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SMART HOME: STATE OF THE ART AND KEY FACTORS FOR VALUE CREATION

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Table of contents

INDEX OF FIGURES

INDEX OF TABLES

ABSTRACT (English)

The Smart Home, a specific application area of the IoT, is a socio-technological theme of great interest and that in recent years has gained a fundamental role both in the national and international scenario. Interconnected and intelligent home products, indeed, have a huge impact on every aspect of our house life, being ubiquitous and fitting seamlessly into day-to-day activities; the possibility to improve the quality of householders' life, thanks to the automation of routine activities and the consequent reduction of time wastes, thanks to the remote management of products and implementation of services, thanks to the intelligent capabilities of monitoring, controlling, optimizing and automating actions, has allowed Smart Home products and services to have a great diffusion, as the growth of global markets shows. Therefore, mostly in the recent year, the Smart Home becomes a promising area of competition for all the companies that have exploited this new arena in order to take advantage of significant opportunities and create new value; however, at the same time, this firms have been forced to rethink their traditional business model, in order to exploit the new potentialities offered by the IoT technologies and to face the new market requirements and barriers. This work fits within this general framework.

After having clarified some general aspects, e.g. features and functionalities of common Smart Home products, enabling technologies, barriers and challenges, the thesis focus on a dual purpose: firstly, it focuses on giving a macro-level picture of the global Smart Home offer, mapping and analysing the available solutions in the international arena, with a strong focus on the Italian market; this work let to understand the current state of the art and to get insights about the future trends. Secondly, it focusing on the critical factors that each firms should take into account in its business model if operating in this sector, in order to create additional value. This second purpose was accomplished thanks to the analysis of both OTT (Amazon, Google, Apple and Samsung) and smaller companies, startups (AICO and FIBARO) and SMEs (Homey and Eve), in order to have a picture as comprehensive as possible. This analysis has been run first using the Business Model Canvas (the traditional business model most widespread, also used in the IoT domain) and then enriching this general model with the analysis of factors peculiar and strictly linked to the Smart Home field, necessary for a correct and complete analysis.

ABSTRACT (Italiano)

La Smart Home, nuovo fulcro dell'ecosistema IoT, è un tema di grande interesse, che negli ultimi anni ha acquisito un ruolo fondamentale sia nello scenario nazionale che internazionale. I prodotti interconnessi ed intelligenti, infatti, hanno un impatto enorme su ogni aspetto della nostra vita domestica, essendo onnipresenti ed adattandosi perfettamente ad ogni attività quotidiana; la possibilità di migliorare la qualità della vita domestica, grazie all'automazione di attività routinarie e alla conseguente riduzione degli sprechi di tempo, grazie alla possibile gestione da remoto di svariati prodotti ed all'implementazione dei relativi servizi, grazie alle capacità di monitoraggio, controllo, ottimizzazione e autonoma implementazione di azioni degli oggetti intelligenti, ha permesso al settore Smart Home di avere una sempre più grande diffusione, come è dimostrato dalla forte crescita del mercato a livello globale. Pertanto, soprattutto negli anni più recenti, la Smart Home è diventata una promettente area di competizione per tutti i tipi di le aziende, che hanno sfruttato questo canale per creare nuovo valore; allo stesso tempo, tuttavia, queste compagnie che sono entrate nel mercato, sono state costrette a ripensare il loro tradizionale modello di business, al fine di sfruttare le nuove potenzialità offerte dalle tecnologie IoT e far fronte alle nuove esigenze e barriere del settore. Questa è la cornice generale su cui la tesi è incentrata. Dopo aver chiarito e descritto alcuni aspetti maggioritari, ad es. caratteristiche e funzionalità dei prodotti Smart Home, tecnologie maggiormente utilizzate, barriere e sfide a cui far fronte, la tesi si concentra su un duplice obiettivo: in primo luogo, dipingere una macro immagine dell'offerta globale, attraverso la mappatura e l'analisi delle soluzioni disponibili nell'arena internazionale, con una forte attenzione al mercato italiano; questo lavoro ha consentito di comprendere lo stato dell'arte dell'attuale mercato e le future tendenze. In secondo luogo, si mira ad individuare i fattori critici che ogni azienda operante in questo settore dovrebbe includere nel proprio business model, al fine di poter creare valore aggiunto. Ciò grazie all'analisi di OTT (Amazon, Google, Apple e Samsung) e di aziende più piccole, startup (AICO e FIBARO) e PMI (Homey ed Eve), al fine di avere un quadro il più completo possibile. Questo studio è stato eseguito dapprima utilizzando il Business Model Canvas (modello di business tradizionale più diffuso, utilizzato anche nel dominio IoT) e successivamente arricchendo questo modello con l'analisi di fattori peculiari e strettamente collegati al campo della Smart Home, necessari al fine di un'analisi corretta e completa.

