39 billion in 2017.
Reasons for this growth are urbanization, capital availability, migration, and demographics.
A higher annual trading rate is due to the combination of more transparent transaction management with lower costs. The result would be further multi-billion-euro growth in the real estate FinTech industry (Feth, 2018).

6.1 Crowdfunding

Real Estate crowdfunding is based on a shared economy model and has involved a lot of new entrepreneurs.
Crowdfunding is important because it can resolve two main issues:

- The capital requirement for less financially capable buyers
- The limit due to geographical barriers

Many platforms, nowadays, use their crowdfunding solutions as a retail distribution channel (Baum, 2017).

6.2 Portfolio Management and Property Leasing

Leasing and portfolio management are the two main issues that drive cash flow and return. The modeling of a portfolio cash flow has represented a complex challenge because of the risk of building datasets in Excel.
Management of the leasing process has been inefficient. For this reason, companies have provided real-time portfolio analytics to the top landlords and brokerage firms in the world (Baum, 2017). This kind of management platform allows brokers and landlords to manage their deal activities, identify trends, and managing portfolio performance using their devices. The share of information enables owners and managers of commercial RE to monitor the letting process in real-time.

For example, JLL, the leading global financial and professional services firm specializing in real estate, and Leverton, the leading global machine learning company, announced a cooperation agreement in 2016.
In this case, the machine learning technology of Leverton enables to extract the identification and manage key terms and data from leases and contracts, in more than twenty languages (Baum, 2017).
The integration of these technologies into JLL's platforms transforms the way lease documents are managed for the clients, who benefit from the more efficient process and the reduced operational risk.

Storing lease data becomes more efficient and can lead to the possibility of having greater liquidity of leasehold interests. The efficiency in this process can represent the start of a new market, which is related to the application of Blockchain technology.

According to an analysis made by The Economist, in 2017, China is the world's leader in FinTech. It is developing in the real estate sector too, even if slower, because of the asset class.

6.3 Italian scenario

The sector of Real Estate Fintech is the one with the highest number of firms in Italy. They are 34 and can be divided into three main areas:

- Brokerage
- Crowdfunding

- Investment and Auction

The Brokerage category is the one with the highest number of firms, 16, which offer online trading services.

The Crowdfunding area includes 9 firms, which operate as online platforms and offer forms of financing and investments of various kinds in real estate projects.

In the end, 9 firms can be classified in the Investment and Auction section, which are focused on competitive online auctions for the purchase of properties.

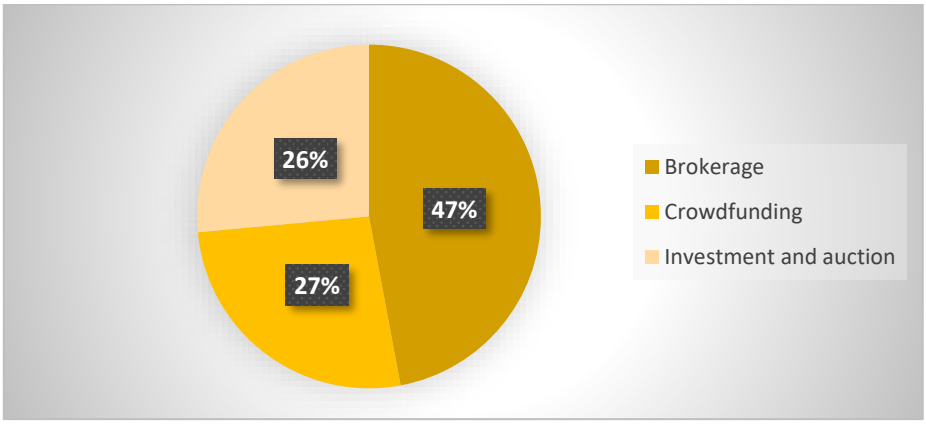


Figure 29. Real Estate FinTech sub-categories division (Bellintani, 2019)

7. Platform Real Estate

Digital real estate technologies can be considered as platforms. They can be defined as "*Digital infrastructures that enable two or more groups to interact"* or *"Businesses based on enabling value-creating interactions between external producers and consumers".* (Shaw, 2018)

The concept of a platform from the real estate point of view fits with the software and economics concept. A platform is intended as the technology used beyond a firm, which brings multiple parties together for a common purpose. More products and services are offered by the platform, more users are gained, and the platform's value increases.

Platforms comprehend both technical and economic domains and are characterized by a complex nature as hybrid organizational-technical forms that are not reducible to a market or a machine.

PropTech can be revisited as Platform Real Estate (Shaw, 2018) because the platform is defined as something connecting users and including things together into new aggregations, creating value.

It has been conducted an analysis based on different real estate platforms about user connections.
The term connection means that each platform has a shared user base where each group of users takes on an actionable meaning concerning the others (Shaw, 2018). The actions include transactions, communications, or data analysis.
The sample includes 393 real estate platforms, which have been studied in the new year.
In Figure 30 a thicker node and edge size imply more user connections and therefore that they are operated by more platforms (Shaw, 2018).
It is possible to see from the image that many companies connect homeowners directly with tenants, this is the case of Airbnb, while a lower number of companies connect agencies with tenants.
The platforms are divided into four clusters:

- Capital Investment activity
- Commercial market
- Building management
- Residential market

The first one includes platforms that offer a set of information and data analytics products intending to help asset managers and investment managers making better market decisions.
Market participants are better connected through those platforms with information that enables better decisions around capital investment and the pursuit of profit. They are typically aimed at large investors, but the aggregation of open data sources allows tools to emerge that might be available to smaller investors and agents.
The second cluster is the commercial real estate market and includes investors who have become commercial landlords and need to connect to their tenants and users.
The fourth cluster is equivalent to the second one but is about the residential market. The thickness of the edges in this cluster shows that many platforms are operating in this market.
These two clusters are those to which many platforms belong.

The third cluster is in the middle because is the building management area, where it is possible to find maintenance platforms that operate between residential and commercial markets.

The analysis made by Shaw shows a picture of the real estate platform landscape and two important issues about it (Shaw, 2018):

1) The market structure and the areas of activity, the four clusters, are not especially new. They include connecting users as they turn from home buyers to homeowners and tenants to estate agents.
2) The real innovation of Platform Real Estate is the connection between the users in a manner that is related to digital technology and in the storage and the processing of data and digital information. It is unprecedented in the application to the real estate market.

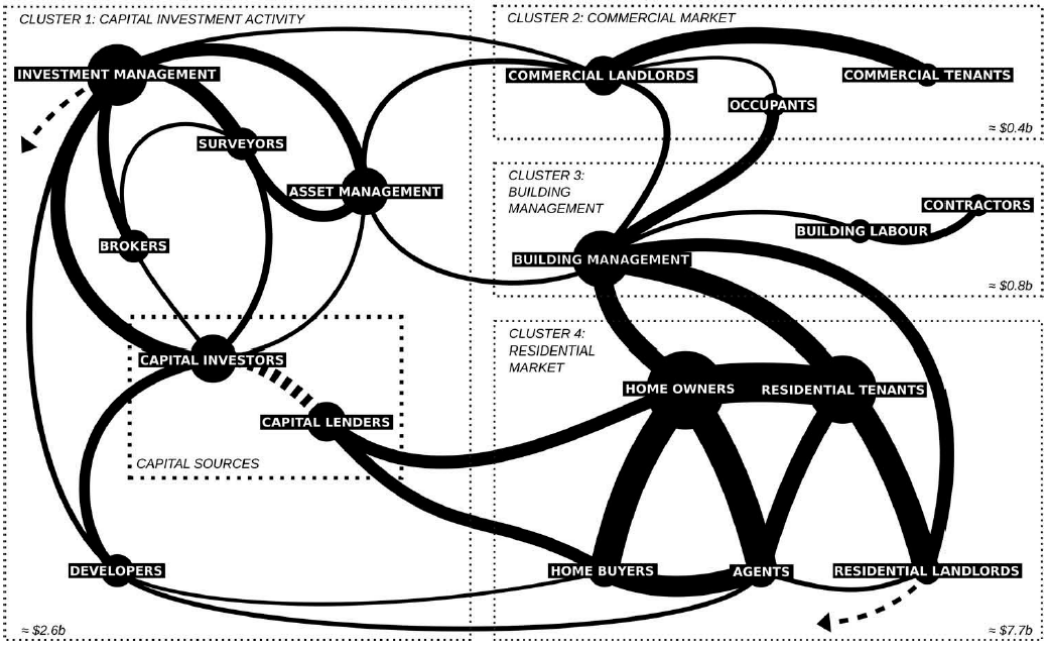


Figure 30. Map of the most common user connections in Platform Real Estate (Shaw, 2018)

The market participants of the Platform Real Estate are connected by platforms that are structured based on two market activities:

- The ownership or occupancy of buildings
- The satisfaction of the goal of making a profit as part of a capitalist economic system.

The digital real estate platform technologies can be recognized through user connections' shapes that they offer between market participants of Platform Real Estate. They can be the user of thousands of devices in various combinations and on a large scale.

It is possible to understand digital real estate platforms as arrangements of user agencies within interoperable layers of digital technologies, which produce and offer a path of action to the real estate market participants (Shaw, 2018).

Figure 31 shows the arrangements of user connections that the real estate platform technologies can offer to the market participants.

The platforms can be characterized by a path that they offer to a user through the stack of technology within which they operate (Shaw, 2018). As it is shown in the image, the real estate market's path concerns land and capital.

The platform is also represented with different digital technologies' layers that produce and offer certain paths of action to the user.

In the specific case, it has been identified as a path of action related to the Airbnb platform, where they are identified homeowners, the platform owner, and vacationer as market participants.

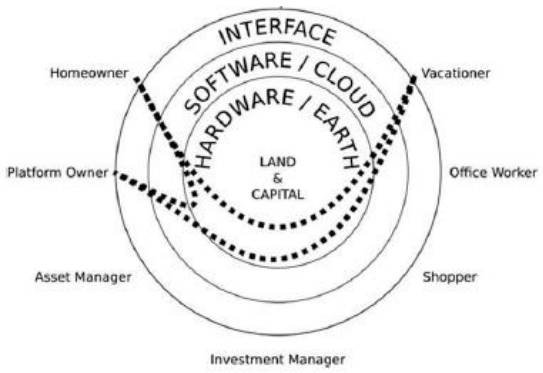


Figure 31. Path of actions of Airbnb digital platform (Shaw, 2018)

The user connections that characterize the Platform Real Estate represent a way of collecting data. In Figure 30 the thickness of the edges implies a particular opportunity to collect data about the market processes; it is an indicator of the accumulation of data exchanged by market participants through a platform.

The image shows that the residential market, due to the thickness of the edges, is the biggest site for the collection of data using platforms.

The accumulation of data is important to generate revenues for platforms' owners through a process of user data surpluses and data sales.

Platforms offer to users a generic view of urban real estate assets. Because the marketplace related to Platform Real Estate includes urban spaces and actors, PRE is defined as an urban phenomenon.
The global production and accumulation of data are principally observable in an urban context, providing a great opportunity for PRE to address social processes as a part of the real estate market. They can create a new urban real estate environment with more market opportunities.
The future economic performance of urban real estate markets will be influenced by how PRE is designed to let to know the urban world.

