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REAL ESTATE INNOVATION: THE IMPACT OF BLOCKCHAIN AND SMART CONTRACTS ON THE REAL ESTATE INDUSTRY

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Abstract

The residential real estate brokerage industry is lacking behind technological innovation. Brokers need to adapt to dynamic, technology-centered environments. Innovation and retaining are firm's best chance of survival. This thesis addresses the European market's attractiveness and analyses the industry's most important technological trends.

As part of PropTech, Blockchain can be the solution to a much-needed upgrade in real estate. This paper reviews the role of Blockchain and Smart Contracts in the real estate industry. Through a survey and literature review, this paper concludes that Blockchain and Smart contracts can improve management of transactions and land registry process in real estate.

Keywords

Real Estate, Innovation, Blockchain, Future, Smart contracts, Disruptive Technologies.

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1 Introduction

While other industries saw major disruptions due to technological advancements, the real estate (RE) industry has so far been slow to innovate (Tawania and Rao 2020). According to Ullah et al. (2018), the industry is five years late on technology innovation. However, although RE has been slow to keep up with the times, the next wave of technology disruption is expected to have a significant impact on how the business is conducted. The business environment is getting aggressive, and customers are becoming more demanding as the digital transition progresses (Schwager and Meyer 2007).

The objective of this paper is to first comprehend the need for innovation in RE and ultimately understand what these key innovations will be. For the purpose of this research, the focus will be on the residential RE market in Europe. In the group contribution an overview of the European industry, analysis on past trends impacting RE and an exploration of the next wave of technological disruption are presented. A special focus will be given to future platform models in RE and three specific innovations impacting the industry in the near future, which will constitute each member's individual contribution to this thesis. These innovations include Virtual Reality (VR), Augmented Reality (AR), Internet of Things (IoT), and Blockchain & Smart Contracts. Individual contributions provide a general overview of respective innovations, their importance, applicability, and potential impact.

This paper addresses an important issue for European RE industry stakeholders and future market entrants. As new technologies start disrupting the industry, it is important for companies and agents to understand how their business will be impacted and where their focus should be. While these technologies are vital for the industry's growth, they can also represent a challenge for businesses that are reluctant to innovate (Tawania and Rao 2020). Therefore, an increased concern must be given to the understanding of the next big disruptions shaking the industry. Real estate players should know how to take advantage of these in order to achieve business

development, satisfy customer demands and stay competitive in the fierce business environment (Grant and Cherif 2016).

2 Literature Review

2.1 Real Estate History

Floyd and Allen (2002) define real estate simply as the "land and things attached to it". The term covers any property that is willing to be bought, sold, rented, or exchanged for other goods or services (Graaskamp 1981). Throughout time, real estate has been influenced by changes in economics, politics, demographics, and technological advancements.

At the end of the 18th century began one of the most influential revolutions of modern times, the first Industrial Revolution. Production processes became mechanized, leading to the mass production and opening the door for other industries to follow their lead and increase productivity (The Economist 2018). Technological advancement allowed for a relatively better standard of living and increased labor productivity, which led to growth and prosperity in European countries (Maddison 1995). Within the first decades of the 20th century urbanization accelerated and created the need to build collective spaces in the cities, such as factories, hospitals, schools, housing blocks (Britannica 2020). Innovative construction techniques and materials were developed such as reinforced concrete, steel frames, curtain walls, or ribbon windows (RIBA 2021). Thus, architectural functionalism was born. It is based on an innovative concept that tries to join the form of a building with its specific function, thereby minimizing costs and presenting great sobriety and volume in buildings (Craven 2018).

In 1914, World War I began, and the growing prosperity slowed. Economies contracted and the Gross Domestic Product (GDP) of Western European countries declined and did not return to pre-war levels until a decade after the war began (Maddison 1995; Edelstein and Edelstein 2020). Many countries changed their borders and vast landscapes were damaged (Smith 2021).

While the war brought destruction, industrialization continued to grow, and new jobs were created to rebuild cities and repair infrastructure (Eichenberg 2019).

After the war, parts of Europe experienced a period of relative prosperity. In 1933, the Charta of Athens was agreed upon. It aimed at separating working districts from living districts, ultimately leading to the concept of car-friendly cities, and fundamentally reshaping the physiognomics of European cities (Rubin 2009). The period of relative prosperity ended with the start of World War II 1939. The death toll was estimated to be around 39 million, double the estimates for the First World War (Maddison 1995). The constant ground fighting and bombing led to the destruction of RE and many people were forced to leave their homes (Kesternich et al. 2012). After the war ended, the United Nations (UN) was formed to restore peace and prosperity (UN 2011). As had been the case since the mid-1800s, most jobs and educational institutions were located in major cities. Modernism continued to impact city landscapes and functionality as urbanization increased the demand for affordable housing in the suburbs (Vidal-Abarca et al. 2016; Craven 2018).

Between 1945 and 1975, pressured by the UN and weakened by the war, European countries left Africa and Asia in a process called decolonization. This process continued to stimulate the construction of houses to accommodate people returning from those colonies (Peralta 2019; Getachew 2020). Nowadays, there is still migration from rural areas to urban areas and buildings continue to adapt to the new necessities while integrating new technological advancements (Vaisi 2012).

2.2 Industry analysis

Within the industry analysis, the macroeconomic development of the European Union (EU) is analyzed to assess its market attractiveness. Moreover, real estate types are divided into four

segments: Office, Retail, Logistics, and Residential. Finally, the competition in the European RE brokerage market is scrutinized to understand industry pressures.

2.2.1 Macroanalysis

From a chronological perspective, it is essential to understand the factors responsible for the growth and decline of the European economy, as they correlate with the ups and downs of the housing sector (Martins et al. 2021). For instance, after each major economic downturn, Europe shows a sharp recovery, with each country having its specific demand characteristics. In recent decades, the demand for RE in Europe has been on the rise, changing dynamics of house prices, supply, and demand (CaixaBank 2020). Affected by economic growth, this demand led to changes in property prices, homeownership rates, and various monetary policy changes. A discussion of these aspects from a macroeconomic perspective is presented below. These different characteristics contribute to the focus of this paper on Europe.

Economic History of EU

Between 2000 and 2007, most European countries experienced slow growth in house prices. Some countries even experienced negative growth, such as Germany and Portugal. The countries that experienced high growth rates during this period, e.g., Latvia and Spain, grew due to monetary policies that lowered interest rates (Martins et al. 2021). These monetary policies facilitated purchasing a home with much lower down payments. After the global financial crisis (2008) and until 2012, Europe experienced slow growth in economic activities. After the European debt crisis in 2012, the European economy recovered well and even continued to grow (Deloitte 2021). This growth continued until the recent economic disruption caused by the Covid-19 pandemic, resulting in a worse economic situation of declining GDP then the 2008 financial crisis. The damage control process has forced governments and European Central Bank (ECB) to print money and make various fiscal changes that have been

leading to recovery in several countries. According to CaixaBank (2020), the higher employment rate over the last decade, combined with higher disposable income and positive economic growth, has increased housing demand and property prices in the European housing market.

As indicated earlier, banks play a crucial role in determining the potential development of houses based on the monetary policies they pursue. However, Martín, Moral-Benito, and Schmitz's (2019) research argues that house prices can also determine the status of an economy. The high exposure to financial instruments (i.e., leverage, loans) from advanced economies contributes to higher construction rates and house prices, thus lead to a potential housing bubble. This is observed in the case of Spain between 1995 and 2007-2008. The same research also suggested that when Spain's housing bubble burst, banks handed out higher credits that increased risky mortgages. As a result, this increased the probability of a financial crisis. Thus, suggesting that the housing cycles can be correlated with spillovers in an economy (Martín, Moral-Benito, and Schmitz 2019).

Geographical Disparity in Europe

The European housing market is characterized by its differences rather than its commonalities. A report published by the European Commission in 2021 finds a correlation between European housing cycles and vast differences between each country's housing markets (Martins et al. 2021). Regarding the rate of homeownership, countries across the EU vary considerably. While rates are high in Hungary (91.3%) or Slovakia (92.2%), rates are much lower for Portugal (77.3%), France (64%), or Germany (50.4%) (Eurostat 2021). In addition, the household mortgage debt to GDP diverges strongly among EU member states. On the low end, Romania exhibits a household mortgage debt to GDP ratio of 15.4%. Portugal is slightly above average with 63.5%, and Denmark is located on the high end with 110.2%. Not only does the amount of indebtedness vary but also the characteristics of mortgage debt. For example,

fixed-rate mortgages dominate in Germany, Belgium, or France, whereas in Portugal, Spain, or Italy, adjustable-rate mortgages are prevalent (Albertazzi, Fringuellotti, and Ongena 2019). This difference explains to a certain degree why housing cycles in the EU show less synchronization than business cycles (Rünstler and Vlekke 2018). Martins et al. (2021) also found that structural differences can be attributed to each country's individual development in the past. It is suggested that, although these differences are significant, they do not tend to change much over time, implying that structural peculiarities are relatively constant.

EU Outlook

The European RE market is estimated at a total of €860.3 billion in 2021, and this is expected to increase to €921.1 billion by 2025, with a compound annual growth rate (CAGR) of 1.6% (MarketLine 2021b). In comparison, the CAGR between 2016 and 2020 was 1%, thus showing a good, compounded growth overall. Similarly, transaction volumes in the European RE market are expected to grow by 1.2% annually between 2020 and 2025. In contrast, the CAGR of the RE market volume between 2016 and 2020 was 0.9% (MarketLine 2021b; Appendix I).

Again, this shows strong growth, even after the Covid-19 pandemic. Overall, while the RE market is looking at relatively strong upcoming growth, its development can be closely linked to the net economic growth of Europe. This growth is due to the correlation of financial activities such as mortgage rates, which can be strongly affected by any macroeconomic shock (Cunha and Lobão 2021; Reichert 1990). These macroeconomic shocks can also create an imbalance in housing prices caused by the disequilibrium in supply and demand. This is evident when low mortgage rates allow for more property sales, leading to higher homeownership rates.

The European GDP was in a position of slow growth between 2008 and 2012 due to the global financial crisis and the European debt crisis, respectively. However, with a projected annual GDP growth rate of 4.2% and 4.4% for 2021 and 2022, respectively, Europe is on track

to achieve its fastest economic growth since 2017. Spain and France are expected to lead this growth (European Commission 2021). Between 2021 and 2026, the EU's GDP is expected to increase from $17.07 trillion to $22.14 trillion, indicating a long-term slowdown. By 2030, the EU's GDP growth rate is projected to be -0.36%, another slow projection (International Monetary Fund 2021).

The ECB continues to support the European economy with its low-interest monetary policy. Most importantly, the Pandemic Emergency Purchase Programme (PEPP) was initiated in March 2020, buying up securities for €1.85 billion (ECB 2021). As a result, EU27 states can keep increasing their debt at low interest rates, stabilizing financial markets in the short-term (Ghiaie 2020). Although inflation was low during the pandemic in the EU27, considerable increases in inflation were recently reported (Appendix II). According to Eurostat (2021), average European inflation arrived at 4.1% in October 2021, representing the highest level since inflation data was first collected in 1997. With regards to interest rates, the situation stays favorable for RE investors in Europe. Short-term interest rates remain low and are not expected to increase at least until 2023 (CBRE 2021).

Overall, it can be said that the European market is characterized by strong disparities and uncertainties. The Covid-19 pandemic imposed tough macroeconomic challenges, which were countered by the ECB with the PEPP. The financial policy is projected to remain ultra-accommodative due to low interest rates (CBRE 2021). In combination with rising inflation, the attractiveness of brick-and-mortar assets to investors increases in the short term. However, the medium- and long-term outlook is considered negative because of the continuously shrinking GDP.

2.2.2 Real Estate Types

In European RE, numerous distinct segments exist on the market. It encompasses traditional asset classes such as commercial or residential, but also more specialized classes like hotel, healthcare, or entertainment (CBRE 2021). This research focuses on the main commercial RE types (office, retail, and logistics) and residential RE. This section aims to provide an overview of the most important asset classes and assess each sector's investment attractiveness. Key risk factors for each sector are analyzed and a market outlook is provided. Ultimately, this section provides the foundation for determining on which RE type the focus of this research should be put on.

Office

The office market segment encompasses all types of RE space associated with professional working environments. It includes all sizes, ranging from co-working spaces to office buildings (Poleg 2020). However, it only applies to office spaces affiliated with the tertiary sector and does not include home offices (CBRE 2021). One of the key indicators within the industry is the so-called “take-up”. It describes the “cumulated floor space of all new lettings or sales to occupiers that will be used as offices” (ImmoStat 2019). Take-up for office space in Europe equaled 9 million sqm in 2020, representing a decrease of 40% when compared to an office take-up of 15 million sqm in 2019 (BNP Paribas Real Estate 2021b). The pan-European vacancy rate for office space is expected to increase from 7.2% in 2020 to 8% in 2022. However, the prime rental growth continues to grow at an average of 0.6% in 2022 with an average prime total return of 6.36%, thus maintaining its attractiveness for investors. In contrast, investment volume in office space decreased by 29% in 2021 due to the Covid-19 pandemic, arriving at €92.3 billion in 2020. The general outlook for office spaces is complicated to determine due to the unknown long-term effects of the pandemic. Nevertheless, it is assumed that a 20% surge in employees choosing home office will transfer into a 10% decrease in

occupier demand (BNP Paribas Real Estate 2020b). Therefore, the actual impact on demand is yet to be determined. Also, the long-term development of the office space segment depends on the industry's ability to adapt to the increasing demand for environmentally friendly spaces. A key risk factor is that new building developments cannot meet long-term environmental requirements, necessitating re-development in the future.

Retail

Retail REs are properties that are solely utilized for the purpose of marketing and selling consumer services and goods (Gilmour 2019). Investment volume in the retail sector decreased by 17% from 2019 to 2020, arriving at €37 billion in 2020, the lowest value since 2012 (BNP Paribas Real Estate 2020d). The majority of the investment volume, roughly 32.5%, is directed to Germany, while 2.5% flows to Portugal (BNP Paribas Real Estate 2020d). In Europe, high street prime rents are deemed a key indicator for the industry. It shows the highest rental value for a top trading location, such as the Avenida da Liberdade, in Lisbon (BNP Paribas Real Estate 2020d). Differences between countries and cities across Europe are large. Average high street prime rents range from €135 per month per sqm in Lisbon to €300 in Berlin and peak at €1,986 in London (BNP Paribas Real Estate 2020d). A central challenge of the industry is to adapt to the Covid-19 pandemic and its corresponding changes in customer behavior. It is feared that consumers' shift to online shopping could be constant, especially due to the surge of online grocery buying and e-commerce (BNP Paribas Real Estate 2021c). However, BNP Paribas Real Estate observes a strong correlation between retail sales and consumer immobility caused by, for example, national lockdowns. It becomes clear that retail sales strongly rebounded after each mobility shock, emphasizing that decline in demand is primarily attributable to external shocks rather than general changes in customer behavior (Appendix III). This is further underlined by the fact that 74% of consumers in the EU and the US prefer to buy products in local stores or collect them in-store (Uberall 2021). Another positive outlook for the industry is

the consumers' trend towards sustainability. Social and environmental costs associated with online shopping and returns are high. The growing importance of environmental friendliness for consumers could decelerate the advancement of e-commerce and yield an opportunity for traditional retailing (BNP Paribas Real Estate 2021c).