EXECUTIVE SUMMARY

Smart Home: introduction

"A Smart Home is a residence equipped with a communications network, linking sensors, domestic appliances, and devices, that can be remotely monitored, accessed or controlled and which provide services that respond to the needs of its inhabitants".

Balta-Okzan et al. (2014)

The Smart Home is taking a leading role in Internet of Things (IoT) universe. The importance and positive impact that interconnected and intelligent home devices can have on people's lives, have allowed Smart Home products and services to have a great diffusion both in the national and international scenario. Therefore, mostly in recent years, this area has become a fertile arena of competition and an opportunity of value generation for companies. In particular, the Smart Home is enabling the adoption of new business models, transforming the way companies create value for their customers; firms should now satisfy new needs and in a new way, more comprehensive and innovative. The thesis work fits within this context.

The first chapter is dedicated to present the conceptual bases on which the entire thesis has been built and to give a general overlook on the argument, mainly referring to the existing literature.

Starting highlighting the evolution of the terms *Domotics*, *Home Automation* and *Smart Home* over the last century and after having underlined the difference among them, the focus shifts on the Smart Home. Smart Home main characteristics, key features and functionalities are discussed, according to frameworks proposed in literature by different authors. A particular focus is given to the model suggested by *Hamernik, P. et al. (2012)*, in which the author categorized the functions by level of importance to the operation of the Smart Home and provided a concrete summary of the functions of each category making it easy to choose them according to the type of Smart Home user; this model has been chosen since it well stress on the concept of flexibility and adaptability of the same functions to the specific users' requirements, a point of fundamental importance. At the end of the paragraph, four possible summary perspectives from which the Smart Home functionalities can be exploited are listed: accessibility, inclusion, availability and sustainability. Then a quick overview on the enabling technologies follows in order to introduce the most commonly used communication protocols. Another important topic analyzed in this chapter is the one related to data valorization: each smart object can collect an enormous amount of information; understand how to exploit these data and how to extract value from them is crucial to get access to new business opportunities; the more information the firm is able to extract on the environment and/or on customers' habits and preferences, the better the products/services delivered can be. To conclude the paragraph, a spectrum of the emerging application for data analytics in the Smart Home field is presented. Subsequently, the current state of the global market and its growth forecasts are described, focusing on two perspectives: firstly, the geographical perspective, describing which countries at the moment have higher market shares in the world

and the ones that are expected to growth and develop in the near future; secondly, the market segment perspective, illustrating the sectors through which more value is created. Then a deeper analysis of the Italian Smart Home market follows. In the whole thesis work a particular attention has always been given to our national context, carrying out more in-depth analysis and comparing the results with the European and global situations. The first chapter is completed with a description of the main barriers and challenges to adoption of the Smart Home devices that could slow down the market growth; the barriers are grouped into: *situational-topic* and *individual traits* barriers; the first refers to barriers that are found in the IoT and Smart Home literature (security and privacy, dependence, intrusiveness, price, ease of use, value perception, novelty); individual traits consist, instead, in characteristics peculiar to each individual person.

Research questions and methodologies

The thesis objectives have been set out in the form of two research questions:

RQ1*: What is the state of the art of the Smart Home supply solutions in the international arena and in Italy?*

To understand the Smart Home world supply, it is essential to study the state of the art of the market and the characteristics and peculiarities of the offer, understanding how they have changed in recent years and getting insights about their future direction.

RQ2*: Which are the critical factors in the business model of a firm working in the Smart Home ecosystem that allow to create added value?*

Being the Smart Home a quite recent field of research, it is essential for a firm to understand which are the factors that lead to value creation, in order to encompass and enhance them in its business model and strategic decisions.

In order to pursue the aforementioned research questions, the methodologies exploited were:

- *Analysis of existing literature*, through which the context of the research work has been outlined. The academic materials have been found through online databases for scientific publications: Scopus and Google Scholar.
- *Analysis of secondary sources*, consisting in reports, website articles, white papers, digital market outlooks, producers and retailers' websites.
- *Qualitative framework,* some coming from the work of authors, others created during the work.

Current state of the art

In order to have a macro level picture of the Smart Home solutions available on the global market and in order to understand how the offer is structured, a database (Excel file), realized in collaboration with the Internet of Things Observatory of Politecnico di Milano, has been analysed. It consists in 698 Smart Home solutions, covering a time range from 2000 to 2020. Firstly, general information about the solutions analysed are provided, e.g. a brief description of the product/service itself; general information about the company that launched it; the year and the country of development; the industry and the sub-domain to which it

belongs to. Then, the information about the business model are exploited, e.g. the type of offer through which it is delivered; the availability or not of dedicated app and services; the possible integration with the two Smart Home speaker at the moment more diffused on the market (Amazon Echo and/or Google Home); the description of the communication protocol enabled; the main sale channels and, lastly, information about the pricing model are reported.