8. Blockchain

Management of information and record of transactions can be revolutionized using the Blockchain tool.
Blockchain is a database that holds a public ledger of all the transactions. It can be defined as a distributed ledger able to collect decentralized trustless transactions of data, that does not require the intervention of a third party to validate the process.
This technology is built on decentralized peer-to-peer transactions, where decentralized refers to the storage of data, which is not done through only one network with a common processor but is a distribution over several networks.
The second main characteristic of Blockchain is the information collected because it can create a permanent ledger of transaction details.
The trust-based interaction, which is not established by third parties but through an encrypted consensus, is the revolution to which the system leads because the governance is transferred from centralized institutions to networks of peer-to-peer collaborations, thus creating an acceleration of the process.
The differences between this technology and other internet-based transaction technologies are difficult to be comprehended, but there are banks, investment, and technology companies that are evaluating the potentiality of Blockchain in the market.

Blockchain can be interesting for service providers too, who can derive a great share of the value generated for themselves (Baum, 2017).
Members, who manage the platform and make decisions, gain all the revenues for the services provided.

Among the potential benefits of Blockchain there are:

- Data quality
- Transparency between transactors
- Faster transactions and lower costs

International standards about the data exchange are important because of the variety of assets and the different geographies involved and for the improvement of trust in this kind of transaction.

A Blockchain distributed ledger consists of five core elements:

- DLT
- P2P network
- Cryptography
- Consensus mechanism
- Validity rules

DLT stands for Distributed Ledger Technology and is the main characteristic of this revolutionary method, where there is a shared ledger between all the participants of the network. Participants are also called nodes. There is no centralized version of the database, but everyone has an identical copy.
Peer-to-peer transactions can be made between participants without the need for validation by a third party, but any change to the database is by the agreement of everyone on the network. Instead, transactions are validated according to a consensus mechanism.
The consensus mechanism is an authorization that is based on the trust between the nodes. Trust is created by cryptographic proof (Wouda, 2019).
The validation of the transactions is reached if a set of validation rules is respected and then some nodes can create new blocks. (Wouda, 2019)
The distributed ledger can develop a digital secure identifier for a transaction and offers the possibility to transfer funds in new ways, such as using digital cryptocurrency.

The technology is said to be extremely secure because if a copy is hacked or corrupted, the other ones remain intact. Moreover, anything is stored in a digital form.

The distributed ledger technology disrupts the centralized model. A central authority acts as an intermediary in a large part of the transactions, for example, in finance, everything passes through a bank (Baum, 2017).
In the case of a transfer of money, these steps are followed:

1) The bank of the person who wants to transfer money alerts the recipient's bank.
2) The money passes from the customer's account to the bank's account.
3) Money goes into the recipient bank's central bank account and from there into the recipient's account.
4) The two banks must exchange confirmations of the process.

The disadvantages of this procedure are the time-consumption and the huge cost.

Blockchain's peer-to-peer network allows passing an asset directly between the accounts. Moreover, the members of the network are anonymous, and this has a double effect because it protects users from identity theft but can give rise to criminal activity.
In Blockchain it is used a security protocol where a mathematical tool can check if there is any change in every transaction, in every block where all the transactions are grouped, and in every link between blocks in the chain. The system acts every time there is an update and any anomaly will immediately appear (Baum, 2017).

8.1 Blockchain's operation

Table 4 reported below shows the sequence of operations that happen during a Blockchain transaction. It is hypothesized the case of a transfer of money between two users (Baum, 2017).
When the transaction begins, they have been created two cryptographic keys that will be held by both the users. The keys are sequences of characters and numbers.
Anyone can view the address using a public key, while the private key is known only to the users and enables access to the address (Baum, 2017).
The keys work together to encrypt and decrypt mathematical representation of the file's contents, called "hash". The transaction becomes a hash when it has been

verified and added to the chain of blocks, so the hash allows verifying that the transaction has not been hacked.

It is related to the second step of the process, *"the first user encrypts the file hash with its private key to create a digital signature and transmits the file, signature, and corresponding public key. The signature is decrypted using the public key to verify if the file's contents are intact"* (Baum, 2017).

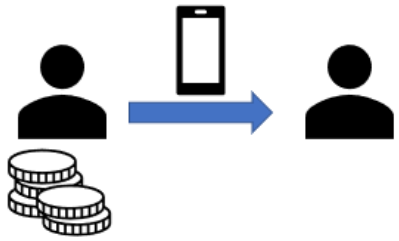
The third step is called "Mining". This process is the update of the network with the creation of new transactions. They are grouped into a block, and through the mining process, the block is broadcasted to the network.

There is also an economic incentive associated with this technique because miners are rewarded if they solve a complex puzzle attached to the block. The goal of this is guarantying that transactions in the block are valid.

Each block is tied up to the previous one, so the Blockchain is created (Baum, 2017). When the validity of a block is verified, the process continues with the next one in the chain. The cons related to a peer-to-peer transaction without an intermediary are those needed for ensuring the security of the system; thus, significant computing power and time are mandatory.

For the users, the downloading and synchronization of the entire network would be a heavy and unnecessary process, since they are only interested in the ultimate success of the transaction in which are involved.

For this reason, a process of Simplified Payment Verification (SPV) is applied. The user needs only the confirmation, through the most recent block, that the transaction has been collected in the chain.

1		The first user wants to send money digitally to the second one.
2		The first user sends money through a digital wallet up. The app stamps the transaction with the first user's digital signature.

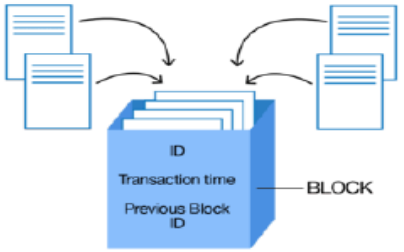
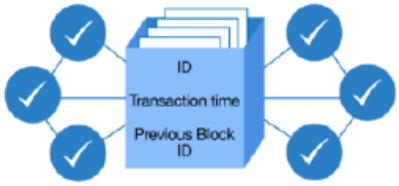
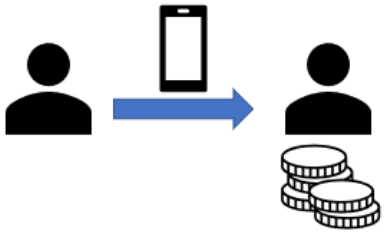
3		A new block is created. The transaction is grouped into the block with other transactions that occur simultaneously. The block is characterized by a unique ID.
4		The block containing the transaction must be verified broadcasting it to the entire network.
5		After the check, the block is added to the head of the blockchain, becoming a permanent and transparent record of transactions.
6		Once the verification is ended, the second user receives the money from the first one.

Table 4. The sequence of operations in a Blockchain's transaction (Baum, 2017)

8.2 Blockchain's limitations

For the application of this new technology, some challenges will need to be solved. They are:

- Technical standards
- Privacy
- Speed
- Performance

Technical standards are needed to allow a broad adoption and guarantee compatibility across industries.

It will be important for the spread of blockchain to overcome conflicts and differences in business processes.

Privacy is the main issue. It is difficult because different layers of anonymity can attract or detract members from participating.

The speed's issue to the decentralization. Any distributed database is lower than a centralized one.

The level of security related to the use of blockchain has some limitations. The private key represents an additional source of personal identification, such as a bank account number.

If a private key is lost or stolen, it would be difficult to solve the problem. At worst, this loss can represent a complete loss of control of the user over all the transactions stored in the blockchain.

8.3 Application of Blockchain technology to Real Estate

Blockchain technology can be applied in the Real Estate sector. It can support and enhance the reliability, efficiency, and security of data transferred among a network, seeming to fit with the transaction processes that happen in the Real Estate market (Wouda, 2019).

There are some reasons for the application of new technologies, such as lack of transparency, inefficiency, and complexity that characterize real estate transactions.

In the graph reported below (Figure 32), they have been summarized some effective applications of blockchain technology into Real Estate.

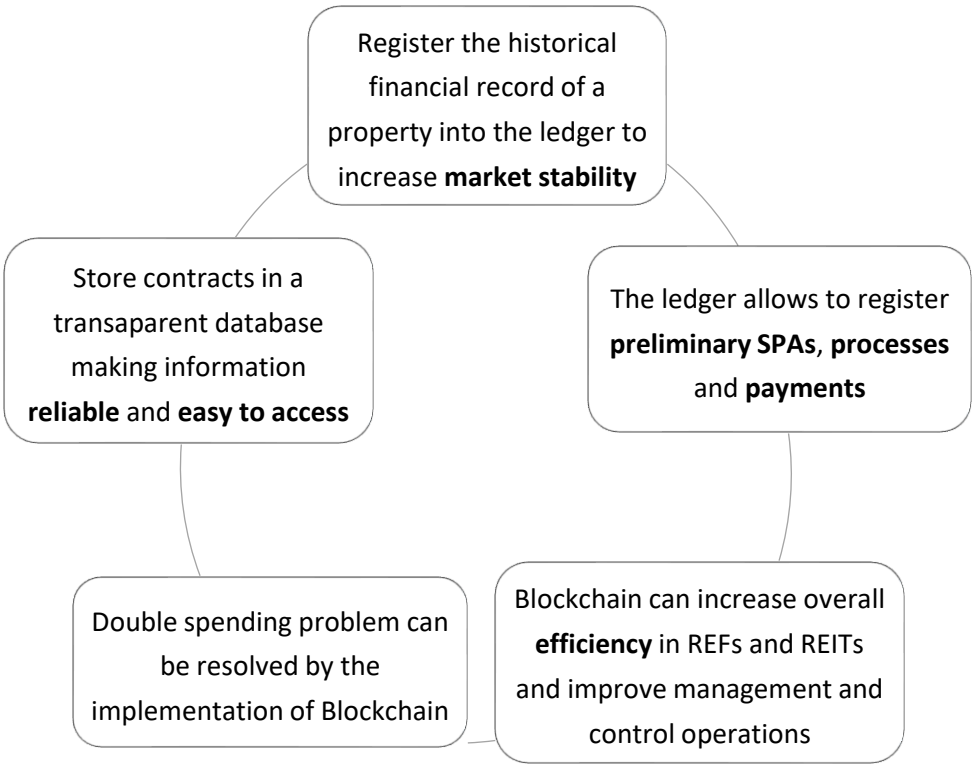


Figure 32. Blockchain applications and advantages into Real Estate sector (Author's elaboration)

Moreover, the information exchange has been sped up by PropTech innovators, but the market is dependent on intermediaries. This means that transactions require time and relationships.

There are also problems related to data quality and structure.

In a simple transaction of a residential asset, there are many parties involved, such as:

- Estate agents
- Lawyers
- Structural surveyors
- Local authorities
- Banks
- Credit Rating Agencies

Data, held by the participants, is public but the storage is done in multiple private sites. The lawyer is the authority paid to collect all the information and multiple parties are paid through multiple banks.

A distributed ledger can be introduced to collect all the information related to a single property and make it available all the time to every participant.

Assets and fees can be exchanged simultaneously through this technology, which allows the parties to store information into the distributed ledger rather than into their databases (Baum, 2017). Huge savings in time and money would be the pros.

The application of Blockchain would be a new method of decentralized structuring and handling data in other to overcome challenges, such as transparency, reliability, and security of data.

It has been analysed a model based on the data requirements of a transaction (Wouda, 2019). They are split into two elements:

- Physical elements
- Contractual elements

Recording physical and contractual information about an asset can be the first step for the digital representation of a building.