Logistics

The logistics RE market can be defined as facilities related to distribution, warehousing, industrial, and commerce-related system such as fulfillment centers (BNP Paribas Real Estate 2021b). The logistics market is a critical part of the industry, supporting most commerce activities of a country. The rise of e-commerce and the importance of supply chains have only increased the forecasting of its market size (JLL 2021). Fueled by this exponential growth, the European logistics sector saw a 30% year-over-year increase between Q1 2020 and Q2 2021, with over $53 billion injected in 2021. This makes the logistics sector the biggest after the residential market and one of the best performers during the Covid-19 pandemic (BNP Paribas Real Estate 2021a; Savills 2020).

Furthermore, BNP Paribas Real Estate (2021b) also pointed out that the logistics and industrial sector is slowly catching up with the others in market share. This is a result of strong and resilient growth, which saw investments go up by 400%, whereas the market share increased by 100% over the last decade. This market share was deducted from the office and retail segment of the RE industry, resulting in increased investment volume by 9% in 2021. As such, the average rental growth is expected to increase between 1-2% each year until 2025 (BNP Paribas Real Estate 2021a).

The Covid-19 pandemic highlighted the logistics sector’s demand for warehouses and commercial buildings’ focus shift from international distribution to regional (BNP Paribas Real Estate 2021b). As a result, higher demand not being met by the lower supply and higher domestic warehouse demand resulted in many central European countries benefiting from rising

returns on investment (JLL 2021). Over the coming years, this demand is expected to continue rising, led by the rapid technological adaptation in supply chains and distributors globally. Followed by the residential sector, BNP Paribas Real Estate's forecast (2021b) also points out the logistic sector as having an impressive potential for rental growth in the mid-long term.

While the future of the logistics market remains bright, the manufacturing and industrial sectors of the logistics market can face uncertainties and risks. These risks include the interruption caused by new restrictions and lockdowns. This disrupts the demand, leading to supply chain issues (BNP Paribas Real Estate 2021c).

Residential

The residential RE market is composed of apartments, homes (family and single), villas, and various other housing projects such as student residences. It is also the largest sector in the global RE industry, with a value of over $258 trillion, an increase of 8% from 2019. In addition, this sector accounted for about 79% of the world's value of RE in 2020 (Savills 2021). While the Covid-19 pandemic saw major lockdowns, most European countries witnessed a surge in demand for houses during the later stages of the pandemic. A factor for this growth can be since governments across the globe, in the wake of the pandemic, have reduced interest rates. This resulted in more people being able to afford to buy homes (PwC 2021). This demand, driven by urbanization, is increasing house prices in urban, suburban, and medium cities.

Along with a change in demand, a change in consumer trends was also experienced. According to Savills (2020), buyers are stressing the importance of bigger living rooms and the availability of a workstation since more people are willing to work from home (Savills 2020). Supply and demand play a major role in fixing the prices of homes. Therefore, as the demand for newly refurbished apartments is currently outpacing the supply, this is leading to a rise in housing prices in major economic hubs such as Berlin, Paris, and London (PwC 2021; Savills 2020).

Additionally, homeownership across Europe has increased over the last decade for reasons such as lower average cost of housing, and low-interest rates, giving people a higher buying power. In addition to high homeownership levels, residential rents across Europe have also been on a steady rise over the last couple of years (BNP Paribas Real Estate 2021b). Countries like Spain and Ireland have experienced rents rising by over 40% since 2015, with the low supply unable to keep up with demand. As such, it is crucial to understand that what is driving demand are not exclusively families or individuals. A vast majority of house purchases are made by institutional investors aiming to diversify or enlarge their portfolios. The reason for this consists of historically high returns and appreciation of properties. Based on BNP Paribas Real Estate's (2021b) estimation, the average return on investment in Europe, adjusted to risks, is 8.8% for half a decade. This return may foresee a further increase to 25% of Europe's combined investment numbers in the residential RE sector.

In terms of forecast, BNP Paribas Real Estate (2021a) expects higher demand in city outskirts due to increasing demand for bigger houses while being closer to their workplaces. This strong demand also increases the growth of projects that aim to Build-to-Rent or simply construct and rent out to short & long-term tenants. Secondly, rising short-term rents may simply be a temporary trend if vaccination programs reach their goal, allowing tourism back to previous levels. These rising rents and house prices in Europe are shown in Appendix IV.

Given the differences in each RE industry segment, the focus of this paper will reside on the residential sector. Various characteristics such as its high return on investments, resiliency during the Covid-19 pandemic, and increasing demand forecasted suggest a strong outlook for the future (BNP Paribas REIM 2021). Additionally, the fact that the residential market is due for technological advancements points to the sector's high growth potential for the coming years (BNP Paribas REIM 2021). Moreover, given that the residential sector is very liquid,

opportunities for companies to establish themselves as industry leaders can further lead to competition. Consequently, driving the need for innovation.

2.2.3 Competition in the European RE brokerage

The European market for RE brokerage is characterized by its fragmentation and competition. This can be primarily traced back to the low barriers of entry and its high numbers of market participants (Barwick and Wong 2019). According to Eurostat (2021), the total number of RE agencies in the EU28 was 286,841 in 2018, as compared to 233,844 agencies in 2011. In 2015, this corresponded to an average of 0.55 RE agencies per 1,000 inhabitants across the EU28 states (Eurostat 2021; Europa.eu 2021). In a report issued by the European Commission (2018), National Competent Authorities in the EU were surveyed regarding market competition in their respective country. While 17% indicated a "very competitive" market structure, the majority of interviewees (56%) indicated "quite competitive". Surprisingly, zero respondents replied “not competitive”, but 28% stated “not applicable”. An additional survey conducted within the scope of this report found that one property is usually marketed by two or more RE agencies. Consequently, the level of competition in the RE market is further promoted (European Commission 2018).

Competition in the European market is further intensified by increased internet adoption of customers. According to Inmanns (2018), the internet has become the buyer’s de facto broker. This tendency is best underlined by the fact that in 2018 89% of buyers started with an internet search before contacting a buying agent compared to 43% in 2003 (NAR 2018). This trend has severe implications on the relevance of modern RE brokers. For instance, the percentage of households that first discovered their house with a RE agent dropped from 50% in 1997 to 33% in 2015 (NAR 2015). As postulated by the National Association of Realtors (2020), the share of home buyers who used the internet to search for a home increased to an all-time high of 97

percent. Another contributing factor to RE competition is the availability of real-estate information on the internet. This data was previously held exclusively by professionals but is nowadays free accessible. Relevant data points are, for example, property values, historical sale prices, property features, or number of houses on the market. While this data is scattered across the various available platforms in Europe, it is bundled in the Multiple Listing Service (MLS) in the US.

2.3 Covid-19 impact on RE

In late 2019, the world was impacted by a global pandemic, described as a black swan event with a substantial negative impact on the economy (Yarovaya, Matkovskyy, and Jalan 2022). This event disrupted industries worldwide (Haydon and Kumar 2020). The Covid-19 outbreak forced governments to install "stay-at-home" policies, locking down billions of the world's population. Daily activities and business stopped as waves of infections appeared, causing most countries' GDP to decline (Uchehara et al. 2020). Contrarily to past crises, after which demand and preferences soon returned to normal, Covid-19 impacts are expected to be much stronger.

What is now known as "the new normal" brings up changes affecting all sectors and long-term instability affecting industries' performance (Uchehara et al. 2020). The RE industry is no exception to the rule. Covid-19 has reshaped the way business is done, and RE professionals will have to adapt their business in the face of the changes caused by the pandemic.

2.3.1 Short-term challenges

Covid-19 has altered the life of billions of people, as people's daily routines changed. Massive lockdowns were marked by empty streets and closed businesses, and few stores continued operations (Gujral et al. 2020). Other than some essential services, businesses' revenue momentarily ceased to exist, which inevitably led to extensive lay-offs and business

failures. Consequently, this brought much uncertainty to people's lives. People started being more cautious about how they spent their money (Balasubramanian 2021). The uncertainty and fright of the future due to the pandemic led citizens to start rationalizing purchases more than ever. In the short-term, this led to a decrease of more than 30% of existing home sales (Balemi, Füss, and Weigand 2021). According to D'Lima, Lopez, and Pradhan (2020), this sudden decline happened not only due to decreases in demand but also in supply. On the one hand, buyers had less purchasing power, and they were also unable to perform optimal house searches due to restrictions and safety concerns regarding physical visits. On the other hand, the decrease in transactions was also explained by suppliers' risk aversion in selling houses in the uncertain Covid-19 market (D'Lima, Lopez, and Pradhan 2020).

Along with this, RE companies had to mitigate the health risks associated with physical visits. This factor represented a challenge, as physical tours are an important and decisive factor in the purchasing journey, and buyers wanted their safety guaranteed (Gujral et al. 2020). This also constitutes a long-term challenge, as people move towards e-commerce and demand superior experiences through safe online channels.

2.3.2 Long-term challenges

Covid-19 effects on the RE industry are more than just an immediate challenge. Adding to the short-term decrease in demand, the unprecedented crisis also brought lasting changes in customer behavior. These changes will, in turn, cause the need for long-term changes in the RE business itself (Gujral et al. 2020).

One of the leading lifestyle changes due to Covid-19 was increased work from home. The urge for social distancing decreased the necessity of commutes to the office (Ramani and Bloom 2021). This experience with "smart working" made people realize the lack of space in their homes (Billio and Varotto 2020). There was also a shift in demand from city centers towards

the suburbs (Ramani and Bloom 2021). After the early pandemic impacts, people see the benefits of living away from crowded cities and prefer options such as quiet suburbs, replete of social distancing, and outside spaces (Taylor 2020). Consequently, demand is expected to increase with the search for bigger suburban houses (Billio and Varotto 2020). Although households are increasingly cautious with the way they spend their money, low interest rates, together with preferred social distancing, are increasing the desire for privately owned homes (Balemi, Füss, and Weigand 2021).

Additionally, Covid-19 accelerated technological transition and digitalization. People were already performing online purchases, but with the closure of shopping centers midst pandemic, even consumers resistant to change were forced to adopt e-commerce. While more customers shifted buying habits towards the digital world, RE brokers also started to increase digital presence (Marona and Tomal 2020). According to Marona and Tomal (2020), who conducted a survey with RE brokers in 2020, 60% of professionals confirmed to devote more time to the digital world after Covid-19. Market players felt the need to digitize and provide more distinctive experiences to their online clients (Gujral et al. 2020). This move towards online commerce also represents a solution for safety concerns. The most intelligent players will perceive this change as permanent and adapt their long-term strategy. This can be done while deepening relationships with stakeholders, increasing transparency, efficiency, and resilience for future events (Balemi, Füss, and Weigand 2021).

Given this, the economic slowdown is not expected to last long-term. However, Sulaiman et al. (2020) inform that RE is one of the industries most affected by this worldwide disease and changes caused. Real estate companies will have to adapt their service to new customer demands and with new strategies in mind. According to Billio and Varotto (2020), the change in the industry resulting from the pandemic will be characterized by the adoption of current futuristic trends and innovation.

2.4 An Overview on Innovation

The challenges created by Covid-19 increased the pressure and need for innovation in RE. Innovation in the RE sector is simultaneously driven by the need to streamline procedures, improve customer experience, and enhance relationships between stakeholders (Maarbani 2017). Researchers have defined "innovation" as the generation of a new idea or the acquisition of new knowledge and its implementation into a new product, service, or process (Kogabayev and Maziliauskas 2017; Afuah 1998). In general, it is known as developing something new to the market and should benefit both the company and its stakeholders (Wong, Tjosvold, and Liu 2009). On the one hand, the new idea must answer a market need or a change in customer demands or lifestyle (Baregheh, Rowley, and Sambrook 2009). However, according to Kogabayev and Maziliauskas (2017), innovation is also about optimizing processes, maximizing profits, increasing efficiency, and companies' economic growth. Finally, it is not a punctual phenomenon but a long-term process that develops over time and involves changes and decision-making processes (Castro et al. 2010).

To survive in the new dynamic business environment, companies must constantly innovate, adapt and respond to changes in the industry (Danneels 2002). Companies that keep developing new offerings targeted to the needs of the market and the desires of customers are more likely to grow in the market (Gault 2018; Bytyqi 2014). To understand how the global and regional RE market will evolve, it is important to look into the past and analyze RE trends and developments to get a better market overview.

2.5 Trends in Real Estate

The following literature review seeks the reasoning behind major trends in the market and their influence in terms of innovations and improvements. These trends can provide an outlook on how the current state of the market might develop and how technological and human

advancements will play out in the future. The two major influential factors in the European residential RE market were identified as demographical and technological shifts in the industry.

2.5.1 Demographic factors

A geographical migration's effects on the RE markets worldwide can be profound. It can lead to a major transformation in global demographics and changes in a country's demand and supply for housing. As such, a demographic trend in the RE market can be linked with migrations across the world. The first industrial revolution resulted in a mass geographical migration due to increasing manufacturing, services, and technological advancements in various cities. This resulted in increased job creation and a much better quality of life (Çağlar 2014). Urbanization undeniably led to an increase in prices for urban and suburban houses. Recently, this demand was pushed even further by the Covid-19 pandemic all around the world, and it is expected to increase further (Savills 2020; MarketLine 2021b). Based on a report by the United Nations (2018), Europe is expected to reach 80% of its population living in cities or urban areas by 2030, which represents an increase of 10%. In terms of potential, human migration plays and will most likely continue playing a crucial role in defining a country's supply and demand for residential housing (Parker et al. 2018).

Furthermore, a study by Parker et al. (2018), reveals that the change in demand and supply for housing can be greatly affected by the population structure of a country. As higher urbanization leads to higher urban demand, it is no surprise that with higher population comes higher demand. As a result, most countries in Europe experienced increasing house and rent prices over the last decade (Eurostat 2021). For a large share of the population moving around and working from abroad, a rental system is highly preferred over having owned houses in terms of financial ability. This happens because purchasing a home usually takes up a large proportion of one's disposable income (MarketLine 2021). This scenario can be linked with the

rising tenancy ratios in Europe. One of the biggest tenant ratios in Europe is in Germany, with almost 50% of the houses occupied by rental (BNP Paribas Real Estate 2021c). This rising tenancy has pushed rental prices even further in cities like Berlin, indicating a willingness to rent over buying, thus changing the demand further.

Along with the population structure, the development within an economy contributes greatly to demand and supply change. Research by MarketLine (2020) indicates that in developing economies, people prefer to live less in rental houses compared to the higher number in developed economies. Similarly, developing economies would face lower regulations such as rent control in the industry by their own government versus a typically high intervention for developed economies. This is due to various internal and external factors, such as the geopolitical risks involved and the demographic structure of an economy (PWC 2021). From a customer point of view, government-driven rent control rules and regulations may be beneficial for various countries. For example, the introduction of affordable housing in numerous cities has allowed more people to rent homes and at lower prices in European cities (MarketLine 2021). However, from an organizational point of view, rent control may contribute to higher rivalry between players in the market, leading to lower rental returns due to various government programs in place. As a result, rent control may contribute to lower evictions, thus less people forced to reallocate, leading to lower geographical migrations (Pastor et al. 2018).

As part of demographics, each country may attract investors from different countries due to differences within an economy. Portugal, for example, saw a massive inflow of foreign money over the last couple of years. Programs like the Golden Visa allowed foreigners to obtain Portuguese citizenship by investing a certain amount of money into the country's RE sector and holding it for approximately five years (SEF 2021). This program has led to one of the highest investments from all over Europe. Foreigners from China, Brazil, Turkey, and United States were among the most contributing investors, respectively, with over €5.8 billion invested since

2012 (SEF 2021). Additionally, the EU Next Gen Programme has allowed for further inflow and purchases into the economy. The factors above have led to a higher demand coupled with a lower supply of houses in Portugal, leading to much higher prices to rent and purchase homes. With such high prices in capitals and major cities, the demand for suburban houses has steadily increased across Europe, and the pandemic has additionally pushed this demand higher (BNP Paribas Real Estate 2021a).