Having completed and described the dataset, an analysis of the data mapped has been done in order to describe the current situation of the market and to identify the main trends.

The first aspect analysed is the geographical one, considering both the continent and the country geographical distribution. Europe, America and Asia (China) account for 80% of the entire Smart Home worldwide market. About half of the analysed solutions belong to the European market and are mainly distributed in Italy, Germany and France. America is placed immediately after, with a higher concentration of the Smart Home market in the North of the continent, especially in the USA, that alone gives home to about 37% of the described solutions, gaining the first position among the countries analysed, far beyond the European ones. The factors that explain these results are: for Europe, the increasing number of European companies that in the latest years started to focus on the Smart Home market and the strong focus that during the analysis has been kept on our country: 20% of the mapped solutions come from Italy; for the North America, the fact that it was the earliest adopter of Smart Home solutions and that in past years has been the preferred nest of many startups, that move their headquarters particular in the Silicon Valley, where growth opportunities and possibilities were generally greater.

The second aspect considered in the data analysis is the distribution of the offer among different types of company: *Big player, Small and Medium Enterprises (SMEs*), *Startups*. The evidence is that the majority of the products/services are offered by Big Players and Startups, while SMEs are still a small portion in the sample considered. Startups were the first to exploit the opportunities in this business; indeed, in the years before 2014 more than 50% of the mapped products came from startups. Big players have started to take hold on the market from 2015/2016, when the Smart Speaker market born and spread. It is important to point out the link between giants and startups, that in the latest years is becoming stronger, thanks to the huge number of mergers, acquisitions and partnerships signed. Analysing how these different types of companies are spread in the global territory, it stands that in Europe the contribution of Big Players is fundamental, while the startups play a second role; on the other hand, in the area of America, especially North America, the startups dominate the market, given the fertile soil for them, as before assessed. Asia is showing a similar path compared to the European one, with Big players pulling the market, but followed by SMEs. This probably because the firms that provide solutions are mainly local, while startups do not find a fertile soil, due to licensing and censorship issues.

The further step is the analysis of the industries and the sub-domain to which the solutions belong. To categorize the industry, the type of product/service provided (furniture, personal care, domotics, household

appliances, consumer electronics, electrical equipment, platform, robotics, sanitary, sensors, security systems, utilities) and the class into which the company falls (eCommerce; retailer; GDO- Gross Domestic Market; OTT- Over The Top; telco; insurtech) have been taken into account. The most diffused one are: *Consumer Electronics*, followed by *Domotics* and *Household Appliances*. This distribution is verified for the whole world market, since both for America, Asia and Europe the results are quite aligned.

As far as the sub-domain analysis is concerned, among the wide existing application areas, the most important category on the market results to be *Security*, since it responds to a primary need of people: protection; *Household appliance management* and *Scenario management* follow. Household appliance sector, as prospected at CES 2020, is growing more and more, thanks to the application of AI and machine learning that allow the diffiusion of continuous learning systems embedded in the products offered. *Scenarios management*, instead, is relevant because of the importance that interoperability gains: controlling every device through a single hub/app is crucial to customers and nowadays it represents one of the biggest limit of the Smart Home solutions that companies are trying to overcome. *Lighting, Entertainment, Cooling/Heating, Environmental conditions monitoring*, *Other* (a category including all the products that do not fit the sub-domain analysed) follow, with a market share between 8% and 5%. As far as the devices for consumption management, *Water consumption monitoring appliances* are the most diffused ones, overcoming *Energy consumption monitoring* and *Electricity consumption monitoring* devices. The domain *People assistance* is noteworthy, since alone cover the 3% of the market. Lower common are the solutions for *Animal monitoring, Watering management* and *Smoke, flood, fire monitoring*.

Concluded the analysis of the first section, the factors deeply related to the business model of the companies (the type of offer delivered, the pricing model and the channels used) have been deeply analysed, in order to have an overview on how the companies act in the Smart Home market. Most of the companies result to have a business model that combines products and services; there is indeed an increasing attention towards the possibility to add services to the physical offer (e.g. information on energy consumption, cloud storage of data, notifications and alerts, 24/7 services); this is also confirmed by the increasing partnerships with professional technicians, utilities and insurances companies in order to complement the physical offer. Another aspect that merge from the analysis, it is the essential importance of the availability of a dedicate app (most of the case included in the price, so delivered for free), in order to remotely manage the physical device or allow the implementation of the service, via smartphones or tablets. The trend of servitization, before highlighted, impacts also on the pricing model proposed to the householders for paying for the offer. The *As a service* approach, although still less common, in recent years has shown a significant expansion and it is likely to grow more and more; currently, in combination with the *Una tantum* pricing model, it is the second preferred method. However, the *Una tantum* solution, in which the customer pays only at the purchase of the product/service, is still the most widespread method, mostly used by all the types of companies (OTT, startups and SMEs). This is probably due, as far as startups are concerned, to the companies'