Data associated with those elements are logged on the blockchain, where consensus mechanisms and cryptographic methods are applied.

The original files would be only stored on the involved parties' servers and in the blockchain, would be uploaded the essential validation information.

The possible infrastructure of the transaction process of an office building, as it has been hypothesized, is represented in Figure 33.
The transaction process starts structuring the available information about the asset, for example, the office building.

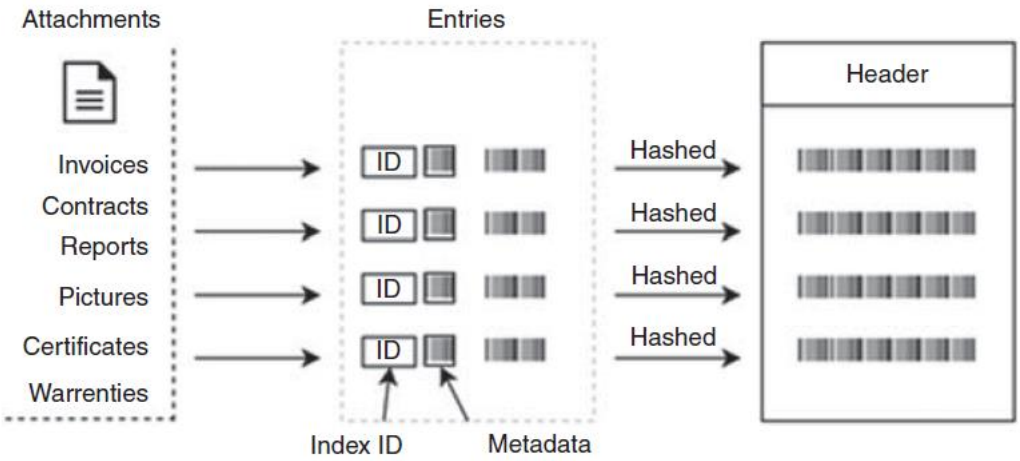


Figure 33. Blockchain infrastructure in the transaction process of an office building (Wouda, 2019)

The record of digital and contractual elements comes with some challenges due to the immaturity of the technology and a lack of standardization.
Data, such as reports, must be standardized to add value to the system. Once this goal will be achieved, it will be possible to link the record-keeping application to external databases by way of an Application Programming Interface, API (Wouda, 2019).
Moreover, it will be possible to validate data without being analysed by users and the authorization rules will be much more written in detail.
There would be also benefits for a bank like (Wouda, 2019):

- *Increase of reliability;* all the parties must validate the information shared in the network.
- *Increase of transparency;* the information shared between the parties is the same.
- *Increase of efficiency;* structured and standardized data would create an input for internal workflows and analysis.

Reliability and transparency of information would have a positive impact on reducing the possibility of fraud in Real Estate financing.

The Blockchain infrastructure improves the transaction process structuring data and guarantying quality by its consensus methods.

Figure 34 shows the transaction process. The benefit related to the trust between the parties and the reliability of information would reduce in time processes such as the due diligence and the negotiation.

Structuring physical and contractual information in one place can improve the knowledge about an asset. Moreover, the use of blockchain guarantees the quality of data.

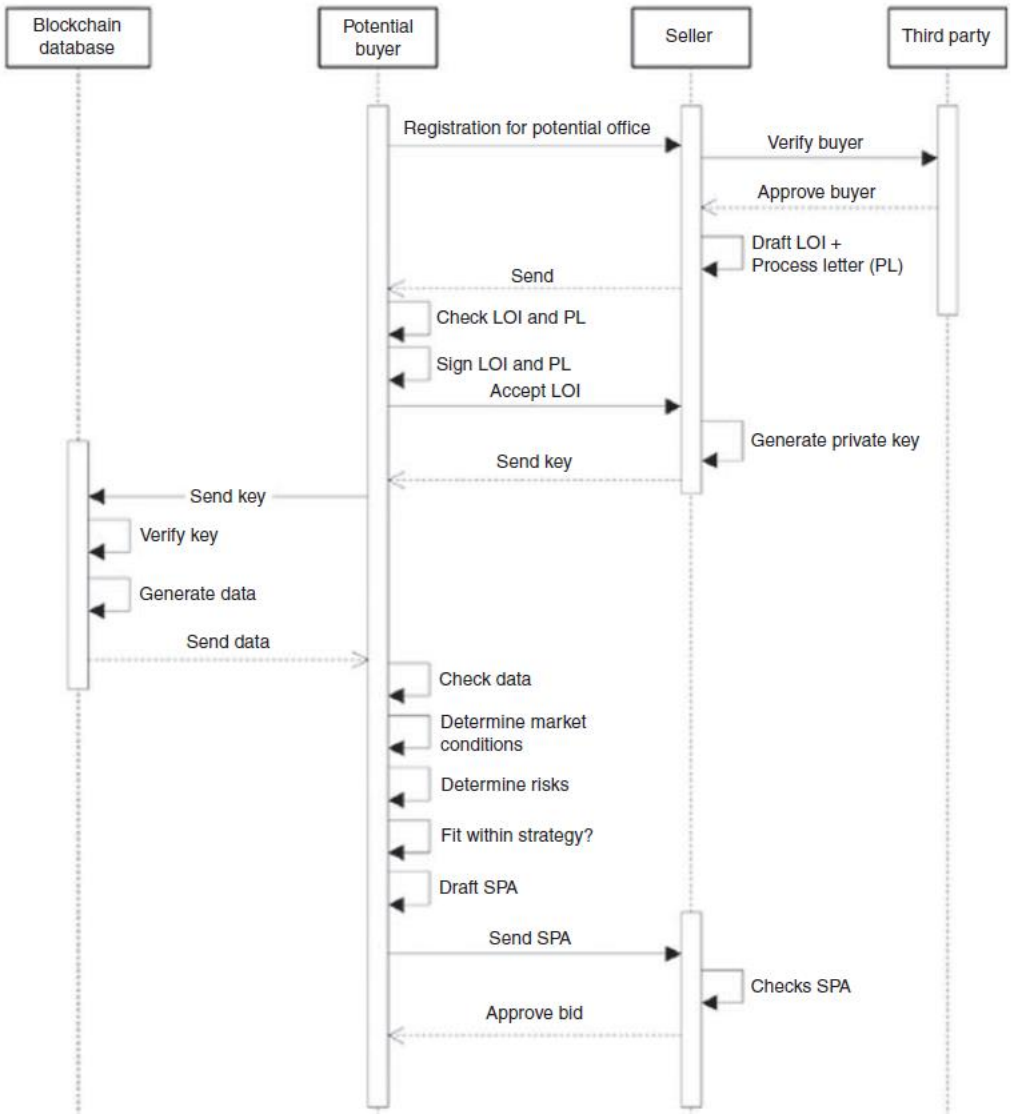


Figure 34. Blockchain's transaction flow (Wouda, 2019)

It is possible to analyse the main challenges and related opportunities connected to the purchase and sale or lease of the real estate assets (Morena, 2019).

The first issue is about the presale and prelease due diligence and the financial evaluation.

Challenge	In Commercial Real Estate, a lot of time is spent on due diligence activities because manual verification processes increase time, costs, and possible errors.
Solution	A blockchain-based solution, together with adequate digital infrastructure, can simplify the system by verifying digitally the physical identity of the assets.

Table 5. First challenge and solution (Morena, 2019)

The second issue is about leasing, property, and cash flow management.

Challenge	The management of a lease and the related cash flows is a complex process. It results very expensive and long since several actors and payments are involved.
Solution	Time and costs for property and cash flow management can be optimized through the automation of the procedure. It would be possible to use a smart tenancy contract instead of a traditional one. Registering transactions on the blockchain would ensure high transparency and would be easier to do automatic payments to real estate owners and property managers. Moreover, a smart contract can implement a deposit function, managing an initial deposit and automatically giving the deposit back once the lease is finished.

Table 6. Second challenge and solution (Morena, 2019)

The third issue is decision-making.

Challenge	In Commercial Real Estate, databases and processes are characterized by not easily reliable information.
Solution	The blockchain can create a network between the systems and the actors involved in a lease or purchase transaction. By providing a shared database, it would be possible to share

	real-time information faster among the stakeholders, allowing them to make better decisions.

Table 7. Third challenge and solution (Morena, 2019)

The fourth issue is financing and payments.

Challenge	In Commercial Real Estate, the process of property transactions involves several players, and the money transfer for payments or funding results very expensively and time-consuming. If the buyer purchases a mortgage, it implies high costs and a loss of time.
Solution	Blockchain can facilitate the financing process using smart contracts accessible to the parties. It would manage the loan application, the documentation, and the due diligence, allowing real-time control of the mortgage. Moreover, it reduces risks and payments delay.

Table 8. Fourth challenge and solution (Morena, 2019)

8.3.1 Issues relating to the current market

The inefficiency of the real estate market can be resumed by those factors:

- Personal biases
- High transaction costs
- Slow transaction process
- Transparency problems

Transaction costs are caused by the huge number of actors involved in a transaction of a property that makes it expensive.

For this reason, it is registered a low number of transactions and the properties are usually held for a long time.

Blockchain can solve those problems, reducing the number of actors involved, improving the number of sales with lower costs of transactions.

Personal biases can cause overvaluation of the property by the owners. This can create real estate cycles with booms and busts.

Moreover, access to information can increase transparency and allow better decisions. If the market is not transparent, there would exist information asymmetry on the market.

If the real estate market were more transparent, there would be an effect on the valuation methods of the properties. For example, blockchain would allow the implementation of a new valuation system without intermediaries, such as brokers.
In this case, there would not be any personal contact between brokers and buyers during the transaction process. Thus, there would be a passage of trust from brokers to mobile phone applications or digital platforms.
Blockchain technology can be important in making a transaction process secure even if without intermediaries. It can contribute to a trust-transformation, where the trust between actors operating in the market loses importance.

One of the major issues is digitalization.
To survive, companies will have to adapt to the changing demand and the customers, acquiring new skills.
The implementation of new technologies will allow companies to stay competitive in the market. Companies can reach revenue growth by redefining customers, products, the value offered, and delivery methods.
It would be important for big companies too to implement new technologies even if they are currently relevant in the market.
Digitalization is changing the world at a rapid pace, and the new emerging technologies have those consequences:

- Competition growth in the market
- Difficulty to make profits.

The real estate sector is particularly conservative and characterized by a delay in the digital revolution. It is due to the reticence of the companies to invest in technologies if they are not established in the market and on the hype of their potential. Firms do not invest if technologies have not proven their worth.
The application of digitalized systems is certainly more consolidated in other markets, such as healthcare and security ones.
For example, in the financial sector, there have been a lot of investments in digitalized systems to create a standardized blockchain-based system among banks.

The real estate market is not changing fast as the financial one because there are still brokers working into transaction processes and contracts are signed using papers.
Costs of development and implementation of new systems can represent an obstacle for a company.

It is possible to resume the main challenges about blockchain application:

1) Trust of the public.
2) The unwillingness of companies to invest.
3) Uncertainty about the outcomes of an eventual implementation of the system.

Moreover, it can be considered also the replacement of human labour in some sectors with digital systems.