All in all, over the last decades, human migration, population change, and economic attractiveness have contributed to a change in housing supply and demand. Thus, resulting in the rise of house and rental prices, foreign investments, and the introduction of various policies to control pricing dynamics.

2.5.2 Technological factors

Another major trend identified in the RE industry is the growing influence of technological advancements such as the rise of PropTech. PropTech is an acronym for Property Technologies. It can be defined as the technologically driven evolutions occurring in the RE sector to improve efficiency (ING Economics Department 2018). PropTech, in general, encompasses various emerging and potentially disruptive technologies, such as Virtual Reality, Augmented Reality, drones, Blockchain, and Internet-of-Things-enabled sensors or appliances (Siniak et al. 2020). According to Braesemann and Baum (2020), the concept of PropTech can be categorized into the following three tiers: PropTech 1.0, PropTech 2.0, and PropTech 3.0.

PropTech 1.0, or the first wave of PropTech emerged after 1970, when the first personal computer and its powerful future-oriented potential was unveiled, showcasing what data can be used for. Eventually, this wave of digitization was interrupted by the dot-com bubble burst in 2000 (Siniak et al. 2020). Although this wave mainly occurred in the US and UK, it also birthed online platforms, e-commerce, and various other services (Baum 2017; Shaw 2018).

PropTech 2.0's rise in 2007-2008 resulted in the mass availability of data online. This wave led to the rise of smartphones, cellular and mobile technologies, cloud computing and big data (Braesemann and Baum 2020). PropTech companies such as Airbnb, Zillow and OpenDoor are redefining our interaction in the RE market while showcasing the power of Artificial Intelligence (AI) and Big Data. This second wave witnessed companies like Airbnb adapting to the significant changes in technological adoption, experienced around 2008. This change happened through property management software, architectural platforms, and the increased implementation of FinTech transactions in the marketplace (Braesemann and Baum 2020). This innovative wave also saw the conceptual birth of smart houses, smart cities, and IoT-enabled devices. Additionally, while urbanization increased the demand for residential development, the implementation of PropTech 2.0 also included an increasing trend in sustainability (Baum et al. 2020). Additionally, work by Shaw (2018) has observed that PropTech 2.0 experienced a massive inflow of money worth over $12 billion in 2018 invested into this wave of innovation. This investment represented an increase of over $5 billion from 2017, showcasing higher confidence in these technologies year over year. Undeniably, this digitized growth has empowered the purchase and sale of houses at a much faster rate using online marketplaces and platforms. Throughout PropTech 2.0, a benefit to users (renter/leaser) is a more simplified, yet smarter search element (ING Economics Department 2018).

PropTech 3.0 or the third wave, quickly introduced further innovation into the industry from 2014 onwards (JLL 2018). It allowed disruptive technologies like 3D printing, Machine Learning (ML), Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), drones, smart contracts and Blockchain to come to life. This wave brings simplified transactions and improvements in customer experience while making the most of available data (Baum 2017). Since the RE industry is slow to evolve, the wide-scale applications of these emerging techs remain distant yet inevitable (Braesemann and Baum, 2020). Baum (2017) also argues

that although PropTech 3.0 is not implemented yet, AI and Blockchain may be the biggest winners of this wave, with real possibilities to disrupt the industry. Moreover, Statista's (2020) research has shown that between 2008 and 2018, PropTech companies' investments multiplied from less than $1 billion to over $18 billion. This number is expected to continue growing, with most of the funding coming from the US. While PropTech is still focused on growing economies like China, India, North America and, certain cities in Europe, its widespread capabilities may take time to develop further (Kasprzak 2015).

The rise of these technologies has already sparked an evolution in various sectors such as transportation and agriculture. This transformation led to more efficiency, which allowed for reduced costs (Ullah, Sepasgozar, and Wang 2018). Such advancements can allow better management, planning, transactions, analytics, and marketing of properties. Consequently, this introduces more efficiency, autonomy, transparency, sustainability, and innovative ideas in the global RE market (Kasprzak 2015; Baum 2017).

The application of the mentioned technologies involved in PropTech can benefit tenants and owners of properties. Owners can benefit from the implementation of PropTech by potentially having higher added value on their properties through smart buildings while having better market information through the availability of data and AI (ING Economics Department 2018). Meanwhile, users and tenants can benefit from an enhanced market understanding. This can be achieved with search optimization and higher transparency in the market enabled by IoT, Blockchain, AI, and potentially more technologies.

What remains to be evaluated is how the RE industry can leverage technology and innovation. Additionally, it is essential to understand how the approach towards RE is altered while using technologies such as MLS, Blockchains, IoT, AR, and VR to innovate while keeping risks lower and opportunities high for all parties (ING Economics Department 2018).

2.6 Upcoming Real Estate Technologies

Within this section, eight technological developments for the RE industry are analyzed. This analysis follows the "Systematic Review of Smart Real Estate Technology" published by Ullah, Sepazgosar, and Wang in 2018. However, their proposed structure of the "Big 9 technologies" was adapted and enriched by external sources and expert opinions. As this paper's literature review established the importance of blockchain for the industry, it was incorporated in this review. Due to the limited applicability of wearables to the RE brokerage industry, it was removed from the list, and Software as a Service (SaaS) was integrated with Cloud technology. The analyzed technologies can be divided into three main categories: data mining technologies, networking tools, and data collection technologies.

2.6.1 Data Mining Technologies

Data mining refers to the systematic application of statistical methods to big data sets (IBM 2021). Its main target is to create links between different sets of data and to draw industry-relevant conclusions from its analysis. This yields several benefits that primarily support marketing and business intelligence efforts (Ester and Sander 2013). With regards to RE, it has already been applied to identify risk factors prematurely or to automize business forecasts (Ullah, Sepasgozar, and Wang 2018). Although data mining applications can be found in a variety of shapes, the focus of this research is on Big Data, AI & Robotics, and Clouds.

Big Data

The term Big Data describes the increasing availability of large amounts of data. Big data is defined as a collective phrase for massive and interconnected databases that need innovative software and processes to obtain relevant information (Winson-Geideman and Krause 2016). According to Chen and Lu (2018), most existing definitions for Big Data circulate around three features: processing speed, large data volume, and data coverage. According to the "2017 Big

Data and Analytics Forecast", Big Data total revenues are expected to accumulate to $99.4 billion in 2027, representing a CAGR of 12% between 2016 and 2027 (Gilbert 2017). Concerning RE brokerage, Big Data analytics primarily helps to understand market trends and customer behavior. Also, it saves brokers time because analyses do not have to be conducted manually and thus, it enables brokers to focus on their primary responsibilities (Ullah, Sepasgozar, and Wang 2018). Some companies, such as Zillow.com, Immobilienscout24.de, or casafari.pt adopted Big Data analytics already. They supply insights to customers such as buying price averages and forecasts, area developments, crime rates, or average time on the market (Zillow 2021; Immobilienscout24.de 2021). Therefore, Big Data analytics is considered beneficial to agents and consumers.

AI & Robotics

AI can be defined as the capability of machines to imitate human skills such as logical thinking, planning, learning, and creativity (European parliament 2021). Robotics uses AI by implementing it in modern robots, thus enabling them to solve complex problems without human interaction (Kehoe et al. 2015). The global market for AI is growing rapidly and industry revenues are expected to increase by approximately 1,250% between 2018 and 2025, eventually arriving at $126 billion in 2025 (Omdia 2020). It must also be mentioned that AI is expected to be responsible for the loss of more than 75 million jobs by 2022 (World Economic Forum 2018). However, AI is also expected to create 122 million jobs during the same time period but forcing employees into higher-skilled roles (World Economic Forum 2018). The net effects for the RE industry remain unknown at the moment. The applicability of AI and robotics within the RE industry is manifold. On the agent side, AI may be used to create 3D renderings of properties, do initial screenings of customers to save time, or improve targeting of marketing strategies (Ullah, Sepasgozar, and Wang 2018). Robotics could be used to do routine inspections and maintenance as well as cleaning and mowing of remote places (Warburton

2016). On the consumer side, AI can facilitate the search process with personalized filters, improve the matching process, save time, and reduce the probability of human errors (Ullah, Sepasgozar, and Wang 2018). Concrete examples for AI applications within the RE industry include selling price forecasts which were implemented in Italy (Morano, Tajani, and Torre 2015), machine-learning based selling and building decisions (Rafiei and Adeli 2015) as well as RE business predictions (Rossini 2000).

Blockchain

Although not part of Ullah, Sepazgosar, and Wang's "Systematic Review of Smart Real Estate Technology", experts believe that Blockchain has a major role to play in terms of innovative technologies in the RE industry (Baum 2017). As defined by IBM (2021), Blockchain technology is a digitally accessible database (or Distributed Ledger Technology) capable of recording, tracking, and verifying transactions. A key component of blockchain is its ledger functionality and the fact that transactions' details on the chain are tamper-proof, hence immutable. Additionally, Blockchain has the capability to run and store digitally automated contracts known as Smart Contracts.

According to Goldman Sachs (2016a), Blockchain technology can be applied to several industries in the economy. The financial sector is already a major winner due to Blockchain-enabled transactions that have saved the industry billions of dollars annually. The RE industry benefits from the transactional use of Blockchain and transforms its title registry process. Since Blockchain minimizes transaction costs and human mistakes, it is estimated that Blockchain could save between $2 and $4 billion in the United States alone by facilitating land transactions and registrations (Goldman Sachs 2016a).

Moreover, because Blockchain is a relatively new technology, experts do believe that a full-fledged implementation may take more time and bigger adoption if implemented right (Lansiti and Lakhani 2017). However, it is essential to note that the increasing market size for

Blockchain is seen as a major plus point for adoption. A study by Statista (2018) estimates that the global market size for Blockchain stood at $1.57 billion and is forecasted to hit over $160 billion by 2027. Europe has witnessed countries such as Spain implementing Blockchain-based transaction and land registry systems to improve on efficiency and security within the industry (JLL 2018). Additionally, to further drive Blockchain development into various fields, the European Commission has launched the "European Blockchain Partnership" that aims to increase communication and information exchange between European countries (European Commission 2021).

2.6.2 Networking Tools

Networking is the process of interchanging data through a shared network in an information system (Scarpati 2018). It allows users to share information through Local Area Networks (LAN) or Wide Area Networks (WAN). Applications in RE are widespread, including Customer Relationship Management (CRM) tools or building management platforms. Clouds and IoT were identified as the most relevant technological developments for the RE sector, which is why analysis is limited to these technologies.

Clouds

Over the past years, cloud technology started replacing traditional mediums of storage. While it was necessary to run local hardware-based data centers in the past, clouds are now enabling companies to retrieve data straight from the internet (Ullah, Sepasgozar, and Wang 2018). Following the definition of the National Institute of Standards and Technology (2011), cloud computing consists of five fundamental elements: On-demand self-service, broad network access, resource pooling, rapid elasticity, and measure service. The four service models associated with the usage of cloud computing are Infrastructure as a Service, Platform as a Service, Software as a Service (SaaS), and Function as a Service. SaaS is expected to account

for about 56% of total cloud computing revenues in 2025, thus representing the technology's most valuable sector in the medium-term (Statista 2021). It is based on the principle that software and IT infrastructure is operated by external service providers but can be licensed to customers using a subscription model. It provides a decentralized system that allows users to access it through the internet without major investments into privately-owned IT infrastructure (techopedia 2021). That is why the adoption of SaaS creates extensive cost savings and efficiency improvements for companies.

The Technology Market Outlook, conducted by Statista in August 2021, forecasts that the European cloud computing market will rise at a 20.8% CAGR over ten years. The market size is predicted to arrive at €135 billion in 2025 (Statista 2021). However, worldwide cloud adoption is enormously accelerated by the outbreak of the Covid-19 pandemic. In the "2021 State of the Cloud" study from Flexera, 90% of respondents indicated that cloud usage is now higher than it was initially planned before Covid-19. Within the RE domain, cloud computing offers benefits such as cost savings, flexibility, improved CRM, or increased collaboration. It can also improve transparency and communication, thereby solving the information asymmetry between brokers and clients (Stantchev and Tamm 2012). A concrete example for cloud usage in RE is the German company FlowFact which provides a fully cloud-based CRM and marketing tool for agents (FlowFact 2021). More industry examples include Spaceflow, an innovative building management tool to improve the tenants' experience (Spaceflow 2021), or ShowingTime, a showing management tool that also provides market statistics (ShowingTime 2021).

IoT

Internet of Things (IoT) is a network that connects people and the objects around them (Vailshery 2021). It is a technology that enables innovation in most businesses by transforming ecosystems and enabling faster and stronger connectivity between people and IoT devices. This

results in instant data analysis and consequently "smart action" (Deloitte 2017). IoT has numerous applications, most of which have to do with monitoring something tangible, such as the environment, health, industrial processes, customer experience, and even project performance (Chen et al. 2014; Nord, Koohang, and Paliszkiewicz 2019). Furthermore, addition to monitoring, IoT enables the management of fleets, home care, agriculture, logistics, and energy, where it is more than just a smart device but also a service provider (Chen et al. 2014; Bouguettaya et al. 2021).

IoT is growing rapidly and gaining traction among executives who consider it more relevant than AI or robotics (Nord, Koohang, and Paliszkiewicz 2019). As of May 2020, 2,552 thousand companies in Europe have invested in IoT, and the number of IoT platforms has doubled to 620 globally from 2015 to 2019 (Vailshery 2021; Liu 2021). In 2020, total investment reached US$749 billion and is expected to increase to around US$1.1 trillion by 2023 (Vailshery 2021).

IoT can influence RE in several ways. The building of smart houses creates more connected properties, with personalized accessibility, time management, and energy savings, increasing customer convenience (Demir and Ventura 2021). Additionally, it has applications in business decisions in RE. It can be used in office spaces by gathering information about employee wellbeing, productivity, and innovation. IoT can aid businesses investment decisions and optimize operational efficiency (Napp and Ribeiro 2020). Several companies such as MAPIQ and Maps people, are working with businesses to create adaptable solutions to transform the office space into a more productive place through smart technology (MAPIQ 2021; Mapspeople 2021).

2.6.3 Data Collection Technologies

Data collection technologies are physical tools that support users in gathering and modeling data. The applicability within the RE sector is vast. It includes areas such as digital storytelling

through AR, real-time synchronization of virtual and analog data, and autonomous control (Ullah, Sepasgozar, and Wang 2018). While a multitude of technologies exists, this review discusses drones, 3D Scanning, and VR & AR.

Drones

Drones are formally described as unmanned aerial vehicles (UAVs) (Techtarget 2019). They can be operated remotely and are usually equipped with high-resolution cameras within the context of RE. Drones may be applied to take aerial pictures of properties to improve product marketing and give customers more detailed information. Consequently, clients profit from increased transparency and reduced post-purchase regrets (Ullah, Sepasgozar and Wang 2018). Firms of any size can adopt drone technology as it requires limited upfront investment (CompTIA 2019). Real Estate companies in the US are among the top three hiring industries for drone talent, underlining the relevance to the sector (CompTIA 2019). According to a study from Kuzma et al. (2017), drone adoption in RE was already at 52% in France and 48% in the UK, Germany lacking behind with only a 24% adoption rate. Prominent examples in the RE industry are Betterview, which conducts drone-based property inspections, or Pix4D S.A., which creates exact maps and models only from drone pictures (PWC 2018).