financial capability: startups need to maximize revenues in the short run in order to support their business; as far Big Players and SMEs, probably to the inertia of changing the traditional most used pricing model and the lack of a real need for doing it. In the analysis of the pricing model, also the medium price of Smart Home products has been taken into account, considering the *Una tantum* pricing technique. Generally speaking, prices fall into the medium-low category (from €0 to €499,99), confirming the trend according to which Smart Home is becoming a mainstream domain, accessible to the most. Considering the different prices in the different countries, Europe, followed by America and Asia are the countries where the highest prices have been registered; this is probably linked to the maturity of the market: country where the medium price is higher are the same in which the market is more mature, probably because the basic products are already present in the most of the consumers' houses and consumers now require more complex and expensive solutions. As far as the link between the price level and the type of industry, Household appliances, Furniture and Sanitary are characterized by higher prices, given the volume and many functions or, in general, the more complex structure of the products offered.

Regarding the channels, *e-Commerce* is largely the most used one. For startups, it represents almost the only channel used, given the very low percentages achieved by the others, probably due to their need to directly reach the final customer, cutting costs. SMEs and Big Players, instead, tend to exploit more also the other channels such as *retailers* and *professional technician*. In particular, considering the different sub-domains, retail channel is more exploited by companies offering solutions related to the Home appliances management, probably because consumers prefer to see the product before making the purchase decision, given the economical effort required. While, professional technicians result to be a key figure in the Security, Scenario management, Cooling/Heating and also Home Appliances sub-domains, probably because in this fields it is more likely to come with more technologically complex solutions and installations. However, it should be specified that, considering the actual trend, e.g. the shift of focus of both the demand and the supply towards DIY products (self-installing and easy to use solutions), in the next future, the role of professional technicians will surely be resized.

Key factors in the business model and scenario framework

In order to understand how the different companies create value in the Smart Home ecosystem, the analysis of some firms' business model have been done. The study focuses on: the four Tech Big Giant (Amazon, Google, Apple, Samsung), two startups (AICO and FIBARO) and two SMEs (Homey and Eve).

As preliminary work, the definition in literature of both business ecosystem and business model have been studied, underling the strong link between them and the lack of a shared and universally used business model to describe how a company currently operates in the Smart Home area.

In order to run the analysis, among the huge number of models proposed in literature, the Business Model Canvas framework has been chosen, for its simplicity, versatility and diffusion both in the traditional and IoT fields. The BMC is made by nine building blocks covering the areas of offering (through the analysis of the

value proposition of a company), infrastructure (through the description of the key activities, key resources and key partners), customers (customer segments, channels and customer relationship), finances (cost structure and revenues stream). The financial part of the model, since outside of the research scope, has not been covered in the analysis.

The BMC has surely helped to business modelling the companies discussed, but, as a confirmation to what pinpointed by the literature, it does not provide a complete analysis; indeed, being a framework tailored to traditional businesses, although it can be adapted to the IoT areas, it does not let to deepen some topics peculiar of the Smart Home field. Got this point, the next step was to supplement the results obtained through the BMC analysis with a complementary framework.

More in details, the analysis made through the BMC let to highlight some important factors in the field taken into account and common to all the companies analysed, regardless of the type of industry to which they belong to: R&I, R&D, date gathering and info generation, IT infrastructure, the need to create value through services, the importance of key partners. At the same time, other factors considered to be of crucial importance for a firm working in the Smart Home field, such as the ones linked to the technological/innovation side and to user's experience as well as the relation with the external ecosystem, resulted to be still not clear.

The complementary framework developed is focused on the following key factors that complete the results obtained through the BMC and allow a more complete analysis of the firms:

- Disruptive technology: technologies that cause major changes within the industry, characterized by a high technology complexity.
- Integration: this imply the integration of different technologies, devices and scenarios.
- Economic impact: impact that each device could have on the current users' economic situation.
- Home type: type of home the consumer is living in. Each company should make its offer adaptable and usable in most of the scenarios.
- Usefulness: degree to which users see Smart Home new technologies as a necessity, valuable.

In order to give a summary representation, the critical factors identified have been bundled in two groups, called *driving forces*:

USERS EXPERIENCE
- Economic impact
- Usefulness
- Home type

TECHNOLOGICAL INNOVATION
- Disruptive technology
- Integration

These two driving forces allowed to deeply analyse how much each company gives importance to the technological/ innovative side and how it tries to cope with the new users' needs and requirements. By coupling them, it was possible to create a framework (a bi-dimensional matrix) that describes four possible Smart Home scenarios in which each firm could position itself and operate:

- *Hyper House* (high users experience; high technological innovation)

In the top right corner scenario companies create synergies and launch new, disruptive and integrated products, technologically complex but, at the same time easy to use and adapt. This represents the best case scenario that each company, through its way of operating, could work in.