8.3.2 Implementation of Blockchain

The inefficiencies within the market and the biases can be an obstacle to the development of the technology in the short run.
In the medium run, blockchain has proven its potential and probably there will be more companies implementing systems based on this technology.
In the long run, the trends and the knowledge acquired about blockchain technology in the market will cause more implementations of the system by companies.
This can happen after the first hype of the technology.
In the long run, the application of blockchain can prove its efficiency.

Blockchain can eliminate several steps during a transaction process. They are the reason for high transaction costs and the length of the procedure.
Moreover, transaction process time and costs can be drastically reduced if is created a system where all the necessary information about the property, the seller, and the buyer is collected within a blockchain. It can work better in combination with a tool like smart contracts.

Figure 35 shows the possible growth of transactions made through blockchain technology.
In the graph, the negative slope of the curve representing the traditional transactions shows that there will be a reduction of them when blockchain technology will be implemented and proven in the market.
It has been estimated that within fifteen years there will be a peak in the number of ownership transactions due to the novelty in the market, but in the long run, the curve will have a negative slope for a limited period since it will become constant.
In the future, there will be a new normal, higher than the actual one because more transactions will occur.
The development can be explained by several factors:

1) People will have more information about the market
2) Transaction costs will decrease
3) The transaction process will be simpler than the actual one

The consequence of those events will be an increase in sales. The real estate market will be characterized by an increase in liquidity.

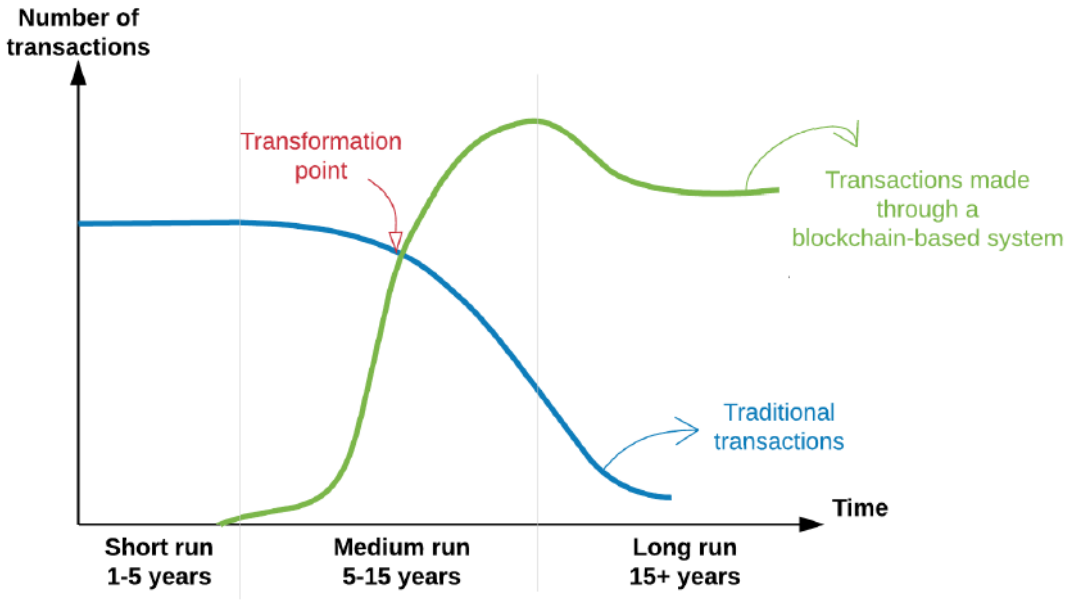


Figure 35. Development of transactions made through blockchain (Corluka, 2017)

The issue related to transparency can lead to a reduction of competition in the market. Less transparent companies, if do not adapt to the changes, will go bankrupt.

8.4 Smart contracts and timestamping process

Blockchain technology can be exploited to revolutionize the contract law and the contract process, reducing human intermediation. The technology, in combination with the use of cryptography, generates smart contracts.

Smart contracts are innovative methods to move data, funds, and agreements automatically.

They can be defined as *"Contracts written in computer code that can react to information sent to them from a storage system, which can be the distributed ledger it is stored on"* (Baum, 2017).

A smart contract is deterministic because an input in a smart contract will always provide the same output. It can manage huge amounts of money and the platforms use an open network to attract parties.
Smart contracts can be self-executing and self-enforcing, the former is a contract that can impose a predetermined outcome once the requirements are met (Baum, 2017). Moreover, they can be (Baum, 2017):

- Standard
- Multifaceted
- Multi-party
- Customized to individual needs.

Smart contracts can be useful because:

- They allow the transaction's entities to inspect the cryptography and decides whether to sign the contract or not.
- They are characterized by a certainty of execution because the code is stored on the blockchain.
- They allow the digital interaction between the users who can constantly verify the success of the procedure and agree or not on the result.

One of the most established smart contract systems is Ethereum which through blockchain technology makes complex contracts possible and automatically executed. They enable different kinds of transactions, such as financial exchanges or insurance contracts.
The automation of the contracts enables selling processes, decisions, and management of employments to be automatically executed without human intervention.
This decentralized platform that implements smart contracts is characterized by a low possibility of downtime, censorship, fraud, and interference of third parties (Baum, 2017).
The property's ownership is represented by blockchain infrastructure, built on the customer's needs. Developers can create markets, store registries of debts or promises, move funds following instructions that have been previously given (Baum, 2017).
Data sharing is hard using a traditional server architecture. If any app goes off, many users can be affected by this problem.

Through a blockchain, it would be possible to guarantee the privacy of the user's data and the decentralization of the apps because anyone can set up anode through which the data that are necessary for all nodes to reach an agreement are replicated.
At the same time, there is an opportunity for companies to be more transparent towards the customers.

The timestamp is a sequence of characters used to record when a document has been received or generally when a certain event occurred.
If the process of timestamping is associated with a decentralized blockchain there would be three main benefits:

1) Trust
2) Cost
3) Convenience

The first advantage is related to the elimination of third parties and the process becomes publicly auditable.
The second one is related to the possibility of creating, for free, an unlimited number of timestamps into one transaction.
The latter advantage of this technology is the possibility of creating a third-party verifiable timestamp instantly, without the need of waiting for a confirmation.

The process of the Timestamping tool is reported in the process below. It begins with the creation of a new technological platform and ends with the purchase or rent of the asset.
"The timestamping can operate in synergy with the current cadastral system for even more efficient and secure registration of real estate titles and their transfer" (Morena, 2019).

Timestamping:
First of all there is the transaition from the traditional structure to the innovative one. The first solution can be implementing the timestamping of documents related to trustee's activity.

Digitization:
The goal is the creation of a Smart Property through the use of a smart contract to manage the asset in an automated way.

Smart Trust:
The needs of the users are colleced into clauses through the smart contract. This operation allows to automate the entire process.

Asset conferment:
The Smart Property is conferred in the Smart Trust with the connection of the smart contract, where the asset is registered, to the one that contains the clauses of the Trust's contract.

Tokenization:
The Smart Property is tokenized, and the asset is divided into shares among the beneficiaries of the Trust according to the wishes of the settlor.

Purchase/Sale
The conferred real estate asset can be purchased by any user of the platform through the use of Trust Tokens, that have been prevoiusly distributed to the benficiaries. Property Tokens received by the buyers certify the ownership in proportion to the shares purchased.

Figure 36. Timestamping process (Morena, 2019)

The end of the process can be based on rent instead of a purchase.

In this case, the conferred real estate property can be rented by any user of the platform through the Trust Tokens, that have been previously distributed to the beneficiaries.

The smart contract is used to manage the payments, that are done automatically every month.

Figure 37 reported below reports schematically the flow of the Timestamping process that has been explained above.

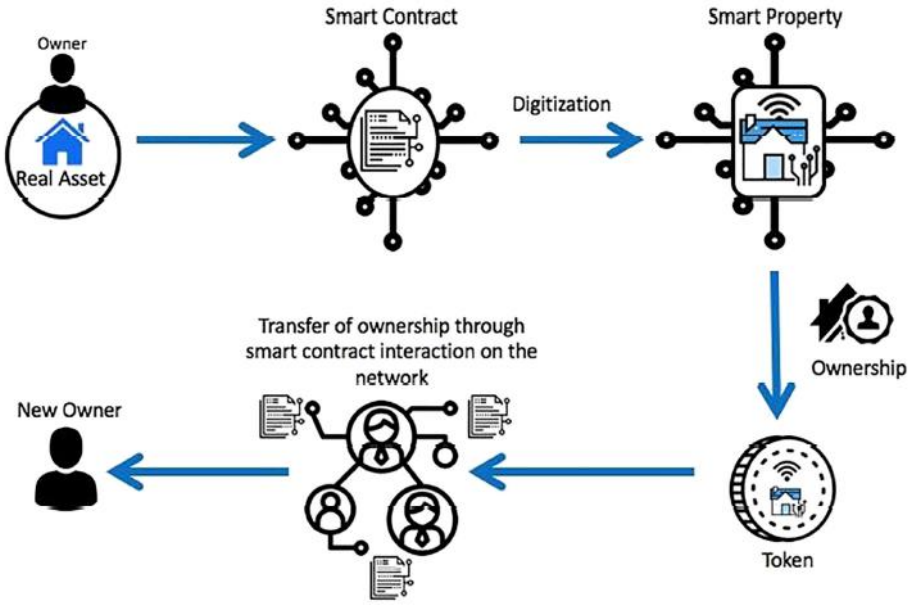


Figure 37. The flow of the Timestamping process (Morena, 2019)

The area of interest that connects blockchain technology to the real estate world is related to the management of the purchase and sale or lease of properties.

The smart contract is the tool through which the blockchain can manage the entire contract and check the payments' progression.

Moreover, it is possible to take immediate actions when some problems arise. For example, it can activate insurance funds or force money transfers (Morena, 2019).

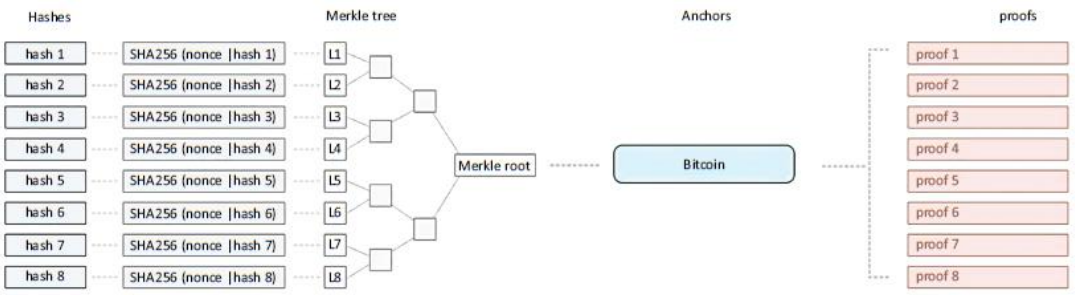


Figure 38. The functioning of smart contracts for a real estate transaction (Morena, 2019)

8.4.1 Tokenization of the Real Estate assets

The term "Tokenization" has its origin in the fields of data security and lexical analysis (Morena, 2019). To tokenize in data analysis means to replace sensitive data with identification symbols that can contain all the information about the data guaranteeing its security.

Blockchain technology can be used to convert the ownership rights of a real estate asset into digital tokens. These tokens are then traded on a digital platform.

The tokenization is not done on the whole asset but on the shares in which it is divided.