3D Scanning

3D Scanning is one of the most recent technological developments among the Big 8 technologies. By using mobile or hand-held scanners, often equipped with laser scanning technologies, multi-dimensional models can be created, and information can be stored (Sepasgozar, Forsythe, and Shirowzhan 2016). This facilitates RE management regarding maintenance and supports the RE broker in the marketing process. The corresponding improvement in the quality of RE objects' information is beneficial to all parties involved, including proprietors, clients and, RE brokers (Ullah, Sepasgozar, and Wang 2018). Arrival3D is an example of a 3D modeling agency that creates multi-dimensional models (Arrival3D

2021). Matterport, a pioneer in the industry, combines 3D scanning with VR and AR functionalities, providing brokers with a full-stack 3D data platform (Matterport 2021).

VR & AR

While VR is a technology that completely immerses users in a virtual, computer-generated world, AR adds to the real world by projecting virtual objects into real environments (Carmigniani and Furht 2011). These technologies have a unique potential regarding improvements in RE customer experience. Some applications include virtual home tours, improvements in housing advertising, and more efficient communication between brokers and buyers (Tawania and Rao 2020). The RE industry is perceived as one of the most impacted by AR and VR, with a projection to reach at least $80 billion by 2025 (Ullah, Sepasgozar, and Wang 2018). According to Goldman Sachs (2016b), luxury RE agency Sotheby's is already providing virtual home tours to its customers since 2016, allowing for increased sales efficiency.

2.7 Disintermediation and Digital Platforms

The discussed technological developments possess the potential to disrupt the RE industry. However, these technologies need to be implemented on digital platforms to add value for landlords, buyers, and brokers. Currently, several digital platform models are competing in the market. By analyzing the peculiarities of each approach, a future outlook on the position of the RE broker in a dynamic environment is provided.

This is relevant because the broker’s profession was expected to become extinct with the rise of information and communications technology (ICT) the internet marketing revolution in the mid-1990s (Saiz 2019). Even though many professions, such as travel agents, suffered immensely from disintermediation, it rarely affected the RE industry (Wigand 2020). As a matter of fact, FSBO rates are today lower than ever before, and some types of digital platforms

are cooperating with agents rather than competing with them (National Association of Realtors 2018). Every year, new PropTech start-ups enter the RE market. Only in 2019, $8.9 billion was invested in RE start-ups, funding more than 500 companies (CB Insights 2020). Hence, considerable differences exist between platforms regarding business models, commission fees, and integration of RE brokers. After conducting a market analysis and literature review, existing platforms for RE brokerage were divided into four categories: digital marketplaces, MLSs, hybrid platforms, and FSBOs. While hybrids and FSBOs aim to disintermediate brokers, digital marketplaces and MLSs focus on re-intermediating brokers (Schlotawa 2018; Barwick and Wong 2019). In most European countries, digital marketplaces are predominant, but hybrid platforms are on the rise, imposing a real threat to brokers (Handelsblatt 2019; Hunziker 2017).

It is feared by industry experts that the PropTech 3.0 wave will lead to massive job losses in RE brokerage (Saiz 2021). Thus, it is essential for brokers, investors, and PropTech companies to understand and monitor industry developments closely. According to Levy and Murnane (2013), adaptation and retraining is the only chance of survival for intermediaries in the future.

3 Individual Contributions

What remains to be evaluated is how these technologies can effectively be implemented on innovative RE platforms and the impacts caused by this implementation. Following this research, individual contributions focus on four disruptive trends and their impact in the RE industry. The first individual contribution was created by Nadine Santos, exploring "The Impact of Augmented and Virtual Reality in Real Estate Customer Experience". Maria João Primitivo produced the second research on "IoT as a Sustainable Solution". This is followed by an elaboration on "The impact of Blockchain and Smart Contracts on the Real Estate Industry",

composed by Nabil Bardai. The fourth and last individual contribution was written by Jan Schmidt, exploring "The Future of Real Estate Platform Models and the Role of the Broker".

4 Methodology

To address the research topics, primary data was collected through two distinct Microsoft Forms online surveys. The first survey assessed the RE brokers' perspective and was directed towards European RE agents and brokers. This survey was distributed mainly through email, but social networks such as LinkedIn were also used. The second survey approached the end-customer perspective, and it was targeted at European residential RE buyers and potential customers. The objective consisted in understanding users' perceptions of the three technologies being studied – VR/AR, IoT, and Blockchain – when applied to RE. Distribution channels included social networks such as Facebook, WhatsApp, and LinkedIn. The software Microsoft Excel was used as the statistical analysis tool for the data collected.

Concerning the methods used to evaluate each question, several scales were applied. The first one to mention is the Customer Satisfaction Index (CSI). CSI consists of assessing how satisfied customers are with a company or product, and the rating goes from "Extremely dissatisfied" to "Extremely satisfied" (Eskelinen 2020). In addition, a Likert rating scale was used. This scale resides in evaluating the level of agreement respondents have with specific statements, in a rating from 1 to 5, ranging from "Strongly disagree" to "Strongly agree" (Albaum 1997). Additionally, some questions were evaluated through the Net Promoter Score (NPS), which measures the willingness of a customer to promote a specific product, technology, or company to others. It is evaluated on a scale from 0-10, and respondents are classified as detractors (0-6), passives (7-8), or promoters (9-10) (Reichheld 2003).

Apart from quantitative research methods, qualitative methods were applied too. Expert interviews were conducted with both industry professionals and academic experts. Experts were

contacted via email, LinkedIn, and the authors' network. The interviews complement the findings from the literature review and the study by indicating the future development of RE platforms in Europe.

5 Results

Regarding the *"End-Customer Perspective"* survey, there were 161 responses collected. Of these 161, only 159 were considered valid because they accepted the terms and conditions. The survey was distributed to people of different ages, nationalities, and countries of residence. Around 66.7% of the respondents are between 18 and 26 years old, while the remaining 34% are distributed in the age groups over 26 (27-35, 13.8%; 36-44, 9.4%; 45-53, 5.7%; 55-62, 3.8%; over 62, 0.6%). Approximately 77.4% of the respondents are Portuguese, 11.3% are German, 3.1% are Italian, and the remaining 8.2% are evenly distributed among Arab, Belgian, Belarusian, Brazilian, Canadian, Chinese, English, French, Ghanaian, Mozambican, Polish, Venezuelan and Tuvaluan nationalities. Except for one respondent living in Tuvalu, all others live in European territory, with 79.9% living in Portugal.

There were 58 valid responses to the *"Real Estate Broker Perspective"* survey. The survey was distributed to individuals of multiple age groups, countries of residence, and roles in the RE industry. Around 36.2% of the respondents are between 45 and 53 years old, 24.1% are between 36 and 44 years old, 20.7% are between 54 and 62 years old, 10.3% are between 27 and 35 years old, 5.2% are between 18 and 26 years old and 3.4% are over 62 years old. In terms of country of current residence, approximately 82.8% live in Portugal, and the remaining 17.2% live in Germany. The majority of respondents are RE brokers (77.6%). About 12.1% are company owners, and both respondents from HR and managing directors make up 3.4% of each of the samples in this survey. The other 3.4% are equally divided into sales managers and marketing managers.

Further results from these surveys are presented in each members' individual contribution according to their relevance for the technology being analyzed.

6 The Impact of Blockchain and Smart Contracts on the Real Estate Experience- *by Nabil Bardai*

Introduction

The adoption of Blockchain in the financial services, healthcare, and manufacturing (supply chain) industries have already begun. This shift has allowed several efficiencies while mitigating risk and maximizing industry performance. Although numerous industries seem to have already embraced the rise of digitalization and technological advancement, the real estate (RE) industry is still in the early stages of such a change in dynamics (Baum 2017). The RE industry, like many others, has several aspects that need improvement such as the process of buying or selling a property. Currently, the real estate industry still lacks accuracy, transparency, trust, and the need to innovate in order to stay in the market. Therefore, this gap can be filled by integrating Blockchain and smart contracts (Lifthrasir 2018).

While Blockchain has demonstrated some of its exciting yet disruptive potential in various industries, this paper will focus on the importance of implementing Blockchain and smart contracts for the real estate industry. However, there are numerous areas where Blockchain could be improved, such as its regulations and public perception. Its new emergence and broad applications need to further be explored. Although Blockchain has been gaining global momentum, this adoption is growing. Thus, the following research question will be answered:

"To what extent can Blockchain and Smart Contracts revolutionize the real estate industry?".

This paper is organized as follows. First, **Section 2** briefly analyses the real estate industry with its flaws and opportunities. Through a literature review, **Section 3** will analyse the technical aspects of Blockchain and Smart Contracts, their components, and their applications in the RE industry. Additionally, **Section 3** will highlight the advantages and disadvantages of the technologies. Furthermore, **Section 4** will debate and analyse the discussion based on the literature review. **Section 5** will evaluate Smart Contracts and Blockchain review, followed by a conclusion in **Section 6.**

Literature Review

Existing Problems in The Real Estate Industry

As discussed in earlier, the shift in trend from PropTech 1.0 to PropTech 3.0 is evidence that exogenous technologies and RE can go hand in hand in laying the foundation for a digitally adapting RE market. The pressure on the RE industry to embrace technological change to succeed and make everyday life easier is high. Nevertheless, there are numerous fundamentals in the RE industry that can be optimized to ensure a smooth process overall. The following section will identify flaws in the RE market that can potentially be solved by implementing Blockchain and Smart Contracts as a foundation.

Currently, the process of buying or selling a property is time-consuming and requires a plethora of documents to be prepared and verified. This process can end up taking months as it involves going through brokers, financial intermediaries or banks, notaries, government agencies, lawyers, escrow services, and possibly more parties (European Law Firm 2012; Bosak, Mayer, and Vogel 2007). Since numerous parties are involved, each entity may hold information in different places, possibly creating inaccuracies, fraud, and slowing down the process (Lifthrasir 2018). Additionally, this procedure involves paying a hefty sum in taxes, fees and other third-party commissions which may take up a vast portion of the transaction,

thus increasing the initial cost. A study by Goldman Sachs (2016) points to an expense of $3.6 billion towards agent commissions in 2016 for the United States. The same study shows this number can be cut down to $2.9 billion using Blockchain based transactions and title issuance, saving over $700 million in one year. Therefore, highlighting the need for disintermediation in the real estate industry (Goldman Sachs 2016; Lifthrasir 2018).

Another problem for numerous countries within the RE industry is the flawed process of land registry. With the increasing world population and rising number of houses built, land rights and problems surrounding it need to be solved. A study by the World Bank (2017) highlights the fact that underdeveloped countries generally have relatively low property rights compared to developing ones. The same study shows that over 70% of the world's population lacks a "legally registered" deed/title for their land or property (World Bank 2017). Since government agencies do not have precise knowledge or information, people are still unaware of their land registry and land rights. Additionally, accurate data on land registry is difficult to obtain and can vary from one source to the other, resulting in higher inaccuracy (Casafari 2021). A good system of land registration would result in much higher convenience and transparency while increasing growth and productivity within an economy. Thus, pointing at the need for a reliable and public database that can eventually increase stability in a market (Klaus 2003).

Furthermore, the real estate industry in many countries has lower transparency in terms of information management. Brokers can access information the public does not have, such as past transactions in a specific city or country (Dijkstra 2017). As such, JLL (2020)'s report on Global Real Estate Transparency Index aims to evaluate over 100 countries based on performance, legal frameworks and transaction procedures. This index suggests that the relationship between a transparent country and investment volume is relatively high (JLL 2020). Countries moving up to the "highly transparency" list from "opaque", are leveraging on PropTech and new sustainability solutions allowing for improved transparency to attract more investors.

Suggesting that with today's greater need for public availability of information, the pressure to push companies and governments to make information public is on the rise (Deloitte 2017).

Various governments worldwide have investigated the possibility of integrating Blockchain and smart contracts into their system to mitigate risks associated with a low registry of houses. These risks can include the high probability of fraudulent activities (Lifthrasir 2016). Countries like Sweden, and the Netherlands are among a few to have implemented land transfer and registry processes through smart contracts (Mcmurren, Young, and Verhulst 2018; ABN AMRO 2017). This resulted in increased transparency of the market as well as a more efficient system of management, allowing faster buying and selling of properties. Consequently, this process led to lower information asymmetry since all parties involved could observe the complete transaction progress in real-time (Mcmurren, Young, and Verhulst 2018).

Overall, the RE industry's land registry and transactions process show the need to evolve. The pain points have been identified, suggesting the need to build better trust and transparency between all parties involved. The various problem mentioned still plague the industry to be disorganized, hence pressure arises to improve the processes involved and seek better alternatives (Lifthrasir 2018). Given that over half of the world still lacks proper land titles and registration, the convenience leveraged from Blockchain can be substantial.

Blockchain

Blockchain definition and technical functionality

The term "blockchain" often goes hand in hand with Bitcoin, but it is paramount to understand the difference between these two terms. Blockchain is the underlying technology that powers Bitcoin, whereas Bitcoin is a digital currency powered by Blockchain (Deloitte 2017; Swan 2015). As the name suggests, Blockchain creates a "block" with secure records of transactions embedded into the "chain", preventing fraud and tampering (Javaid et al. 2021).

Each new block added on the chain contains a timestamp (creation time) along with a hash value (reference number) corresponding to a verified hash from the previous block. Hence, if any attempts were made to change the data of one block, all the blocks (from that specific block until the newest) would have to be altered (Perera et al. 2020). As such, this verification process reinforces the technology's main strengths: immutability and transparency.

The concept of Blockchain was introduced in a nine-page whitepaper by an anonymous entity known as Satoshi Nakamoto in 2008 and was later realized in 2009 through the birth of Bitcoin. This digital currency aims for maximum security and transparency through the combination of cryptography and peer-to-peer technology (Nakamoto 2008). Bitcoin's whitepaper points out how the commercialized world relies on third parties to complete transactions, such as banks or financial institutions. Thus, it results in lost time and the possibility of fraud since these financial intermediaries cannot always resolve disputes between parties. This leads to uncertainties and higher costs associated in transactions, which is what Bitcoin is programmed to avoid (Nakamoto 2008; Swan 2015; Lifthrasir 2018).

Blockchain was not specifically built for the real estate industry. Instead, it was built to be a Distributed Ledger Technology (DLT) capable of record management, payment methods, and automation for contracts while being secured, immutable, and transparent (Deloitte 2017). Every party on the network would have access to the exact copy of the ledger while being updated and validated in real-time. While numerous healthcare and supply chains companies have already implemented DLT, the RE industry is expected to follow (IBM 2017).

Various industries are spending an increasingly significant amount of money researching Blockchain and how its implementation will benefit them. A study by IDC (2021) states that the amount of money spent on Blockchain globally is forecasted to increase exponentially. In 2017, less than $1 billion was spent on Blockchain solutions; by 2024, that number is projected

to hit over $19 billion worldwide. Therefore, the research and investment behind these numbers show the potential disruption that Blockchain can fundamentally change (PwC 2020).

Although four different types of Blockchains (see Appendix VIII) exist, this research will focus on the use of public Blockchains since, by nature, they are more decentralized and usable for public services such as real estate and government registries (Foley and Lardner 2021).

Overall, Blockchain's exponential growth in funding and fundamental uses can have numerous advantages for the real estate industry. Blockchain's immutability and trust-less function has shown great potential for record-keeping using a DLT accessible to everyone on the network. Therefore, Blockchain needs to further be explored for use cases in RE to understand its theoretical and practical benefits.