- *Flowed push* (low users experience, high technological innovation)

In this top left scenario companies collaborate and together push towards innovation, but consumers are not pushed to adopt new Smart Home products and/or are not able to use them in the optimal way, making the most of all their features.

- *Practical pull* (high users experience, low technological innovation)

In this bottom right scenario, the products offered are clear, easy to use, financially accessible, but, on the other hand, do not perfectly respond to the need of innovation and integration.

- *Stagnant* (low users experience, low technological innovation)

In this bottom left scenario both technological innovation and users' experience are at their lowest point. Companies are neither able to find synergies, coming up with innovative and integrated technologies, nor to make people recognizing the added value that Smart Home products/services could bring to their lives.

The last step in the thesis work was to qualitative evaluate the factors aforementioned for each one of the firm taken into consideration *(Table 1),* and then plot each firm in the framework built *(Figure 1),* evaluating in which scenario it actually operates and highlighting which factors it could improve in order to reach the best case scenario.

	TECHNOLOGICAL INNOVATION		USERS EXPERIENCE		
	Disruptive technology	Integration	Economic situation	Usefulness	Home type
Amazon	🟢	🟢	🟢	🟢	🟢
Google	🟢	🟢	🟢	🟢	🟢
Apple	🟢	🔴	🟡	🟢	🔴
Samsung	🟢	🟢	🟢	🟢	🟢
AICO	🔴	🟡	🟢	🟡	🟡
Fibaro	🟢	🟢	🟡	🟢	🟢
Homey	🔴	🟢	🟡	🟢	🟢
Eve	🔴	🔴	🟡	🟢	🔴

🔴 low 🟡 medium 🟢 high

Table 1: Evaluation of the key factors in the Smart Home field for the different companies