The Tokenization of a real estate asset can be defined as "*The generation, through a smart contract, of tokens corresponding to the shares of the real estate asset and the attribution of value to these tokens according to the value of the property"* (Morena, 2019).

Blockchain technology allows the creation of a real-world asset through the representation and record on an immutable decentralized ledger. Moreover, it makes real estate investments more appealing due to an increase in liquidity in the market.

The main advantage related to asset tokenization is security because digital trading tokens avoid this problem for both buyers and sellers (Morena, 2019).

Figure 39 shows the flow of the process related to the Tokenization of a real estate asset.

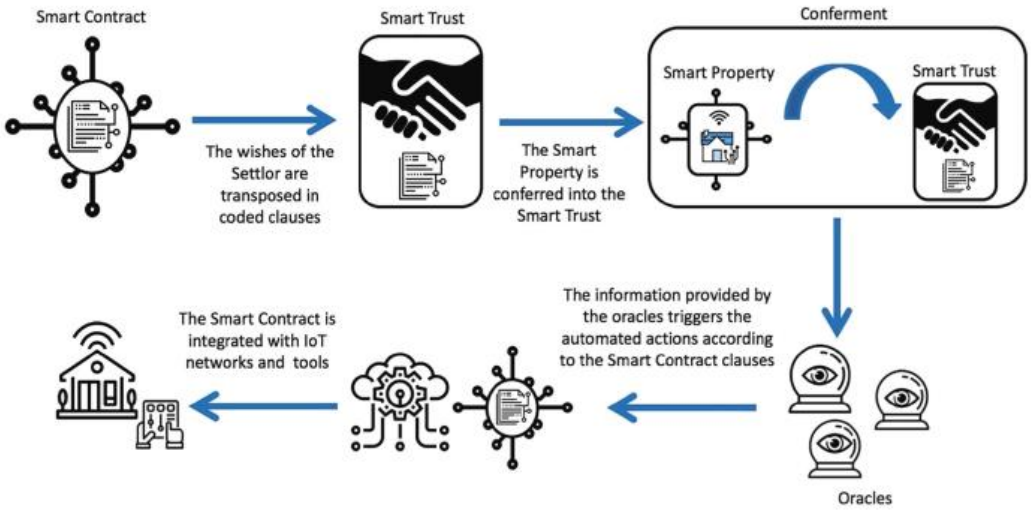


Figure 39. Asset's Tokenization process (Morena, 2019)

In the graph below, they have reported the main challenges related to the process of Tokenization of the assets.

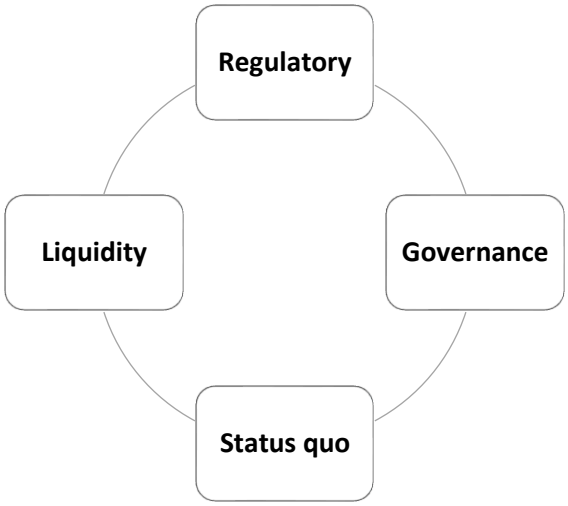


Figure 40. Tokenization process' challenges (Author's elaboration)

The first challenge about asset tokenization will be for global regulatory agencies. Regulation usually follows a long path to adapt to new technologies, which instead are characterized by fast evolution.

The tokenization of the assets will take probably many years to develop.

The second challenge is justified by an expected increase in the volume of trading and the number of participants. The tokenization of the assets allows creating a market with the possibility of having several participants higher than the current one.

The third one is related to the difficulty that can emerge about the management of some aspects, such as maintenance monitoring. The costs of maintenance are higher than the investment made and can discourage the property's owners.
The status quo stands for the current market which will be revolutionized by the tokenization of the assets. The change of the system can be slowed down by the stakeholders who find more benefits in the current one.

8.5 Considerations about the future of Real Estate

New technologies such as the distributed ledger can threaten the current market's structure.
But they represent an opportunity to build a new infrastructure for future use by the industry (Baum, 2017).
Blockchain technology is an opportunity to be explored by firms, local and national government, banks, insurance, and regulators even if its implementation seems to be distant today.
An open-source structure for the movement of assets is like the internet, which is an open-source structure for communication (Baum, 2017).
The commercialization by industries such as finance, retail, social media, telecommunications, transport, leisure, and real estate has allowed the internet to grow. Some examples of these firms are Amazon, Facebook, Google, Uber, TripAdvisor, and Airbnb.
Through their commercialization, blockchain and distributed ledger technologies too can develop and grow in the market.
The benefits of new technologies will be brought by services like smart contracts. Blockchain and distributed ledger technology can be useful to build new applications in the real estate industry.
Smart contracts will take these advantages (Baum, 2017) (Figure 41):

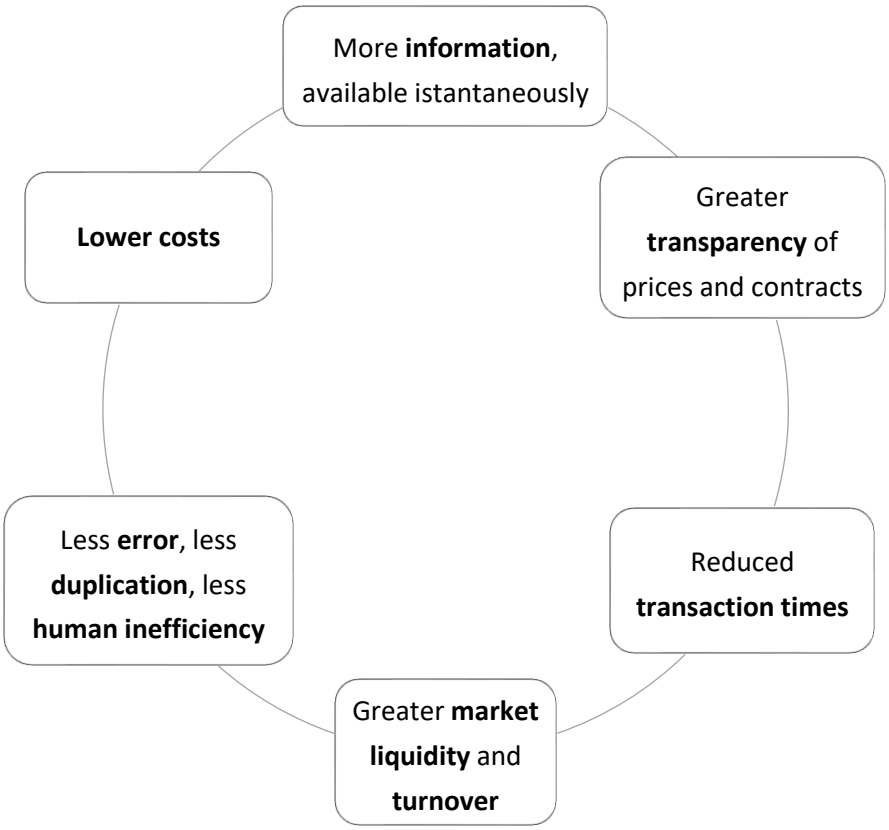


Figure 41. Advantages related to Smart Contracts' implementation (Author's elaboration)

The system that can be implemented by the industry needs to be both public and private since real estate is characterized by the public sector and private data.
The savings in time and money would be guaranteed by the possibility to connect all the public sources to a single, shared ledger system with instant access to the information (Baum, 2017).

It is important also to consider the risks related to the possible implementation of blockchain technology:

- The difficulty of the technology to be implemented
- The unsustainability of the energy's consumption
- Limitations imposed by the government
- Inadequacy of the incentives
- Privacy
- Possibility of fraud

There is a justified uncertainty about the future use of new technologies such as blockchain in the real estate sector.

In the case of success and growth of it, there could be a transformation in the society, through the evolution of digital platforms there would be a huge impact on the tomorrow's cities.

If blockchain becomes the city's operating system, there will be an improvement in citizens' access to goods and services. Moreover, it can be the reason for greater economic opportunities (Baum, 2017).

It is important to underline that technology is yet to mature, but the future is always uncertain talking about the technology revolution.

The real estate industry would have some benefits with the introduction of technology. There would be an increase in processes' efficiency through automation, scale, and uniformity.

The status quo of the real estate market can be revolutionized by the implementation of new technologies, and the next years can represent an opportunity for entrepreneurs, venture capitalists, private equity, and corporations to consider the impacts of technological advancements and create a new real estate cycle.

9. Smart Contract's overview

Smart contracts are the translation of terms and conditions of a contract into computer protocols. This computer program has self-verifying, self-executing, and tamper-resistant properties.

They were introduced by Nick Szabo, probably around 1993, who coined this term to emphasize the goal of changing the practices of contract law and the related business practices to bring them closer to the design of electronic commerce protocols (von Haller Gronbaek, 2016).

Contractual clauses are partially or fully self-executing when predefined conditions are met. The first step is the set of the terms in computer code. Then the contract will run automatically, and terms will be executed impartially by the computer.

Smart contracts are enabled by blockchain technology that allows storage, replication, and update of the transactions made through them. This is the breakpoint with the conventional contracts that need to be completed by a trusted third party in a centralized way (Zheng, 2019).

A blockchain-based smart contract is defined as "*A piece of code, deployed to the shared, replicated ledger, which can maintain its state, control its assets and which*

responds to the arrival of external information or the receipt of assets" (von Haller Gronbaek, 2016).

The combination of automation with the lack of trust-building costs associated with the blockchain infrastructure decreases the transaction costs and makes the exchanges much more profitable.

Smart contracts are based on the model of traditional contracts.

The basic contents of the traditional contracts are (Feng, 2019):

- Subject matter
- Contract participants
- Quantity and quality
- Price or remuneration
- Duration
- Dispute settlement
- Additional clauses

The steps from the preparation to the end of the contract's life cycle are (Feng, 2019):

1) Preparation before signing
2) Contract examination and approval
3) Contract signing
4) Contract review
5) Contract performance
6) Contract filing

They are manually signed, and the implementation needs the protection of third parties. If contracts are signed in a paper version, many difficulties arise about the management and contract process monitoring. These problems have not been solved by the arising of electronic versions.

The traditional contracts are characterized by some shortcomings.

During the signing phase, some problems can arise due to ambiguity and information asymmetry.

The execution phase can be made difficult due to delays, while if a dispute arises there can be conflicts for the different contents of the contracts.

Moreover, keeping the security of the contract implies high management costs.

Compared with conventional contracts, the smart ones have the following advantages:

- Risks' reduction
- Cut of administrative and service costs
- Improvement of the efficiency of the business process

The first advantage is due to the use of blockchain technology that allows storing and duplicate transactions making them traceable and auditable.

The consensus mechanism allows avoiding the intervention of a central broker. For this reason, smart contracts can be activated in a decentralized way saving administration and service costs.

The elimination of a third-party mediation allows increasing the efficiency of the process. It will be completed in a peer-to-peer manner once the predetermined requirements are met (Zheng, 2019).