Blockchain's Components

Inspired by Melanie Swan's (2015) book "Blockchain, Blueprint for a New Economy", the following section breaks down Blockchain's applications into "*digital currencies"* (Blockchain 1.0), "*smart contracts"* (Blockchain 2.0) and "*applications"* (Blockchain 3.0). This section defines each category and provides an application for the real estate industry.

Blockchain 1.0: Digital Currencies

Blockchain 1.0 revolves around its use of digital currency, also known as cryptocurrencies. This can be linked to the use of digital money to perform transactions, transfers, settlements, or any payment from one entity to the other (Swan 2015). Blockchain 1.0 can further be distinguished in three stacked layers that work together towards a more scalable technology.

The first layer is the ledger (DLT) which is usually on a public blockchain as an open and usable database. Swan (2015) refers to this database as "a giant spreadsheet", capable of recording, monitoring, and storing all transactions on the network. Fundamentally, Blockchain's functionality comes from the fact that no transfers on the network need to be

dependent on a third party such as banks, but rather the whole network is globally decentralized (Perera et al. 2020; Deloitte 2017). This means that the ledger's transactions can be viewed by anyone on the network but edited by no one. In addition, it is not just the tracking of transactions, registries, or exchanges that Blockchain is capable of. It can also be used to record keep non-monetary assets such as health data, votes, intellectual properties, and property deeds (Swan 2015). Just as the internet is used to exchange emails, conversations, and pictures, Blockchain can further be used to exchange currencies and properties (Lifthrasir 2016).

The second layer would be the use of the network to digitally send or receive money over the network without any third-party authentication. This allows building a trust-less environment while having almost instantaneous transactions (Deloitte 2017). Additionally, this layer uses peer-to-peer (P2P) protocols to not only transfer money via the network, but P2P also considers each peer as a node or participant. These decentralized nodes are connected to the same network and are tasked with validating and storing records of transactions while everyone on the network can simultaneously access its information (Javaid et al. 2021; Swan 2015).

The third layer is referred as digital currencies or cryptocurrencies. This is where public Blockchain applications such as Bitcoin and Ethereum come into play, each having their individual characteristics (Swan 2015). Most if not all cryptocurrencies offer a lower transfer fee than current alternatives. This is because all transactions are not obliged to be verified by a third party or financial intermediaries, like banks (Lifthrasir 2016; 2018). Instead, transactions are verified by the same network where the exchange occurs, such as Bitcoin transactions being verified in the Bitcoin network by miners through cryptography (Wan and Hoblitzell 2014).

A major limitation facing cryptocurrencies is the regulatory status surrounding them. Countries like China, Russia and Turkey have banned the ownership of cryptocurrencies, criticizing its volatility and ability to transfer money anonymously (EuroNews 2021). This results in further diminishing the image of cryptocurrencies as illegal. While people may think

cryptocurrencies fuels terrorism, a report by the European Union (2017) suggested that terrorists still prefer fiat due to possible tracking features in digital currencies. However, the rise of Bitcoin and other cryptocurrencies can be seen as a positive, gaining trust from society.

Application of Blockchain 1.0 in Real Estate

RE has already witnessed purchases of houses using cryptocurrencies. In 2016, Denmark had its first buyer purchasing a property using Bitcoin (Coinify 2016). Additionally, a company in Portugal sold two luxury properties worth over $4.7 million using Cardano (ADA) as another medium of exchange (Cryptoslate 2021). Then in early 2021, the mayor of Miami passed a bill that would effectively allow their residents to transact with cryptocurrencies when paying any house taxes or fees to the city (Forbes 2021). This has allowed more people to use the network, hence increasing adoption can be seen. Thus, portraying the technology's transactional potential and global attention (Swan 2015).

Since the decentralized nature of Blockchain would allow for reduced fee transactions, the real estate industry could benefit greatly (Lifthrasir 2018). In 2015, the average commission fees for buying agents were roughly 3% in the EU, while the US had 5%, followed by Japan's 6% (WSJ 2016). Although these commission fees have been reduced over the last years, it remains at a vast amount spent within the RE sector. Again, highlighting the removal of third parties can further decrease transaction costs (Lifthrasir 2018; Swan 2015).

The use of DLT for informational communication between countries and companies is getting more attention. The European Blockchain Service Infrastructure (EBSI) is a combined attempt from all the European Commission, Norway, Liechtenstein, and 27EU countries to allow interoperability of public services within the continent (European Commission 2021). Notary services could use the application of Blockchain to keep permanent records and save time during the process. The transfer of ownership and identity management are also part of this network's ability (Swan 2015). In the form of a transaction, legal documentations can be

stored on the network while being time-stamped. This process would further improve security, efficiency, and accuracy (Wan and Hoblitzell 2014). As a result, numerous benefits for commercial and residential real estate, such as increased communication, higher availability of information and better trust between all parties can be attained (Lifthrasir 2018).

Blockchain 2.0: Smart Contracts

Blockchain 2.0 takes paper contracts to the next level to perform more complicated transactions than an exchange of money. As an application of Blockchain, smart contracts and the potential to disrupt the RE industry have contributed to the focus of this paper. Contracts on the Blockchain network are called smart contracts (Swan 2015). Smart contracts were introduced by Nick Szabo in 1997 as a programmable code to be executed if a certain condition is met (Szabo 1997). Currently, the biggest name associated with smart contracts is Ethereum (ETH), a smart contractual-based Blockchain network with the ability to build decentralized applications (DApps) on the network (Karamitsos, Papadaki, and Barghuthi 2018). While the term smart contract has been around for a while, it is Ethereum that fundamentally practicalized this concept (Karamitsos, Papadaki, and Barghuthi 2018).

The word “smart” is not only applied to contracts but also smart properties and smart real estate. Blockchain 2.0 makes use of Blockchain “beyond” just a digital currency; it can be further used in financial markets (i.e., loans, stocks, and bonds), intellectual properties, and more (Swan 2015). The ability to exchange secured information, from P2P while being a decentralized platform can disrupt various industries (Lifthrasir 2018).

Application of Blockchain 2.0 in Real Estate

In the RE industry, the Ethereum platform can have a major impact on property owners and tenants. The use of smart contracts can be leveraged against traditional contracts to build on trust and encounter less fraudulent activities (Lifthrasir 2016, 2018).

The work of Karamitsos et al. (2018) involved designing and applying smart contracts in a RE renting process involving the landlord and tenants through DApps. In short, this design and execution of a smart housing contract resulted in various benefits, such as an exponentially straightforward process to start and terminate any contracts. Further, Karamitsos et al. (2018) also suggested that this process has allowed for better trust between parties since neither of the parties could alter any data. While third parties were not involved, faster transactions and lower costs can also be observed, resulting in higher efficiency and less time consumed. The use of smart contracts minimized fraudulent activities, essentially helping governments reduce money laundering and fake documentation for land or contracts (Lifthrasir 2016). However, Karamitsos et al. (2018) also suggested that although the contracts would have certain conditions to be met, there is no enforcer to make sure such boundaries are respected.

While still in the early stages of development, smart contracts are not just a concept. In 2017, Ukraine witnessed its first Ethereum-based real estate transaction through the Propy platform (WSJ 2017). Propy is a Blockchain-based PropTech platform that aims for "self-driving" transactions with minimal interactions from buyers or sellers (Propy 2021).

All in all, projects over the last few years have demonstrated the ability of smart contracts to take on and disrupt the industry. Through DLT and smart contracts, parties can effectively eliminate distrust among each other and eliminate the middleman. Resulting in timely delivery, lower transaction fees, instant payments, and better transparency (Lifthrasir 2018).

Blockchain 3.0: Application

Blockchain 3.0 leverages the last two categories to expand beyond digital currencies and smart contracts to facilitate the handling of non-economic actions. Developers can use Blockchain 3.0 to create various applications beyond cryptocurrencies and distributed ledgers (Coinbase 2021). These applications, if extending or modifying the network can be known as

"forks". Forks are when protocols for a Blockchain network are changed to create a separate entity and disregard previous protocols. For example, Ethereum's fork (and upgrade) is Ethereum 2.0. It builds on problems that the current Ethereum network is facing, such as the high energy usage used by miners to validate transactions (Coinbase 2021).

Additionally, non-tangible assets can benefit from integrating Blockchain applications, such as voting platforms, digital identity, and government services. Various other applications such as proof of existence and proof of ownership can be combined with Blockchain 1.0 and 2.0's use cases to create fundamental changes in real estate (Swan 2015). This proof of ownership can be transferred from one person to another through the network instantly, without the need for a third-party involvement (Lifthrasir 2018).

Application of Blockchain 3.0 in Real Estate

In a non-economic framework, Blockchain 3.0 can realize the conceptual stages of title registries in the real world. Sweden demonstrates this in cooperation companies such as Kairos Future, ChromaWay, and Telia (Lantmäteriet 2016). These three companies, along with the Swedish government, have launched a pilot project aiming for maximizing transparency and minimizing bureaucracy through Blockchain in the land registry system. Using a consortium Blockchain, Lantmäteriet (the Swedish Land Registry) allowed all parties (banks, buyers & sellers, brokers, and the land registry system) to be part of the Blockchain to limit information asymmetry (Lantmäteriet 2016). This allowed for most of the steps to be removed from the process, such as inspections and visits for signatures. Additionally, this process (see Appendix IX) resulted in less time for due diligence, saving all parties time and cost while capitalizing on another RE market inefficiency (Lifthrasir 2018).

Moreover, a similar project was carried out in India that allowed integration of land records with Blockchain. This collaboration was with the government of Andhra Pradesh with ChromaWay- the same company helping the Swedish government integrate Blockchain

(ChromaWay 2021). Both projects have resulted in a much quicker, transparent, and trust-based method to purchase or sell properties (Lantmäteriet 2016; Singh 2020). These pilot programs further suggest that the application of Blockchain and smart contracts can prove to be a promising integration within RE since many of the inefficiencies in the market are being minimized through Blockchain (Lifthrasir 2018; Lantmäteriet 2016; Baum 2017).

Limitations, Drawbacks, and Challenges of Blockchain

While research surrounding Blockchain have increased, over 80% of scientific database concentrates on Bitcoin's price and security rather than its application (Yli-Huumo et al. 2016). This limitation highlights the need for more profound research into the technology.

The fact that all governments do not see cryptocurrencies as legal, limits people on the financial knowledge and benefits of Blockchain and smart contracts, further damaging the public perception (Dijkstra 2017). The lack of technical understanding of Blockchain can be considered another limitation. However, if more countries like Sweden, and India have gained an advantage in using Blockchain's interoperability, the regulations and perceptions surrounding Blockchain, cryptocurrencies and smart contracts may change positively. Along with public perceptions, companies need to educate themselves further to understand the technology and benefit them or their respective industries (Deloitte 2017).

Additionally, various complexities surrounding Bitcoin and Ethereum's energy usage have been pointed out, resulting in Ethereum eliminating miners (validators) that use electricity to mine. Using electricity to mine and solve mathematical equations on a computer is a mechanism that allows verification of transactions, also known as Proof of Work (PoW) (Swan 2015). In contrast, the new and environmentally friendly mechanism is called Proof of Stake (PoS). PoS will be used by Ethereum 2.0 when the merge between both (ETH 2.0 and ETH 1.0) networks will occur in early 2022 (Coinbase 2021; Bloomberg 2021). This merge points out that current

mechanisms are not very sustainable, and that the new system can be more scalable in the long term (Coinbase 2021; Lifthrasir 2018).

According to Gartner's hype cycle for Blockchain (Appendix X), smart contracts and cryptocurrencies are 2-5 years away from mainstream adoption, while Blockchain's interoperability is still 5-10 years away (Gartner 2021). This highlights that these technologies may further need more adoption and use cases. Thus, another limitation is Blockchain's maturity cycle and time needed for a much higher adoption rate in the commercial and residential RE industries. To increase Blockchain's adoption in the RE industry, governments and businesses would have to fully back the technology and regulate its transactional approach and leverage more on its digital transformation capabilities (Swan 2015).

Methodology

Results and Discussion

While the literature study suggests that adoption for Blockchain is low but increasing, a survey towards customers was distributed to understand various aspects of this adoption and reliability. The survey conducted revealed the following points (See **Appendix XI** for survey).

First, it is essential to highlight that over 67% of the respondents were overrepresented with the age interval between 18-26, followed by 27-35 age interval with only 13%. Thus, representing a young sample.

Second, from these responses, 33% of the 159 people were involved in a real estate transaction. When asked how much time they took to complete a real estate transaction, half of the respondents (48%) reported that it took them 2-5 months. Only 29% reported as 0-2 months, followed by 23% who took more than 5 months. This suggests that although some property transactions can be quick, many are slow and that improving these times may result in a better process. From the potential improvements in the process to be made, respondents reported that costs (taxes, commissions), third party involvement (brokers, banks, lawyers) and time,

respectively, can be improved. Additionally, 55.3% of the responses agreed, and 21.4% strongly agreed that eliminating the third party can save time and money. Only less than 9% either disagreed or strongly disagreed with this notion. This further suggests that respondents see an inefficiency in the market that can be eliminated. Aligning with Deloitte's (2017) findings, Blockchain can effectively reduce transaction time and cost in an industry filled with technical limitations (Lifthrasir 2018; Bosak, Mayer, and Vogel 2007).

Third, only 50% (out of 159) of the respondents knew what Blockchain is, and only 26% knew what a Smart Contract is. This implies that awareness about Blockchain is higher than Smart Contracts, but still suggesting a lower awareness for Blockchain and smart contracts as a concept. This low awareness may lead to longer time for mainstream adoption (Swan 2015).

Fourth, respondents also believed that information asymmetry is high in the market. Over 68% believed that agents and brokers have more information than regular buyers or sellers in the market. Only less than 4% disagreed or strongly disagreed with information asymmetry in the industry, further suggesting a disadvantage for people without access to such data, confirming the real estate market is not fully transparent (Lifthrasir 2018). Thus, aligning with Casafari's (2021) research that property prices and valuations differ between agencies.

Finally, responses were lined up with the willingness to sign contracts digitally. 37.7% of the respondents agreed, and 29% strongly agreed to being comfortable signing smart contracts digitally. While only less than 20% disagreed with being comfortable to digitally sign smart contracts, implying that smart contracts do have the potential for mainstream adoption under the right developments and circumstances (IBM 2021).

Overall, the survey confirmed a belief of low accuracy and transparency, high costs and time-consuming processes associated, and that the knowledge on the Blockchain technology is relatively low. People were also willing to sign contracts digitally, hinting at the mainstream adoption of smart contracts. The survey also confirmed that third parties can be eliminated.

Individual Conclusion

This paper analysed various projects involving Blockchain, and Smart Contracts, along with each technology's limitations and benefits for the RE market. While Blockchain's full potential is still underestimated, the technology has shown its disruptive and exciting potential. Cryptocurrencies, a decentralized distributed ledger, and smart contracts are among Blockchain's first yet successful applications and have proved their potential applications in real estate's transactions and property rights transfer processes.

The questionnaire conducted aligns with the literature study, suggesting that the RE market, has flaws such as high transaction costs, time-consuming processes, and low transparency in the market (Lifthrasir 2018). The survey also highlighted that people are willing to adapt to Blockchain and smart contracts, thus, showing trust in the upcoming technology.