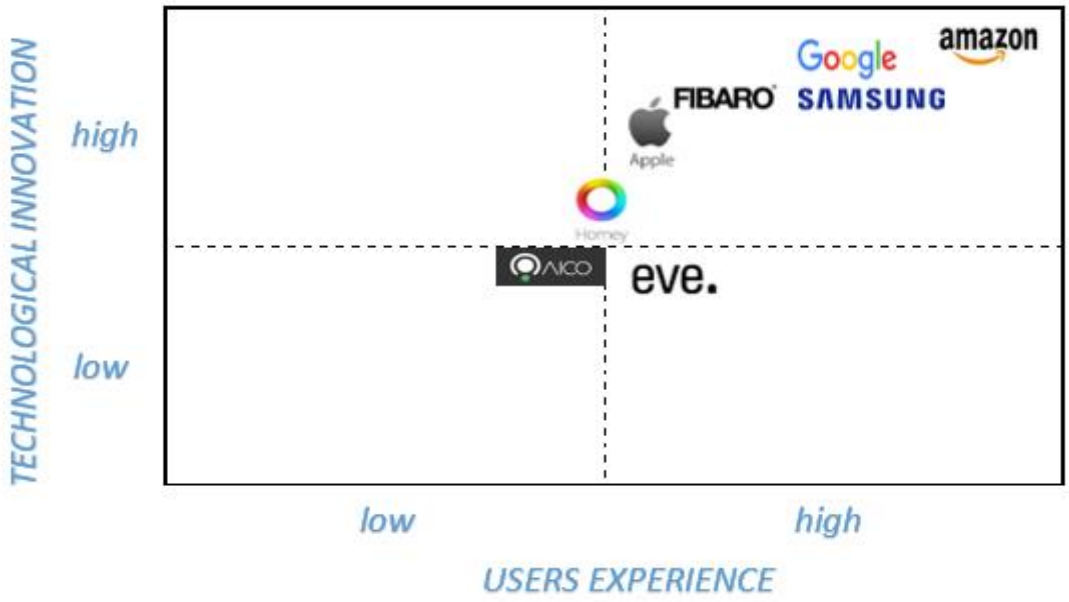


Figure 1: Inclusive final scenario applied to the analysed companies

To sum up, all the OTT industries, nowadays, are the ones that most contribute to create the best scenario, indeed, they operate and position themselves in the *Hyper House* quadrant. Amazon, Google and Samsung cover more or less the same position, while Apple position is slightly different, since its focus on users experience and integration is lower. However, it is needed to specify that in the actual market, the collaboration among firms is still weak with respect to ideal case, since each actor still try to dominate the market. A relevant insight is given by FIBARO, that has a position really similar to the OTT companies, though being a startup. It indeed hardly pushes for innovation and integration, as the analysis of its value proposition through the BMC confirms AICO and the SMEs are all in the middle, with minor differences on some factors. As far as AICO is concerned, it has been positioned in the top right corner of the quadrant *Stagnant*; this choice because the company's flagship product SmartEgg is based on simple and not so versatile technological standards: bluetooth and infrared. Homey, with its hub available in more versions and characterized by a high versatility, assure the compatibility with more than 50000 devices and 1000 brands, although the technology behind is not so complex neither innovative, while Eve is more shifted towards the quadrant *Pratical pull*, having a low interoperability. In conclusion, it would be desirable that each company move more and more towards the top right corner, in order to contribute to the creation of a winning, cross-industry and mainstream ecosystem and to not remain excluded from it. It is indeed necessary to deliver innovation but at the same time to shift the design to a user-centred approach. Indeed, assessing the effects of new technologies on people's lives and adapting them to the real users' needs is essential. Each firm should be able to make its offer appealing to the users, in terms of price, adaptability (e.g. with the type of house/ objects already hold/ external scenario), inclusion and usefulness (users should see the solution offered as a necessity) as well as appealing in terms of innovation.

CHAPTER 1: THE SMART HOME

The aim of this chapter is to introduce and define the concept of Smart Home, that represents the topic of this thesis. Man has dreamed of it for centuries: a home at the service of man; think of the extraordinary devices connected in the rooms of the Pyramids, of the self-propelled machines for Nero's Domus Aurea, or of the dream of mechanical automata, already connected in the seventeenth century. Ingenious devices that followed in the history, until nowadays, when we can finally really talk about the Smart Home. However not everybody still has a correct and concrete understanding of what this term means. The matter will be deeply discussed in the following sections. First of all, it is clarified the difference between the concepts of Domotics and Smart Home; then, Smart Home main features and functionalities are presented according to different classifications. Then a quick overview on the enabling technologies follows in order to introduce the most relevant communication protocols. Subsequently, a paragraph is dedicated to the current state and growth forecasts of the Smart Home market, followed by a discussion on the barriers and challenges to its adoption. Then the different channels used to reach customers are described with a brief mention of the topic of data valorization. The last part of the chapter is dedicated to the description of new trends and to the analysis of the smart assistant.

1.1 The concept of Domotics, Home Automation and Smart Home

The terms *Smart Home, Domotics* and *Home Automation* are often used interchangeably, but there is an actual difference between them, even though they're strictly linked.

The term *Domotics*, was the first to be born. It basically means the electronic and automatic control of household features and appliances. A clear agreement about the etymology of the word *Domotics* cannot be found and it is often explained as (*domus* = house) + *informatics* = domotics, or as *domus + robotics* = domotics, or *domus + tica* (automatics in Greek) = domotics.

Neither there is the possibility of finding a single reference about Domotics. The best known authors and those who have documented this discipline, set its origin in the 1970's, when the x-10 technology began to be used. In the history and in different civilizations, several artefacts and inventions oriented to perform a domestic work followed, but the real step forward happened with the advent of electricity, that drives industrial automation systems and home automation. Therefore, the era of the "cooling machines" begins. From the first cooling machine of William Cullen in 1784, it is not until 1927 that we can find the first domestic and almost immediately, in the 1930s, Willis Haviland Carrier invented the residential air conditioning systems. But only in 1970s there was a milestone that marks a change: the introduction of the X-10 technology in the building process. This technology defines a communication protocol between electronic devices that uses low voltage electrical installation existing in dwellings to connect these devices. Therefore, we can also say that home automation arises when man gets rid of the artefacts and decides to automate

directly the environment in which he lives, the architecture, through the inclusion and integration of information networks, computers, electronics and mechanisms.

French dictionaries are the first to propose in 1988, of an official way, the first definition for the term *Domotique*, in the field of new technological terms, due to the French professor of the Rennes University, Marc Humbert.

Definition: *Domotique is the concept of housing that integrates all security automation, energy management, communications, etc*. (Larousse, 1988).

This first definition is rather general, but it is the first attempt to provide a definition to the term and reflects the desire to automate the most services offered.

The latest literature suggests that the term Domotics is strictly linked to a technological aspect more than others, a collection of technologies that allows to automatize actions in the house and to reduce human intervention (Monteiro P. et al., 2015).

In Italy this term first appeared before 2000 with BTicino, preceding the worldwide digital revolution marked by the birth of the first iPod and smartphone.

Even nowadays, there is not a single definition widely accepted, and for that reason, many other expressions, namely *Home Automation* and *Smart Home* have appeared to describe the automated buildings and homes.

The term *Home Automation* has been around for ages, even before the era of the internet. The simplest example is a motion sensor lights automatically that turn on and off, a timer that let to turn on/off at specific times a device. Home automation altered the worlds of lighting design, landscape maintenance, temperature control, home security, entertainment (television viewing, dinner preparation).