"*The goal of smart contract technology is to automatically generate contracts for real-world application scenarios and adjust according to the user's individual needs*" (Feng, 2019).

After the sign of the users, there is the automatic execution of the contract. The same happens when a predetermined condition is executed, according to a set of established input and rules.

It is possible to resume that a smart contract has the goal of being:

- Intelligent
- Consistent
- Efficient
- Convenient
- Compatible
- Observable

A smart contract would be intelligent if it can be completed automatically without any manual intervention. The requirements are converted from natural language to machine language and then to machine language contracts.

The consistency of a smart contract is from the perspective of the system and the law. The contract is consistent with the law if the clauses cannot violate it and all the actions meet the requirements of the law.

The contract would be efficient if is fast and with low operating costs.

It would be convenient if it is within everyone's reach from a technical aspect without the need for special training for the use.

The compatibility of the smart contract refers to the interface between the contract itself and the asset.
Lastly, the contract must be observable to guarantee the monitor of the execution of the contract. It is important to secure that all the contracts can be effectively supervised after the transaction problem occurs (Feng, 2019).

9.1 Smart Contract's life cycle

It is possible to identify four main phases during the life cycle of a smart contract. They are (Zheng, 2019):

1) Creation
2) Deployment
3) Execution
4) Completion

The creation involves several parties, such as stakeholders, lawyers, and software engineers, who negotiate on the obligations, rights, and prohibitions of the contract. The natural languages of the agreement will be then transformed into a computer language by software engineers.
The creation is an iterative process that involves multiple rounds of negotiations.

After the validation, the contract can be deployed to platforms on top of blockchains. After the storage on the blockchain, contracts cannot be modified. Once the deployment is executed, all the parties can access the contracts using the blockchain. According to the requirements of the parties, the digital assets are locked through the freeze of the corresponding digital wallets.

The third phase begins with the evaluation of the contractual clauses. After that, the contractual procedures will be automatically executed. When a condition is triggered, the corresponding statement will be automatically executed, consequently, a transaction is executed and validated by miners in the blockchain (Zheng, 2019).
The completed transaction and the updates are then stored on the network.

After the execution, there is an update of the states of all the involved parties. The digital assets are transferred from one party to another party. Consequently, the digital assets of the involved parties are unlocked.

During the last three phases, data are written to the blockchain. The process is shown in Figure 42.

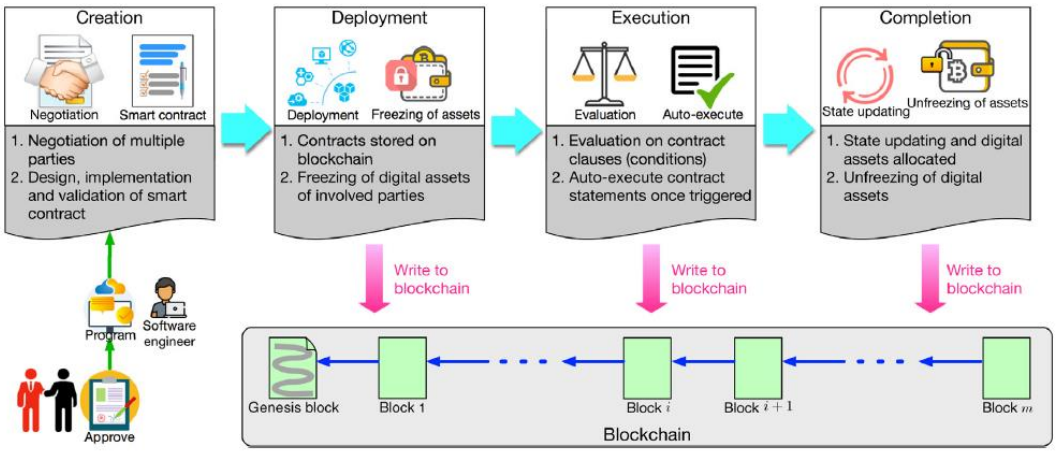


Figure 42. Smart contract's life cycle (Zheng, 2019)

9.2 Smart Contracts' applications

There is a broad range of possibilities for the application of a smart contract. They are:

- Internet of things
- Distributed system security
- Finance
- Data provenance
- Sharing economy
- Public sector

9.2.1 Internet of Things

The IoT's main goal is to integrate smart objects into the Internet and to provide various services to users (Zheng, 2019). It can automate various business transactions.

The potential of IoT can increase with the integration of smart contracts. They can bring benefits to the IoT e-business model that often requires third-party intermediation to complete the transaction.

Supply chains can be speeded up with the automation of contractual rights and obligations during the payment and the delivery of goods.

9.2.2 Distributed system security

Smart contracts can improve the security of distributed systems. It can be used as a collaborative mechanism to mitigate attacks on the servers.

Once a server is attacked, the IP addresses of the attackers can be automatically stored in the smart contract (Zheng, 2019). Thus, all the nodes of the chain will be informed about the address of the attackers.

Smart contracts can be implemented also in the purchase of cloud services to verify the trustfulness of the providers.

9.2.3 Finance

The efficiency of financial services can be improved by the implementation of smart contracts that allow to reduce risks and cut down administration and service costs.

Benefits of smart contracts can be encountered in those financial services (Zheng, 2019):

- *Capital markets and investment banking*; smart contracts can shorten the settlement period consequently increasing attractiveness to customers.
- *Commercial and retail banking*; smart contracts can solve some problems related to mortgage loans reducing the costs and delays thanks to the automation of the processes with the digitization of legal documents in blockchains.
- *Insurance*; smart contracts can save costs especially in claim handling. For example, AXA has launched its insurance for flight delays based on smart contracts. The passengers who purchase the insurance sign automatically a smart contract connected to the air global traffic database, and if is noticed a flight delay of over two hours, it will be activated a function in the smart contract, and passengers will be paid immediately.

9.2.4 Data provenance

Smart contracts can be used to ensure quality information avoiding falsification of data.

The goal of Data provenance is storing meta-data information of data origin, derivation, and transformation.

Smart contracts can track the transformation made to data and any malicious falsification of data can be captured.

Moreover, they can be used to protect the digital property in the case of the infringement of the property right.

9.2.5 Sharing economy

In addition to the various advantages, sharing economy platforms are characterized by some problems such as the high transaction costs of customers, privacy exposure, and unreliability of trusted third parties (Zheng, 2019).

Smart contracts can reshape sharing economy through the decentralization of the platforms.

Sharing economy applications can be developed through the integration of IoT with blockchains that allow the development of peer-to-peer automatic payment systems, traveling systems, digital assets management, and currency exchange platforms (Zheng, 2019).

9.2.6 Public sector

Public sector management can be reshaped by blockchain technology that can avoid data fraudulence and ensure public information's transparency.

Smart contracts can also guarantee the protection of personal digital identity.

For example, a study analyses the possibility of creating a smart property ownership exchange protocol (Zheng, 2019). After the sign of a transaction, it is sent to the seller who will check the transaction information.

If it is correct, the seller signs on the received transaction and broadcasts it publicly. If there is a failure during the process, the whole ownership transfer process will be stopped (Zheng, 2019).

Smart contracts' benefits in the sectors are resumed in Table 9 reported below.

Application	*Benefits*
Internet of Things	o Reduction of costs for maintaining the central server o Automation of peer-to-peer business trading o Reduction of costs for trusted third parties
Distributed Systems Security	o Possibility of sharing attack list o Verification of the trustfulness of cloud service providers o Avoid brokers' usage

Finance	o Reduction of financial risks o Low administration and service costs o Improvement of the efficiency of financial services
Data provenance	o Capturing data falsification o Improvement of data reliability o Preservation of privacy
Sharing Economy	o Reduction of consumer costs o Reduction of costs for trusted third parties o Preservation of privacy
Public sector	o Prevention of data fraudulence o Data transparency of public information o Preservation of privacy

Table 9. Smart contracts' applications and related benefits (Zheng, 2019)

10. The hypothesis of a Smart Contract model

The overview about how digital development can influence the real estate market through the implementation of new technologies leads the work to the hypothesis of a smart contract model.

The goal is to study a method to make smarter the process of a real estate transaction.

A smart contract can offer on-demand services that can be adapted to the people who live in the building.

The trend of this historical period is to have more often empty spaces that make fixed contracts unsuitable. Tenants such as big companies want to save money, and landlords exploit new services to offer win-win solutions to the users.

The pandemic that has occurred in the last year highlighted the low smartness of the real estate sector. About the residential, a lot of people have left the city where they studied or worked, but in many cases, they had to pay their house's rent without living in it.

The same situation occurred in office buildings, that have emptied because of the smart working's solution.

This is due to the existing contract.

The contract is thought for the rent of office spaces.
The innovation stands in the possibility to manage this kind of asset as a good which is possible to rent through the dynamics of the sharing economy.
The smartness of processes like the rent of a car through sharing services and the recent development in the last years of co-working spaces can be the basis for the study of the model.

It is possible to consider an office building like the one in the figure reported below.

Figure 43. Office building model (Author's elaboration)

The first step to build up the model is to identify different kinds of uses of the spaces. The office building can be divided into some areas according to the possible rents, as it is shown in the figure reported below.

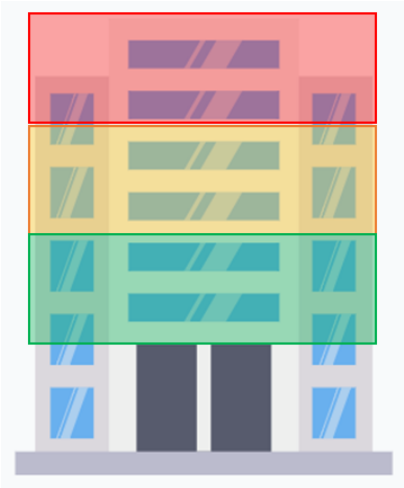


Figure 44. Division of areas of the office building according to the rent (Author's elaboration)

The coloured areas are used to divide the floors of the building according to the kind of contract that the renter wants to stipulate.

The contracts differ in terms of duration and the user's goal. The differentiation is explained in Table 10 reported below.

	Rent of offices for a **single day** use
	Rent of offices for a **weekly or monthly** use
	Rent of offices for a **half-year or years** use

Table 10. Categorization of rent possibilities (Author's elaboration)

The design of Blockchains applications consider three main development phases:

1) Analysis phase
2) Design phase
3) Implementation phase

In the first step is important to collect the requirements to develop the application with the identification of the entities involved.

In the second phase, the entity attributes, and their interactions are modelled to have variables and functions of the application.

During the third phase, the smart contract is implemented. The main components of the smart contract are functions, state variables, modifiers, and events translated into a high-level programming language such as Solidity or Python (Karamitsos, 2018).

The application must be developed to provide a friendly user interface to smart contracts.

For the realization of the contract, the actors must be defined. They are (Karamitsos, 2018):

- The Contract Owner usually is a landlord or a real estate owner and is responsible for the development of the smart contract and external owned account.
- Tenants, who are responsible for the creation of their digital wallet that is necessary to access the public or private blockchain nodes.

If it is selected an Ethereum Blockchain platform, there are four main processes (Karamitsos, 2018):

1) Block validation

2) Network discovery, it is necessary for a new node to join the Blockchain network
3) Transaction creation, allows users to do transactions
4) The Mining process is the broadcast of a new block to the network

In the case of the project, the RE acts as a landlord. The goal is to rent offices using this kind of technology.