To answer the research question, Blockchain and Smart Contracts can contribute to revolutionize the lagging technological adoption in the RE industry and current inefficiencies. These contributions include lower transaction costs and time by disintermediating parties on DLT-based platform and using digital currencies for transaction. An increased transparency in the market by greater and equal information availability on properties can also be observed using this immutable ledger (Deloitte 2017; Swan 2015). Blockchain can further facilitate management processes in the industry by using Smart Contract-based rental agreements and land registry system. As a result, introducing a higher efficiency, accuracy, transparency, and simplicity in the RE industry (Lifthrasir 2018). However, for this implementation to be successful, the issues of public perception and government regulations proves to be a hurdle for mainstream adoption. Nevertheless, the benefits of implementing Blockchain and Smart Contracts in the real estate industry undeniably outweighs its limitations (Lifthrasir 2018). Therefore, pressuring companies and governments to embrace the technology and facilitate transactions and land registry processes in the RE industry.

Future research

While this paper focused on various limitations and benefits for Blockchain in RE, their practical applications and technical limitations can further be explored. This practicality will allow for further data collection, therefore underpinning the arguments addressed in this paper.

Additionally, while this paper addressed opportunities for a better process management in real estate, Blockchain's applications in alternate industries can be beneficial researching.

At last, this research was limited to a broad application of Blockchain in RE, no specific country was thoroughly analysed. Thus, in depth of country's process can further be beneficial.

7 Final Conclusion

This paper aims to identify important PropTech 3.0 technologies that can help residential real estate brokers stay competitive. While technological adoption in RE still lags behind, exciting technologies recently emerged on the market.

The RE industry is influenced by external factors such as economics, digitization, and emerging technological advancements. Similarly, Covid-19 acted as a catalyst in digitalization, creating new business model opportunities and adding innovative pressure. While the retail and office segments became less attractive as people started buying online and working from home, the residential segment and logistics flourished.

The two surveys highlight crucial areas for improvement on current RE platforms, such as low satisfaction, poor purchasing experience, and low industry transparency. That is why individual contributions explore specific technologies, namely VR & AR, IoT, Blockchain & Smart Contracts, to analyze their potential for RE experience enhancement. Further, digital platforms were analyzed to provide an outlook on the future relevance of RE agents. AR and VR represent valuable adoptions in the RE industry when considering improvements in customer experience. Incorporating these technologies leads to better decision-making, faster

purchasing processes, and more satisfied customers, solidifying firms' market position and creating value. IoT has a wide range of possible applications in RE that create a more comfortable and safe living space. Although IoT has been found to contribute to sustainability, such as energy optimization, its large-scale adoption is dependent on people's willingness to implement these solutions. Integrating Blockchain and smart contracts can lead to higher transparency, lower costs and fees, and more autonomous processes. However, governments and institutions need to address low adoption levels and country regulations for successful Blockchain implementation. Finally, it was found that brokers are unsatisfied with current platform models due to their exploitation of power. While a preference for MLS was identified in the study, interviewed experts underlined the unlikelihood of implementing an MLS in Europe.

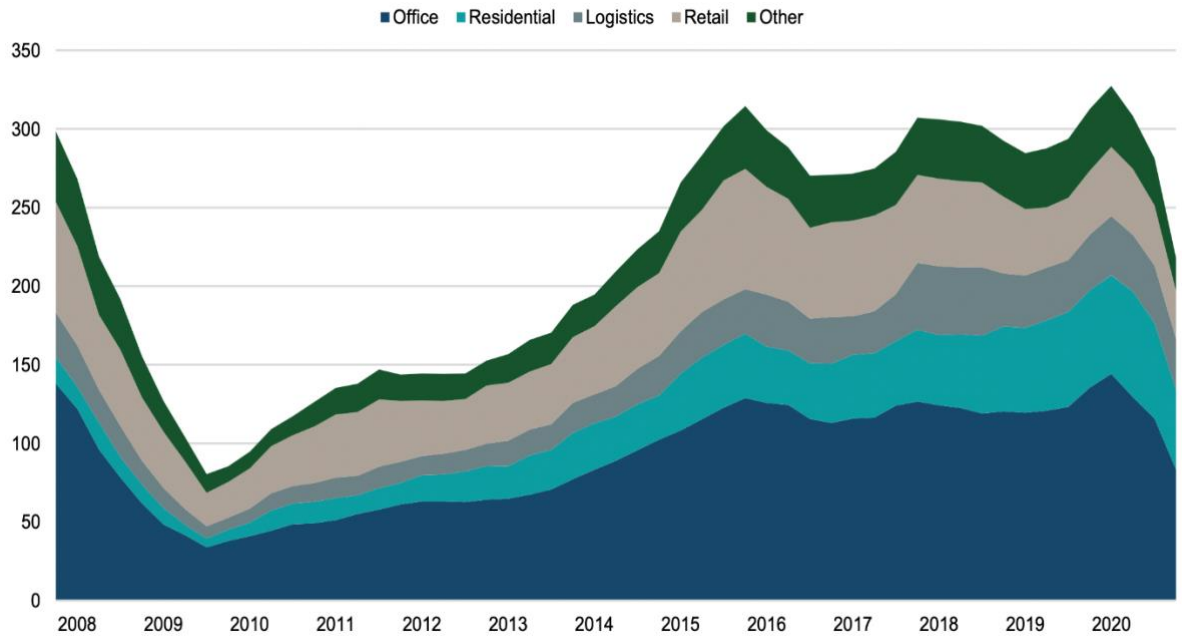
Ultimately, this paper concludes that recent developments in technology have pressured the RE industry. An MLS with VR & AR functionality, on-platform IoT cross-selling option, and blockchain-based transactions could disrupt the RE market. By adopting these technologies, brokers can remain competitive, and customers can benefit from improved experience and market efficiencies.

7.1 Limitations and Future Research

This thesis analyzes future platform models and the importance of technology adoption in residential real estate. The study is limited by focusing on three particular technologies: VR/AR, IoT, and Blockchain & Smart Contracts. Additionally, the potential of the three technologies is addressed through two surveys targeting European real estate brokers and potential buyers. Another limitation is the number and demographics of the "End-Customer Perspective" survey respondents, which might not represent European customers. Moreover, both surveys were distributed in English, limiting the research to those who comprehend the language.

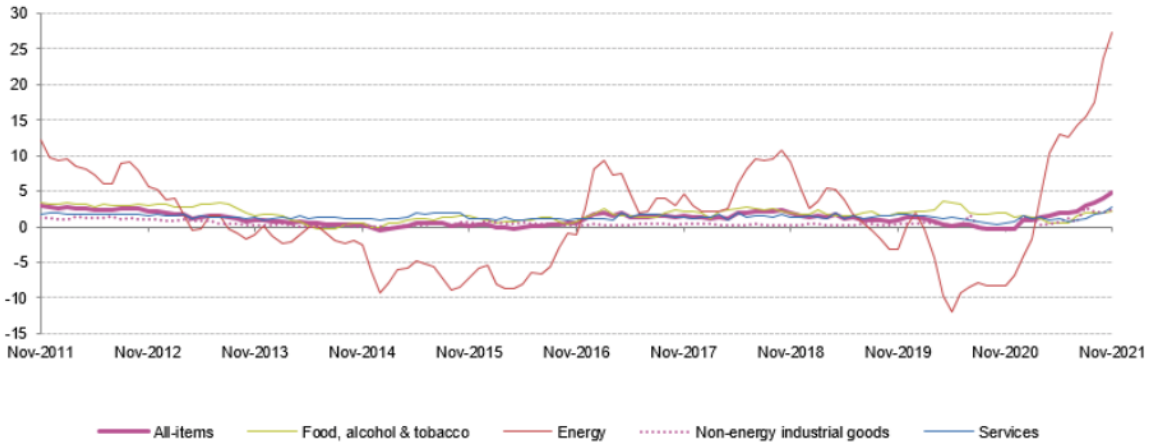
Future research should build on technology application to RE, exploring the remaining technologies mentioned. VR/AR, IoT, and Blockchain adoption have multiple benefits in the RE industry, but further research should focus on other technologies and their impact. Additionally, future studies could focus on specific countries or more restricted areas. These aspects can contribute to higher accuracy when identifying which technologies each company would take a higher benefit from and, therefore, make an investment in.

Appendix



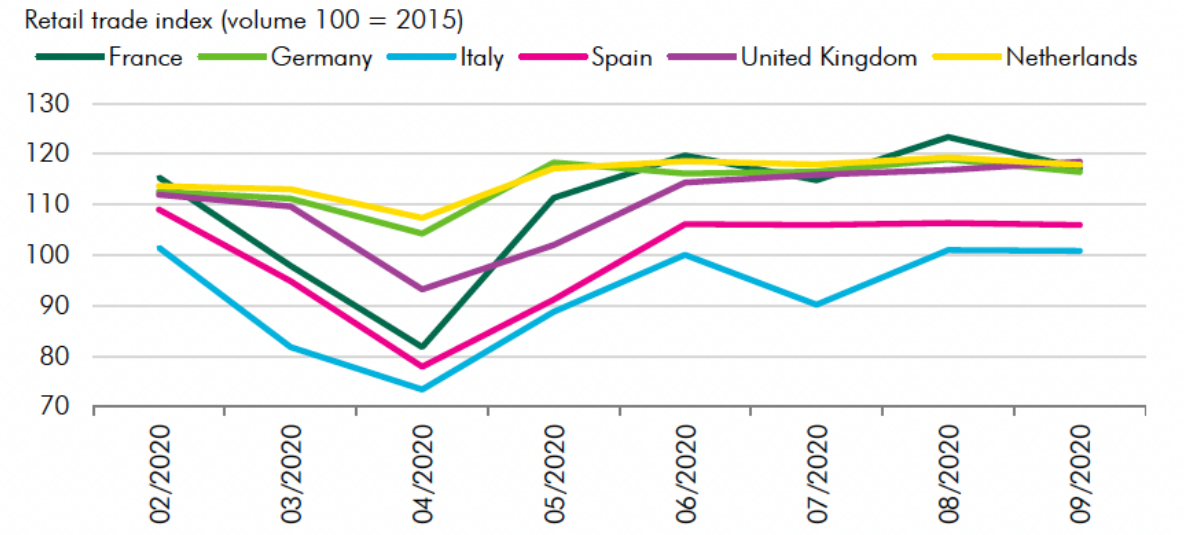
Appendix I: European RE transaction volumes by sector (in billions of €).

Source: Real Capital Analytics, January 2021 (Figure from DWS 2021).



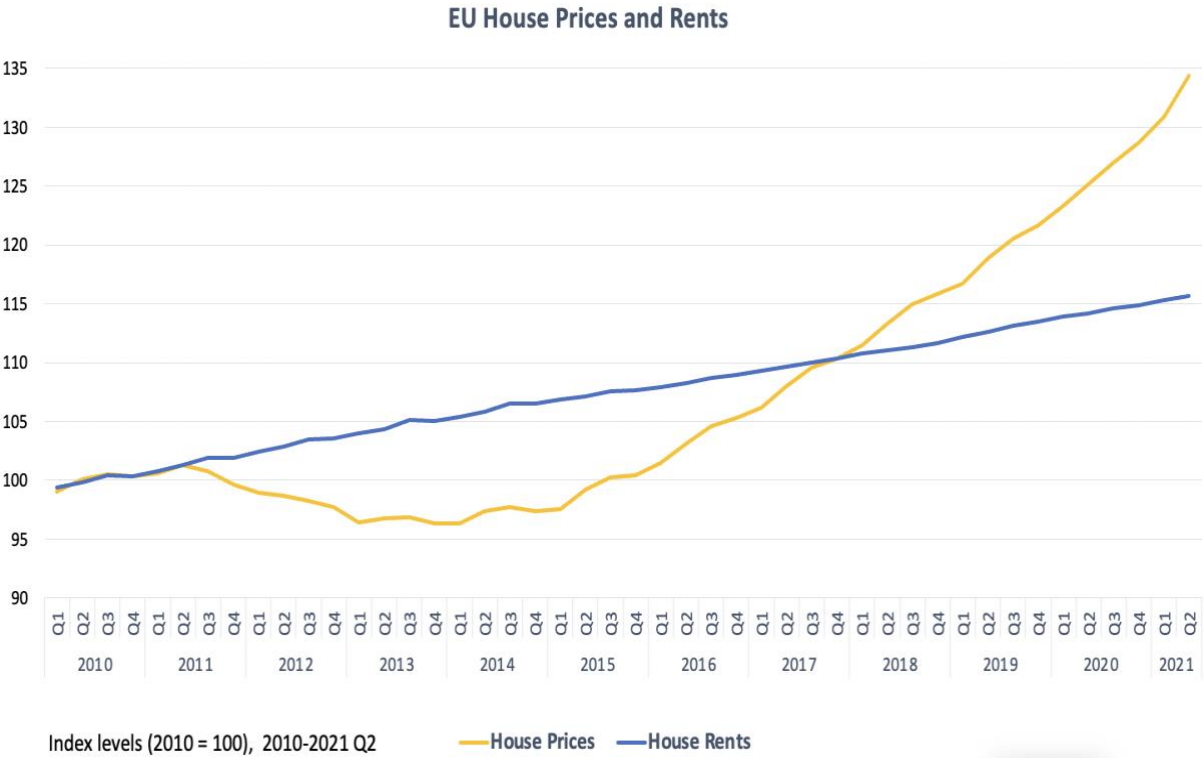
Appendix II: Euro area annual inflation & its primary drivers, November 2011 – November 2021 (estimates).

Source: Eurostat (online data code: prc_hicp_manr).



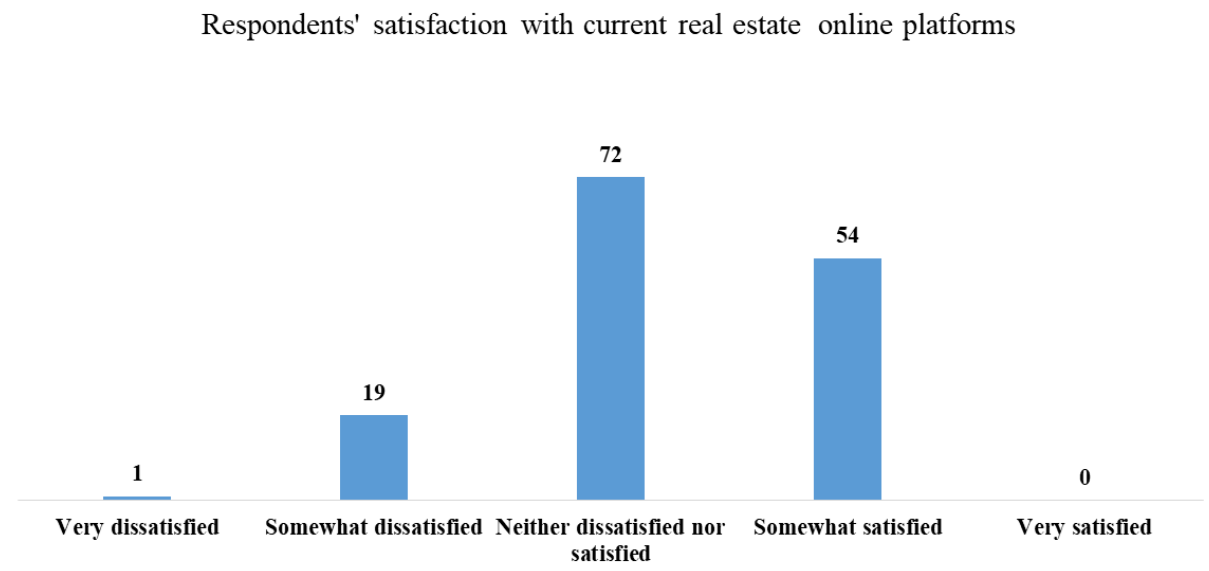
Appendix III: Retail Revenue Recovery in 6 European Markets.

Source: (CBRE 2021).