To sum up, home automation creates a system that doesn't need human constant attention— it's a system that can function by itself. Home automation is a sort of enabler of Smart Homes and represent just one of its features. Indeed, in today's advanced technology, home automation has become part of a Smart Home.

In an automated Home, automated devices and appliances are generally set up to be controlled by something the user wields like a remote control; the Smart Home takes this one step further: it incorporates smart devices into running many parts of the home seamlessly by themselves without human direction. For instance, a smart device includes an embedded operating system with user interface, is capable of supporting multiple tasks and runs autonomously. According to an article published by Michael Porter and James Heppelmann in the Harvard Business Review in 2014, smart products are those that incorporate things such as microprocessors, sensors and software that allows them to run autonomously, for example on a timer or schedule. They're also capable of doing more than one thing.

The term *Smart Home* was coined by the American Association of House Builders in 1984 (Solaimani S. et al., 2011). As for *Domotics*, several definitions of *Smart Home* exist in literature.

"Smart Home is the integration of technology and services through home networking for a better quality of living." (Robles R. J. and Kim T., 2010)

"A private home with many devices of home automatization, consumer electronics and so on, which are intelligent. The networking of these devices should generate new services and additional benefits for the residents." (Strese H. et al.,2010)

"A home which is smart enough to assist the inhabitants to live independently and comfortably with the help of technology." (Dobre C. et al.,2006)

This thesis will work with the concept of the Smart Home according to a definition and description similar to this one, in line with Balta-Okzan et al. (2014) "a Smart Home is a residence equipped with a communications network, linking sensors, domestic appliances, and devices, that can be remotely monitored, accessed or controlled and which provide services that respond to the needs of its inhabitants".

The term *Smart Home* is usually used when referring to a home that comprises TVs, computers, lighting, heating, entertainment systems, security systems, and other electrical and electronic appliances that are able to communicate with one another and that are controllable remotely, via a smartphone and the Internet, used to better the quality of life of the inhabitants.

So to sum up, a Smart Home is truly and essentially an automated home, but the term could be used to only refer to a residence that comprises a plethora of smart devices— devices that don't necessarily function by themselves, generally connected to the Internet, which enables devices to be 'smart'.

Using your smartphone to turn on the foyer light before you unlock the front door? That's the Smart Home at work. Programming your Smart Home hub so that it automatically turns on the foyer light if you unlock the front door after sunset? That's home automation!

Today, tech giants like Google, Apple, Ring, Samsung, Philips, Amazon, and many others have produced a wide range of Smart Home devices ranging from smart lights, thermostats, door locks, security cameras, speakers, light switches, smart assistants, etc. many of these smart devices can be operated and monitored remotely, ultimately turning a home into a Smart Home.

1.2. Characteristics, key features and functionality of the Smart Home

Though the analysis of the existing literature it is possible to define the main elements, key features and functionalities of the Smart Home.

According to Larsen K. (2010), as explained in his paper "Smart Home technology", the Smart Home necessarily consists of this three elements:

- firstly, single functioning devices that operate independently to provide a functions, for example temperature, lighting, entertainment, air quality, water quality and so on. They can be sensors, detectors, meters, switches etc. able to be operated under remote or automatic control.
- secondly, centralized control unit, like control panels or smart mobile devices (phones, tablets) which can control all single functioning devices. The control is conducted via remote (the wireless network Wi-Fi is the mostly used).

- thirdly, shared protocols interacting among the devices and outsiders, e.g. control centres, data processing centres. The protocol setting becomes one mandatory element of a Smart Home being utilized widely and wisely, for instance operated in the context of Internet of Things (IoT).

Another view is proposed by Balta-Ozkan et al. (2013), according to whom the Smart Home is characterized by four key aspects:

- a communications network that enable the communication among different devices;
- intelligent controls to manage the whole system;
- sensors that collect information;
- smart features that on the base on both the data coming from the sensors and the instructions given by the users, respond and act (e.g. respectively a thermostat that autonomously adjusts the temperature and the remote control of home appliances).

As far as the functionalities are concerned, as for the definition and the characteristics, a unique classification of the functionalities offered by the Smart Home does not exist.

Various and many models are proposed by the existing literature; some of them are shown below.

Alam M. R. and Alauddin M.A. (2012) identify three macro areas of functionalities:

- Comfort: the increase of users' comfort is presented in this paper as one of the main goal of Smart Home applications, reachable in two possible different ways. The first is related to human activities detection and identification and then automation of the local environment. The second implies remote home management from distant locations, including the solutions that, through the knowledge of human activity and behavior, automatically control home appliances in order to improve the energy efficiency.
- Security: it represents a crucial users' need. People want to feel safe at home and want to be able to control what it is happening when they are away. According to the author a Smart Home should satisfy this need, in first place bettering security problems related to weak user and device authentication schemes.
- Health: Smart Homes can offer healthcare facilities for especial users, i.e. patients and elderly people. This is implementable though both a local and remote control of the health conditions of a user, in order to provide immediate medical support in case of emergency situation and danger.