10.1 Analysis phase

In this phase, there is the identification of actors and their roles and responsibilities. Many requirements are collected from the organization.
The goal is to understand the benefits that can be provided to the organization by blockchain technology and smart contracts.

The actors are reported in Table 11.

Externally Owned Accounts	They are the Landlord and the Tenants. They are controlled by private keys. They can create transactions to transfer value and create smart contracts.
Contract Accounts	They are controlled by their code. If the code receives a message, the account can send messages to other contracts or create contracts in return.
Miners	They validate the transactions and blocks. The validated transactions are collected into a block. After the validation of the transaction, the miners are rewarded.

Table 11. Actors involved in a transaction process (Karamitsos, 2018)

In the case of the use of a private Blockchain, the Miners' role is not needed because the parties are already trusted and want to make the process smarter without the intermediation of a third party.

The differentiation in the categorization of the rents is included in this analysis phase. There can be fixed some differences in terms of services offered according to the duration of the rent and the deal between the landlord and the tenant.

The cost per workstation can be different according to the user's goal.
It is determined by:

- The rent, which is established according to some factors such as:
    - The property's characteristics
    - The location where the building is sited
    - The connection of the building with the public transport
- The maintenance of the asset
- The facility services

The cost can be managed by creating an incentive for the company to rent the offices for a longer period. If it is assumed that the quality of the workstations offered is the same in the whole building, the costs can be progressive.
If the request of the tenant is to rent the offices for one year, the total cost can be discounted.

10.2 Design phase

The most relevant components of a smart contract are (Karamitsos, 2018):

- Functions
- Processes
- State variables
- Events
- Transactions

10.2.1 Functions

The smart contract is a deal between the real estate owner and tenants.
The main goals of the contract are resumed in Figure 45 below.

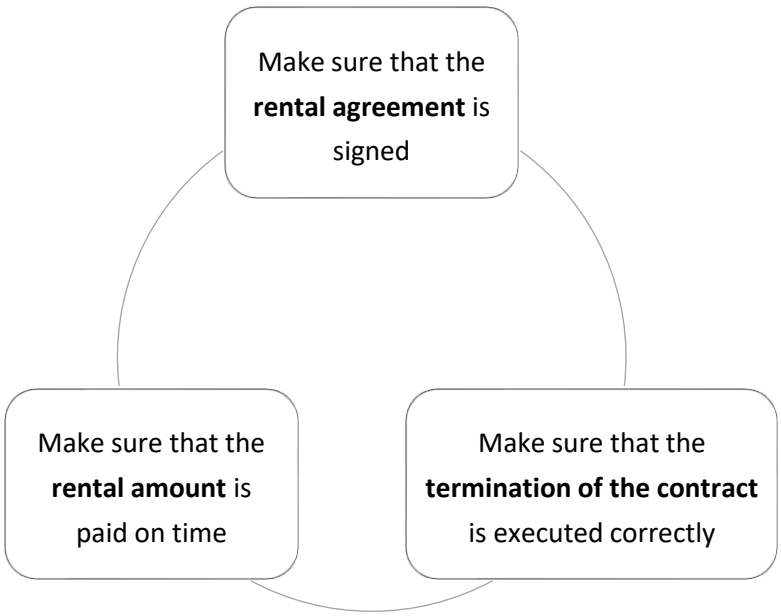


Figure 45. Goals of a Smart Contract's use (Karamitsos, 2018)

The smart contract functions are (Karamitsos, 2018):

1) Creation
2) Start
3) Rent collection
4) Termination

The first function is set by the Landlord, who develops the contract establishing the terms of the rent and adding the details about himself and the tenants.

The Start function is set when the contract is signed by the tenant, and the rent begins. The rental agreement is confirmed once to avoid the chance of overwriting the current tenant.

The third function is the emblem of the smartness of the process because the rent is collected through the smart contract from the tenants and is sent directly to the landlord.

The termination of the contract is done by the landlord, after that, all the balance deposit is sent to the tenant after the check of the property's status (Karamitsos, 2018).

10.2.2 Processes

The process is one-to-many parties.

The smart contract processes are (Karamitsos, 2018):

1) Rent Contract Signature
2) Rental Payments
3) Termination Rent Contract

The first process is the signature of the contract by the parties (Figure 46).

The rental agreement must include the rental value, the payment frequency, and landlord and tenant's details (Karamitsos, 2018).

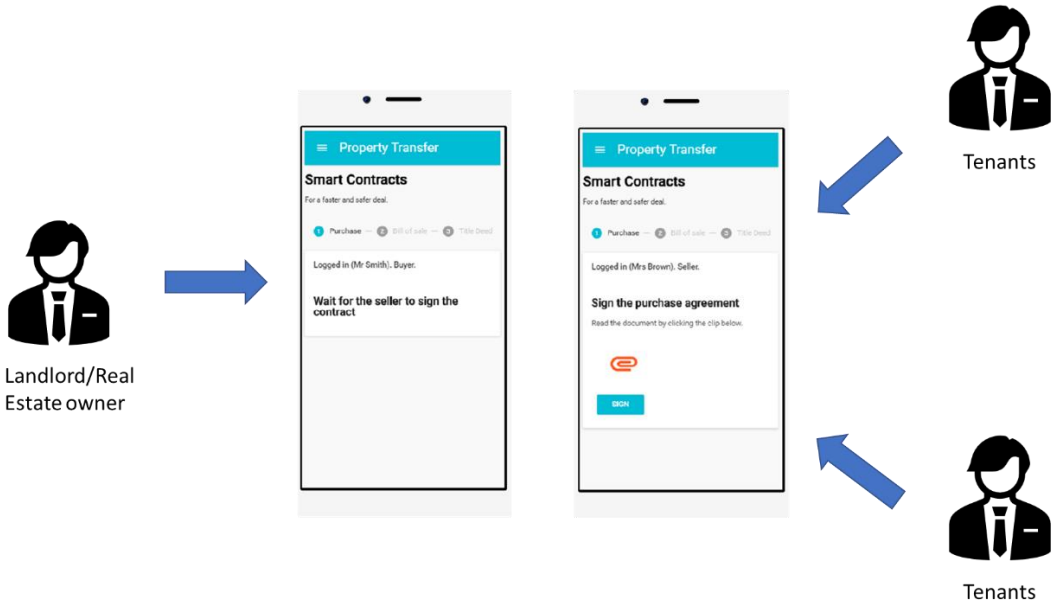


Figure 46. Process of the sign of the contract (Author's elaboration)

The Rental Payments process is executed following the terms and conditions of the rental agreement. Through different modes, the lease payments are sent from the tenants to the landlord and FM contractors (Figure 47).

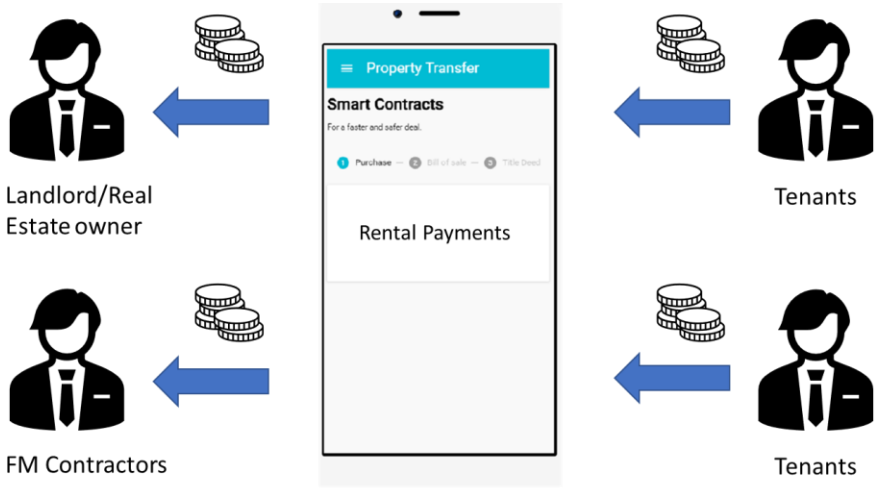


Figure 47. Process of the payments of the rent (Author's elaboration)

The rental payments are executed on the first day of the month of use.

Hypothesizing an application based on the shared economy model, in the case of a one-day use the payment is done automatically at the same moment of the reservation.

In all the rental agreements possibilities the application processes a code.

The users must register their biometric data when they use the application for the reservation.

Biometric verification is applied when they enter the office building to verify their identity and avoid intrusion attempts.

The employees, once entered the building, can start to work unlocking their workstation through a code. It has been sent previously on the application (Figure 48).

It is hypothesized that every workstation is characterized by a specific code. It will be necessary to work independently on the rent case.

If the workstation is used only one day, the code will expire and be restored for a new reservation.

If the contract is executed for many months or years, the code of the workstation will be used every day to unlock the workstations and will be useful for another reason.

Thinking about a smart building, the behaviour of the people who will work into it will be used to correct some aspects of the contract.

For example, the use of sensors and the verification of the workstation's use through the code can make the tenant able to understand if how space is used justifies the investment he made.

The functioning of the workstation's unlocking is inspired by the car-sharing system.

Figure 48. Use of the workstation code (Author's elaboration)

The last process is the termination of the contract. It concludes with the payment of a security deposit to the tenants (Figure 49). It is a premium for the tenants in the case of which there have not founded damages on the stuff.

Another benefit's reason can be related to consumption monitoring. If the firm's employees sustainably use the spaces, there can be established a premium too.

Insurance policies often present this kind of solution, providing some incentives to the customer to obtain a premium for their behaviour.

If the analysis of the tenant through the sensors and the codes gives the result that the rent is not convenient for the company, it would be possible to think of a solution like the "Pay per View" for the TV. In the case of real estate assets, it can be called "Pay per Use".

Thus, if the tenant decides to terminate the contract before the established end, it would be possible to ask for the conclusion of the rent for the month immediately following that of the demand for the end of the agreement.

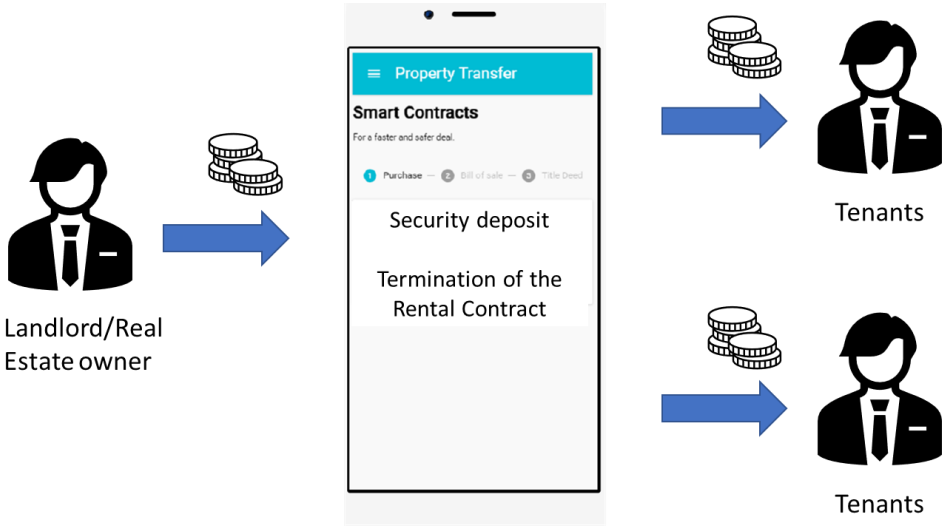


Figure 49. Termination of the rental contract (Author's elaboration)

10.3 Implementation phase

The last phase stands for the elaboration of the code programming for the smart contract. All the functions and processes previously defined are translated into a coding program (Karamitsos, 2018).