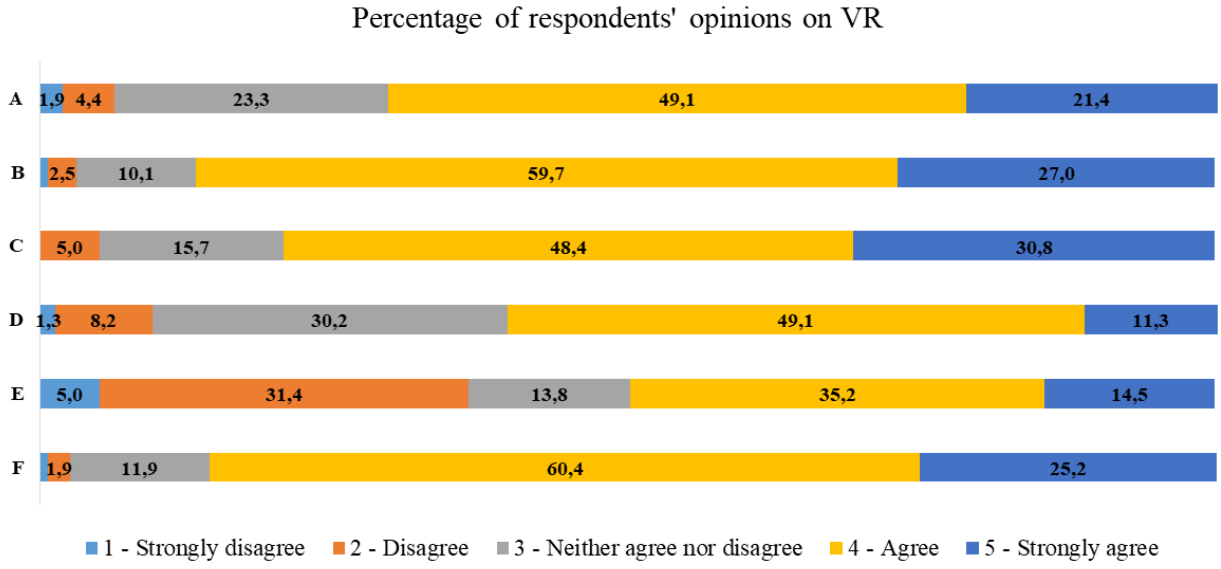


Appendix IV: Rising house and rent prices.

Source: Eurostat 2021 (own figure).



Appendix V: Respondents' satisfaction with current real estate online platforms. Data collected from the survey *"End-Customer Perspective"*. Classification using the CSI.



Appendix VI: Percentage of respondents' opinions on VR. Data collected from the survey "*End-Customer Perspective*". Classification using the Agreement Likert scale on the following statements:

A - Lack of accuracy between pictures and actual space is one of the main problems within real estate online platforms.

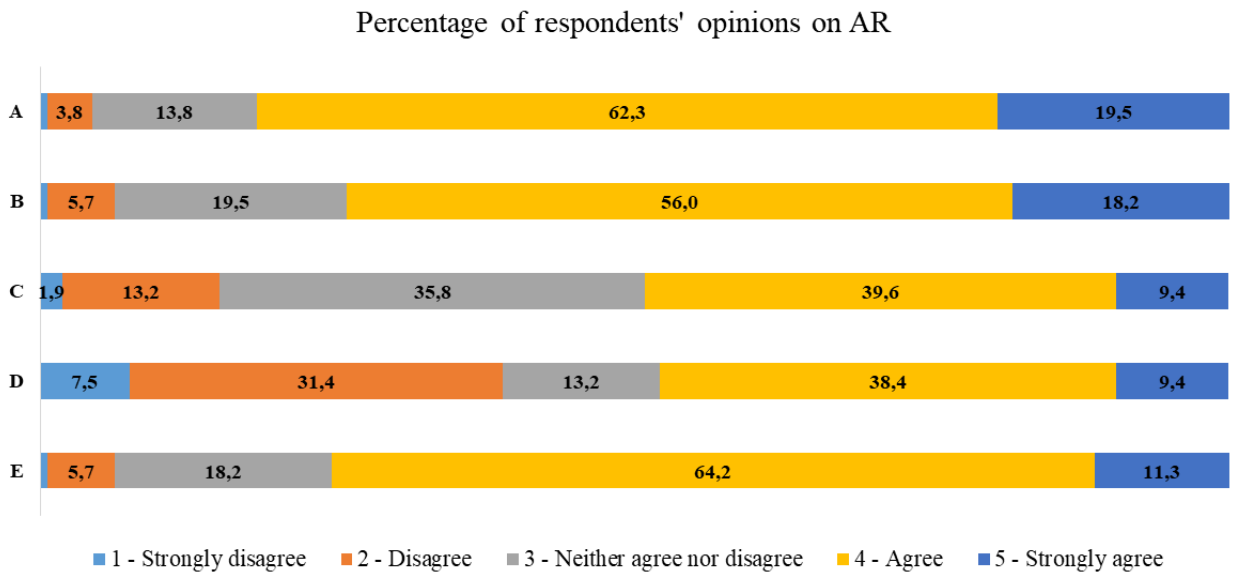
B - The incorporation of VR features within real estate online platforms would enhance my purchasing experience.

C - I would prefer to look for houses in platforms with VR features over platforms without these features.

D - VR features would solve current challenges I have when looking for houses.

E - VR features would speed up the process of finding the houses that meet my preferences.

F - VR features would reduce the need for physical visits.



Appendix VII: Percentage of respondents' opinions on AR. Data collected from the survey "*End-Customer Perspective*". Classification using the Agreement Likert scale on the following statements:

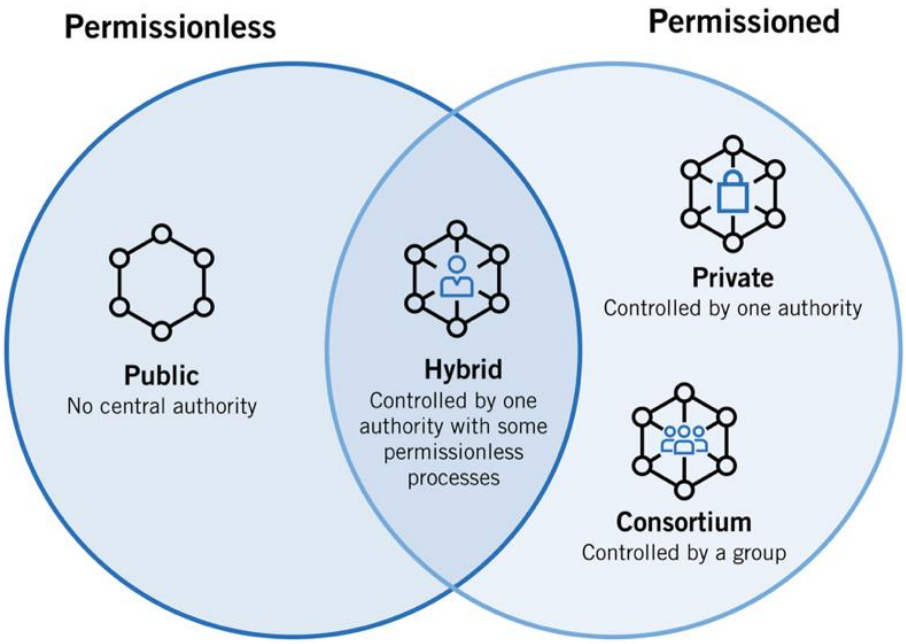
A - The incorporation of AR features within real estate online platforms would enhance my purchasing experience.

B - I would prefer to look for houses in platforms with AR features over platforms without these features.

C - AR features would solve current challenges I have when looking for houses.

D - AR features would speed up the process of finding the houses that meet my preferences.

E - AR features would reduce the need for physical visits.



Source: Foley & Gartner 2021

Appendix VIII: Types of Blockchains

Process:

1 

Buyer and seller log into the app using their Telia (telecom provider) IDs

- The buyers' and sellers' identities are verified by Telia's digital ID solution on ChromaWay's (blockchain start up) app developed for Lantmäteriet (Swedish land registry).
- Telia's ID solutions can be used on mobile phones and can register individuals with or without a personal identification number.

2 

RE agent and bank are appointed and due diligence is done

- Using the app, the seller appoints the RE agent who does the property due diligence and invites the potential buyer.
- The interested buyer invites its bank to the transaction through the app.
- The interested buyer's bank verifies the property ownership through the app.

3 

Agreement is signed

- The seller and the buyer both sign the contract using digital signatures and identification.

4 

Payment is completed

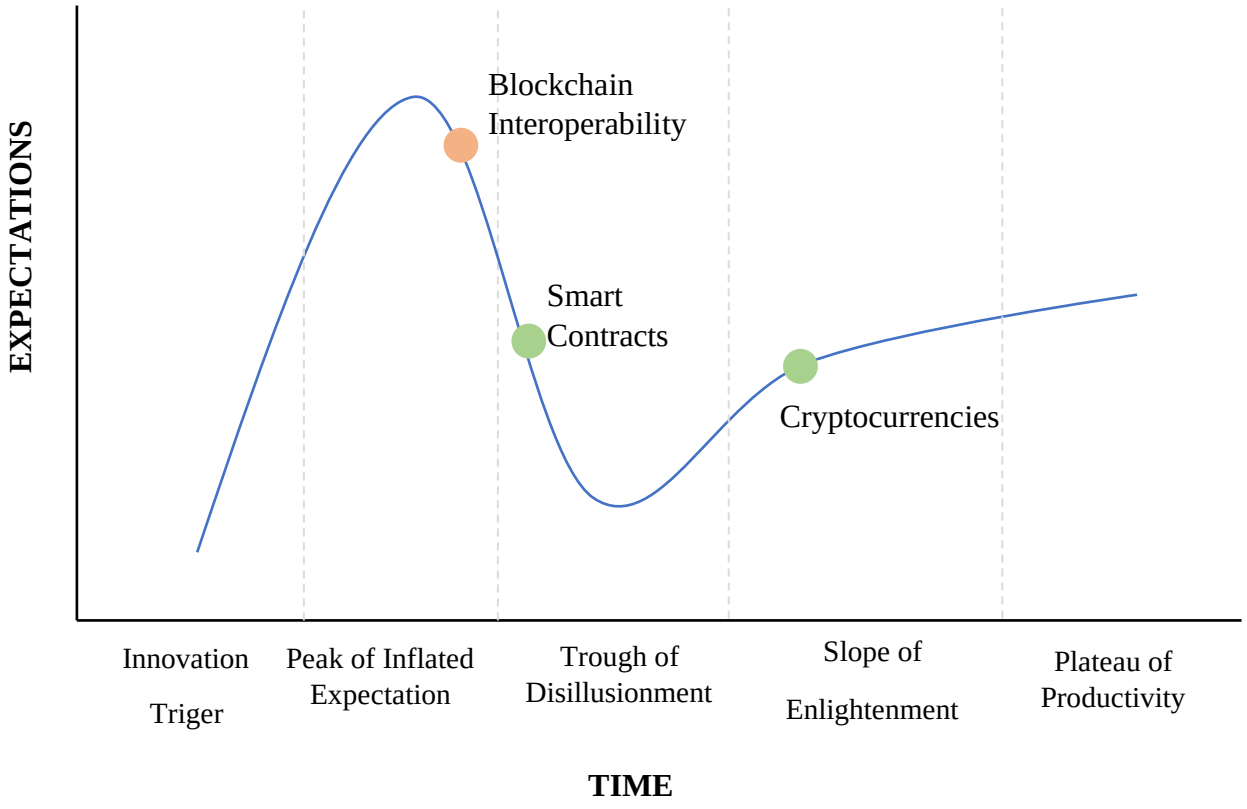
- The buyer instructs its bank to make the payment to the seller. Both parties are notified once the payment is completed.

5 

Property title is transferred

- Upon payment, the registrar receives a notification to initiate title transfer.
- The registrar digitally transfers the title from the seller to the buyer.
- Title transfer is updated on the app and visible to all parties.

Appendix IX: Process for Sweden's Blockchain based real estate platform

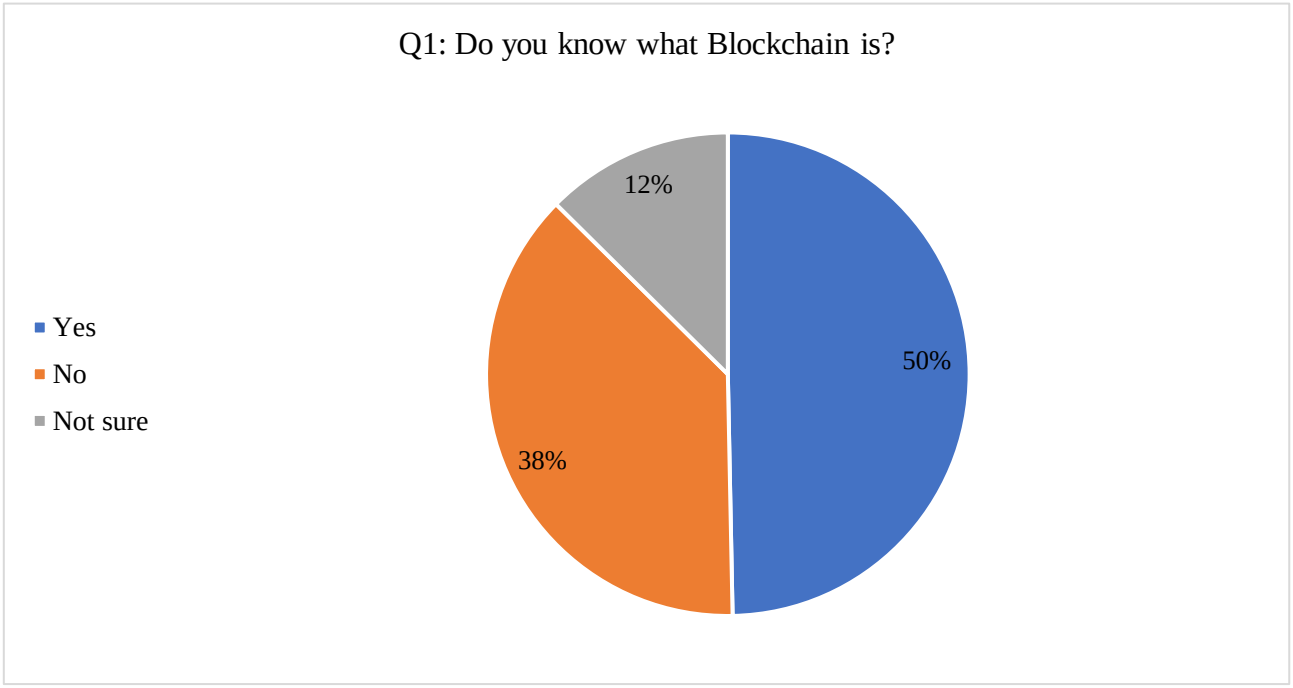


Source: Own figure based on Gartner (2021)

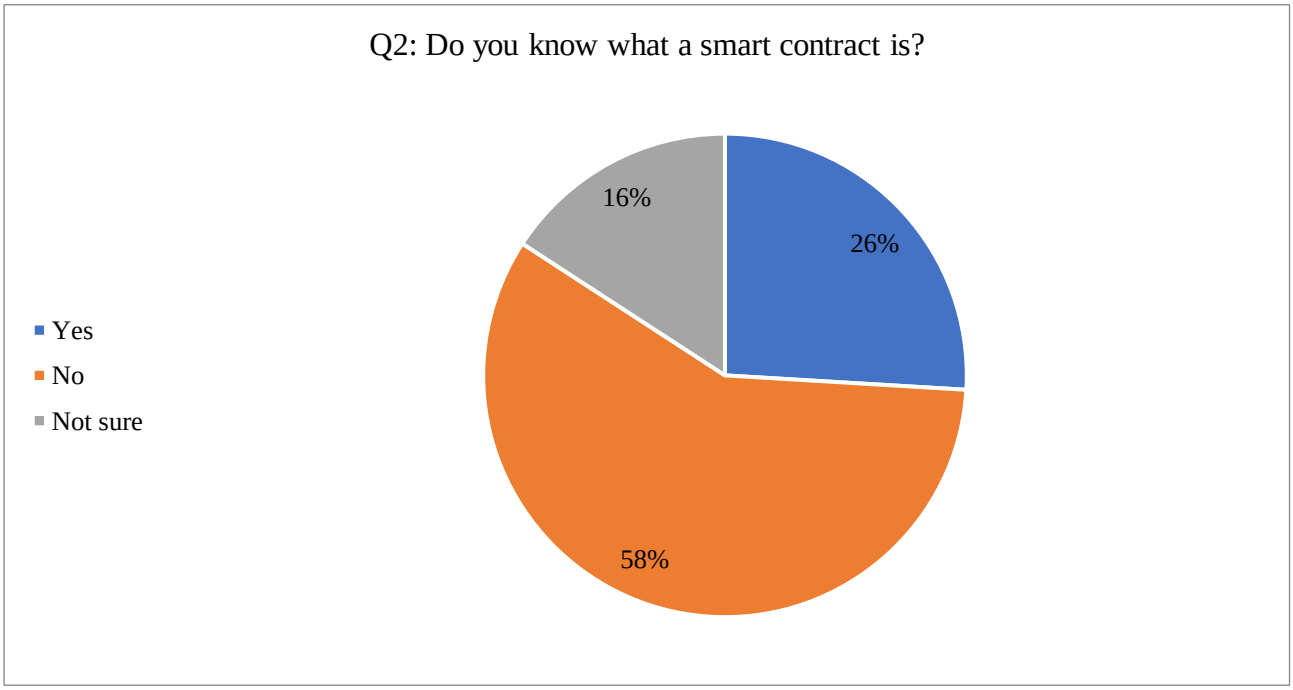
Appendix X: Gartner's Hype cycle for Blockchain 2021

Appendix XI: Questionnaire

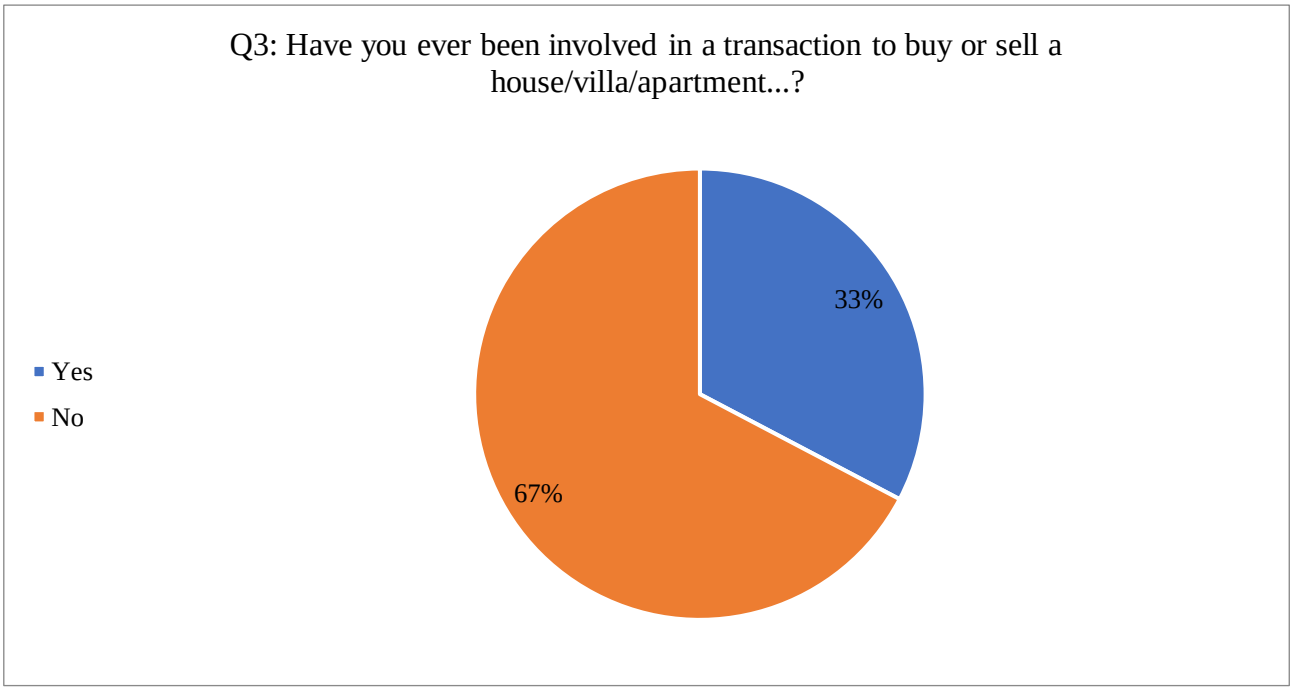
(All graphs were obtained through Microsoft Excel)



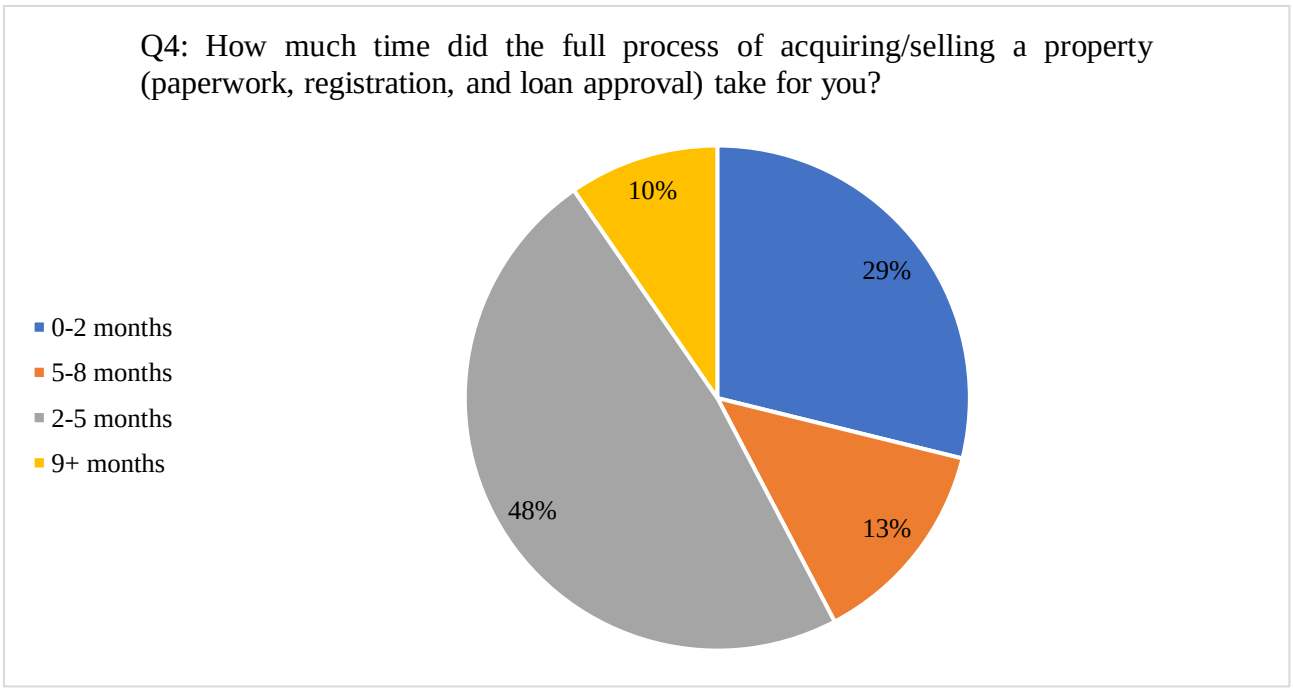
Question 1: Blockchain awareness



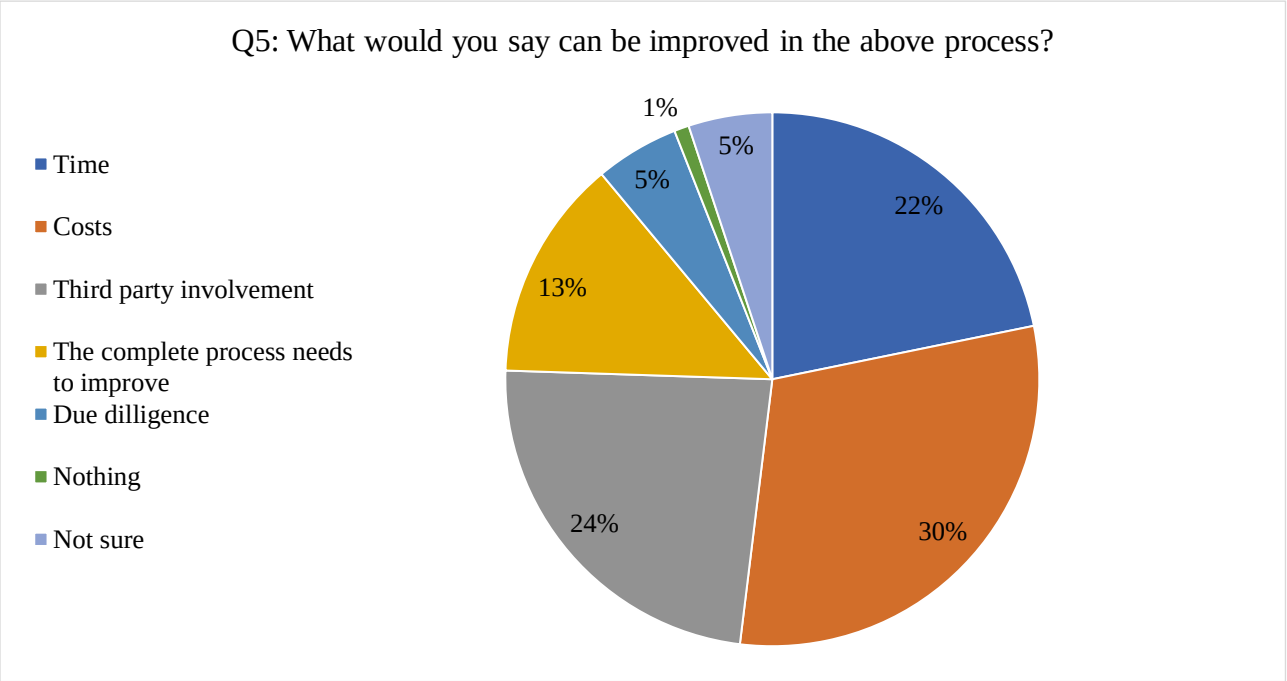
Question 2: Smart contract awareness



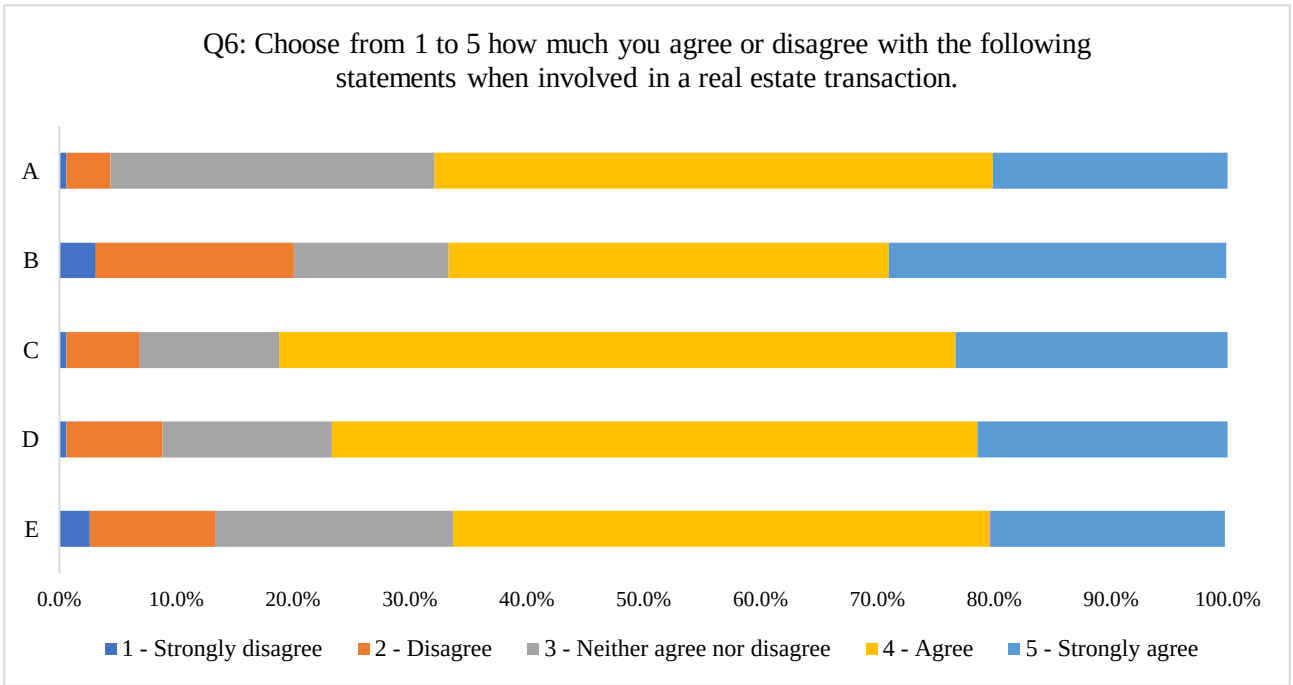
Question 3: Transaction validity



Question 4: Time consumed in the process



Question 5: Pain point identifications



Question 6: Statement Viability

The following five statements were asked for the above question:

A. Human involvement is needed for me to feel comfortable and safe.
B. Elimination of 3rd parties (i.e: brokers, agent, lawyers..) can be very time and cost saving.
C. Paper works, due diligence and contracts can be made and stored digitally with minimised risks.
D. I feel comfortable to sign a digital contract through a phone/tablet/computer application.
E. Agents/brokers have more Information than regular buyers/sellers about the market.

List of Abbreviations

AI	**A**rtificial **I**ntelligence
AR	**A**ugmented **R**eality
CAGR	**C**ompound **A**nnual **G**rowth **R**ate
CE	**C**ustomer **E**xperience
CRM	**C**ustomer **R**elationship **M**anagement
CSI	**C**ustomer **S**atisfaction **I**ndex
ECB	**E**uropean **C**entral **B**ank
EU	**E**uropean **U**nion
GDP	**G**ross **D**omestic **P**roduct
ICT	**I**nformation and **C**ommunications **T**echnology
IoT	**I**nternet-**o**f-**T**hings
ML	**M**achine **L**earning
MLS	**M**ultiple **L**isting **S**ervices
NPS	**N**et **P**romoter **S**core
PEPP	**P**andemic **E**mergency **P**urchase **P**rogramme
RE	**R**eal **E**state
SaaS	**S**oftware **a**s **a** **S**ervice
SQM	**Sq**uare **M**eter
UK	**U**nited **K**ingdom
UN	**U**nited **N**ations
US	**U**nited **S**tates
VR	**V**irtual **R**eality

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