10.4 Model's functioning

The model can be resumed in Figure 50. The start of the model is the deal between the tenant and the landlord.

Then through the application, it will be possible to select among the different rental options.

In the case of a one-day use, it can be established only a malus in case of damages and not a benefit because it would be inconvenient for the landlord.

Moreover, the cost related to a one-day use workstation would be lower than the workstations available for the other contracts.

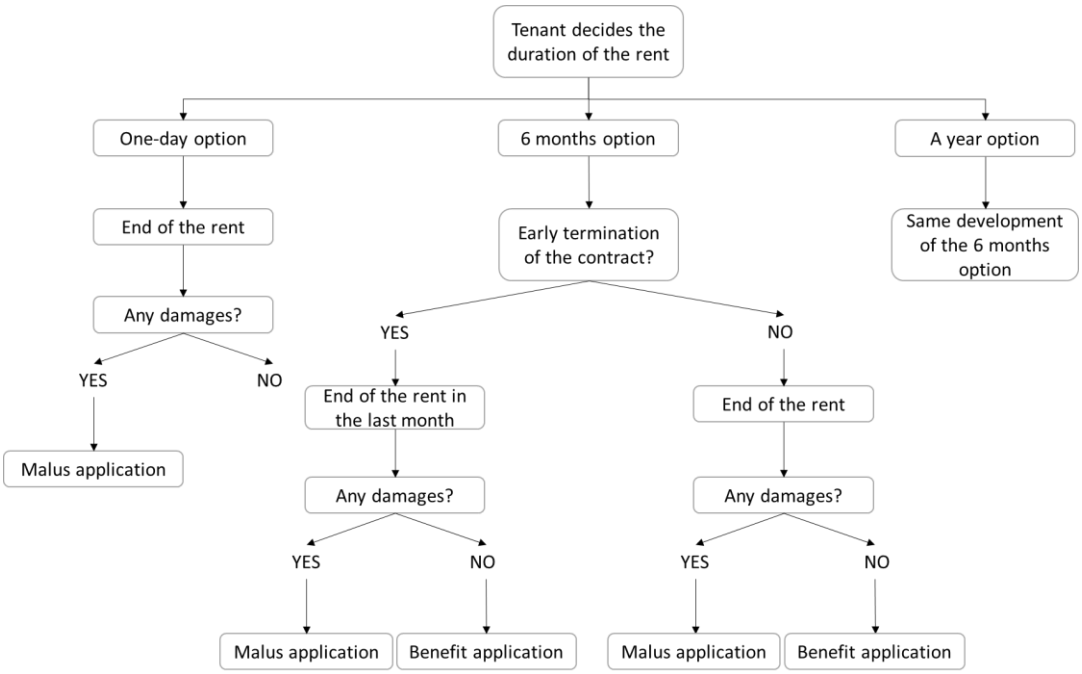


Figure 50. Development of the Smart Contract model (Author's elaboration)

10.5 SWOT Analysis

This analysis is done to identify the four main issues related to the introduction of an innovative solution. They are:

- Strengths
- Weaknesses
- Opportunities
- Threats

Strengths represent the benefits that can emerge from implementing blockchain technology and smart contracts in the Real Estate industry. They are (Karamitsos, 2018):

- *Possibility of modifying the database for different parties;* the actors involved, such as tenants and owners, have access to modify the information through the blockchain network.
- *The easier relationship among the parties;* the actors can overcome the possible lack of trust that can characterize the current real estate transactions.
- *Disintermediation;* transactions are automatically verified and validated by the system without the need for the intermediation of third parties such as brokers.

- *Management of the transactions;* can be more efficient because the transactions can be separated through blockchain technology.

Weaknesses related to this system are:

- *Impact of the change;* difficulty for the firm to change and adapt to a new contract system.
- Unavailability of adequate technological stuff.
- *Impact of malfunctions;* they would have a huge impact for this kind of organization because all the model is based on internet and any problem in the servers would represent an obstacle for an ordinary business day.
- *Transparency and privacy;* blockchain technology is improving the security of the transactions executed and collected in the network.

Opportunities related to this model are:

- *Valuation of the effectiveness of the investment;* the tenant can understand if the rent of the space is convenient for the company or not.
- *New smart working solution;* this system can offer an alternative solution to the smart workers.

Threats related to this model are:

- *Lack of intermediation;* it can be difficult for the companies to do without a third party that regulates the transaction process.
- *Difficult management of the cancellations;* the property's owners must face the possibility of early termination of the rent contracts by the tenants.
- *Failure of the model;* there is the possibility that companies prefer the current contract model. In this case, the owner must consider the possibility of changing its choice and delete the implementation of the smart contract model for the rent of the spaces.

11. Conclusion

This work wants to present an overview of how technology has a huge impact on the world and its dynamics.

The goal is to have an overview of the relationship between two different sectors such as Technology and Real Estate.

The conclusion about the implementation of innovative technologies in the real estate industry is that there is still a long way to go.

The analysis of PropTech highlights how companies in western Europe, northern America, and Asia are developing and adjusting to the implementation of technology in their businesses.

Moreover, the difference is due to the funding invested per PropTech firm. From this aspect, the Asian sector is the most advanced one.

The most active European country is by far the United Kingdom, while a deep overview of the Italian situation has highlighted how the sector is emerging and in the last two years period, there has been an increase in the development of the Proptech companies and the funds invested. The most growing category is the Smart Real Estate one.

The study of Blockchain technology and its implementation in real estate firms allows understanding what the advantages are.

The decentralization and the disintermediation represent a revolution for the current way of executing transactions among parties involved.

In the ned, Smart Contracts represent the operative part related to the possible transformation of real estate transactions.

They transform the current contracts into computer program languages and can be the way to adapt a sector like Real Estate to the smartness that technology is carrying in the world.

The hypothesis of a smart contract model is done to try to think about the implementation of this system to manage the rent of spaces in an office building. It would then be applied to a real case to verify its functionality.

References

Al-Hader, M., Rodzi, A., (2009). The Smart City Infrastructure Development & Monitoring. *Theoretical and Empirical Researches in Urban Management, Vol.4, No. 2 (11) (May 2009), pp. 87-94.* https://www.jstor.org/stable/10.2307/24872423

Asaftei, G. M., Doshi, S., Means, J. & Sanghvi, A., (2018). Getting ahead of the market: How big data is transforming real estate. https://www.mckinsey.com/industries/real-estate/our-insights/getting-ahead-of-the-market-how-big-data-is-transforming-real-estate

Asha, B., Ruchika, M., Abhishek, R., Parth, K., (2016). Smart Contract for Real Estate using Blockchain. VESIT, University of Mumbai, India. https://ssrn.com/abstract=3565497

Barkham, R., Bokhari, S., Saiz, A., (2018). Urban Big Data: City Management and Real Estate Markets. *MIT Center for Real Estate. CBRE.*

Baum, A., (2017). PropTech 3.0: the future of real estate. University of Oxford, Oxford.

Bellintani, S., Bettani, I., Ciaramella, A., Leoncini, S., & Tagliaro, C., (2019). PropTech Monitor. Tecnologie, strumenti e servizi innovativi per il Real Estate. Politecnico di Milano, Milano.

Braesemann, F., Baum, A., (2020). PropTech: Turning real estate into a data-driven market? *Oxford Future of Real Estate Initiative, Version 1.3.* University of Oxford, Oxford. https://ssrn.com/abstract=3607238

Corluka, D., Lindh, U., (2017). Blockchain - A new technology that will transform the real estate market. Real Estate and Construction Management. Royal Institute of Technology. Stockholm, Sweden.

Feng, T., Yu, X., Chai, Y. and Liu, Y., (2019). Smart contract model for complex reality transaction. *International Journal of Crowd Science, Vol.3, No. 2 (2019), pp. 184-197.*

DOI 10.1108/IJCS-03-2019-0010. www.emeraldinsight.com/2398-7294.htm

Feth, M., Grunerberg, H., (2018). Proptech – The Real Estate Industry in Transition. Ritterwald.

Karamitsos, I., Papadaki, M. and Al Barghuthi, N. B., (2018). Design of the Blockchain Smart Contract: A Use Case for Real Estate. *Journal of Information Security, 9, 177-190.* https://doi.org/10.4236/jis.2018.93013

Kehrli, J., (2016). Blockchain 2.0 – From Bitcoin Transactions to Smart Contract applications. niceideas.ch

Liu, S., (2018). Everything you need to know about blockchain and real estate. https://www.propertyme.com.au/blog/industry-news/blockchain-real-estate

Morena, M., Truppi, T., Pavesi, A. S., Cia, G., Giannelli, J., & Tavoni, M., (2019). Blockchain and real estate: *Dopo di Noi* project. *Property Management, Vol.38, No. 2 (2020), pp. 273-295.* DOI 10.1108/PM-01-2019-0005. https://www.emerald.com/insight/0263-7472.htm

Munawar, H. S., Qayyum, S., Ullah, F., Sepasgozar, S., (2020). Big Data and Its Application in Smart Real Estate and the Disaster management Life Cycle: A Systematic Analysis. *Big Data and Cognitive Computing, 2020, 4.* doi:10.3390/bdcc4020004. www.mdpi.com/journal/bdcc

Shaw, J., (2018). Platform Real Estate: theory and practice of new urban real estate markets. *Urban Geography.* https://doi.org/10.1080/02723638.2018.1524653

Shulman, D., (2014). Technology vs. Commercial Real Estate: Retail, Office, and Hotel Markets Face Major Disruptions. *UCLA Economic Letter, Real Estate and the Macroeconomy.* UCLA Ziman Center for Real Estate and the UCLA Anderson Forecast.

Spielman, A., (2016). Blockchain: Digitally Rebuilding the Real Estate Industry. *Center for Real Estate, Massachusetts Institute of Technology.*

Ullah, F., Sepasgozar, S., & Wang, C., (2018). A Systematic Review of Smart Real Estate Technology: Drivers of, and Barriers to, the Use of Digital Disruptive Technologies and Online Platforms. *Sustainability 2018, 10, 3142.* DOI:10.3390/su10093142. www.mdpi.com/journal/sustainability

Von Haller Grønbæk, M., (2016). Blockchain 2.0, smart contracts and challenges. *Computers & Law. SCL Magazine.* Bird & Bird, Copenhagen, Denmark.

Wouda, H. P., Opdenakker, R., (2019). Blockchain technology in commercial real estate transactions. *Journal of Property Investment & Finance, Vol.37, No. 6 (2019), pp. 570-579.* DOI 10.1108/JPIF-06-2019-0085. www.emeraldinsight.com/1463-578X.htm

Zheng, Z., Xie, S., Dai, H.-N., Chen, W., Chen, X., Weng, J., Imran, M., (2019). An overview on smart contracts: Challenges, advances and platforms. *Future Generation Computer Systems 105 (2020), pp. 475-491*. https://doi.org/10.1016/j.future.2019.12.019