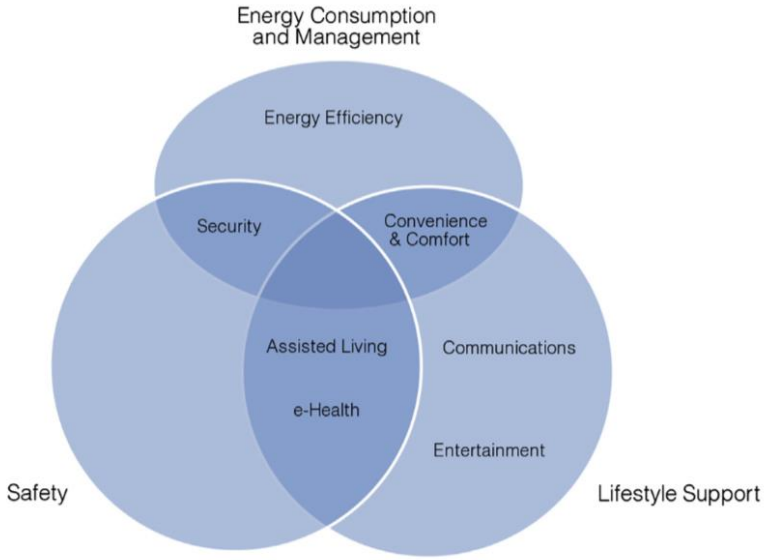


Figure 2: Types of functionalities offered by Smart Home devices; Lê Q. et al. model

Lê Q. et al. (2012) divided the main types of functionalities offered by Smart Home devices into three macro-categories: Energy Consumption and Management, Safety and Lifestyle Support (***Errore. L'origine riferimento non è stata trovata.****2)*. With respect to the previous model illustrated, this one underline a new field: Energy Consumption and Management. The other two aspects analysed can be compared to previous classification: health field and Comfort category respectively. What the author outlined is that a strict classification is not possible and should be avoided: some functionalities do not perfectly fit in just one category; e.g. applications devoted to Assisted Living and e-Heath, for example the ones developed to support old people, belong both to the Safety and to the Lifestyle Support areas.

Luor T. et al. (2015) proposed another classification, dividing the functions of Smart Homes into security, automation and entertainment.

- Security, according to the author, is the most mature application scope and encompasses all the preventive and predictive measures for a better control of the property. A typical example is an alarm system.
- Automation, that refers to the automation of the building and of the household activities. It encompasses, for example, the applications for lighting, air conditioning, heating, home appliances management. Although this category is presented with a different name, it can be compared to the lifestyle management/ comfort category before analysed.
- Entertainment is a new field, not considered in the papers analysed before; it refers to a home cinema and theatre, e.g.: smart TV, touch-screen to play music, web links for shopping and news.

The last model taken into account is suggested by Hamernik et al. (2012). The author proposed a classification of functions in order to cover the greatest range of users *(Figure 3).*

- Group Electro is a set of several functions such as control systems, planning operations in a specified time, control appliances (like kitchen appliances) and control via SMS. Very important part is the placement of individual elements and components: individual functions are centralized in a single controller, facilitating the access to the system.
- The group of Audio/Video includes individual functions such as home theatre, music and games, with a central library of multimedia, internet access and email. This section can be likened to the "entertainment group" explained three years later by Luor T.et al.
- The group Environment, energy and Health oversee the health/ wellness of the user. For example, a simple download window shutters can save costs on cooling, saving modes in the absence of users, family doctor, drug dosage. Generally speaking, this group encompasses most of the function of health, lifestyle support/ comfort and energy management groups, analysed in the previous models.
- Security group, that involve functionalities to protect both the home and the users (for example control of the children); it reflects the functions of the group *Safety*, widely described above in the other models.

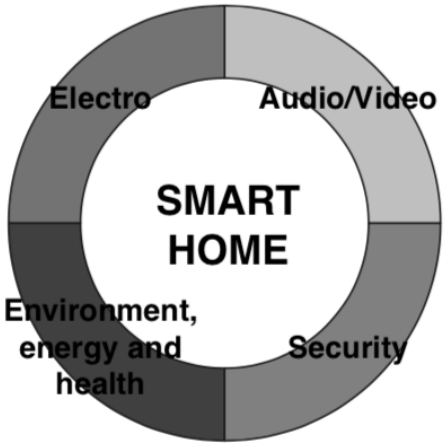


Figure 3: Classification of the Smart Home functions; Hamernik et al. model

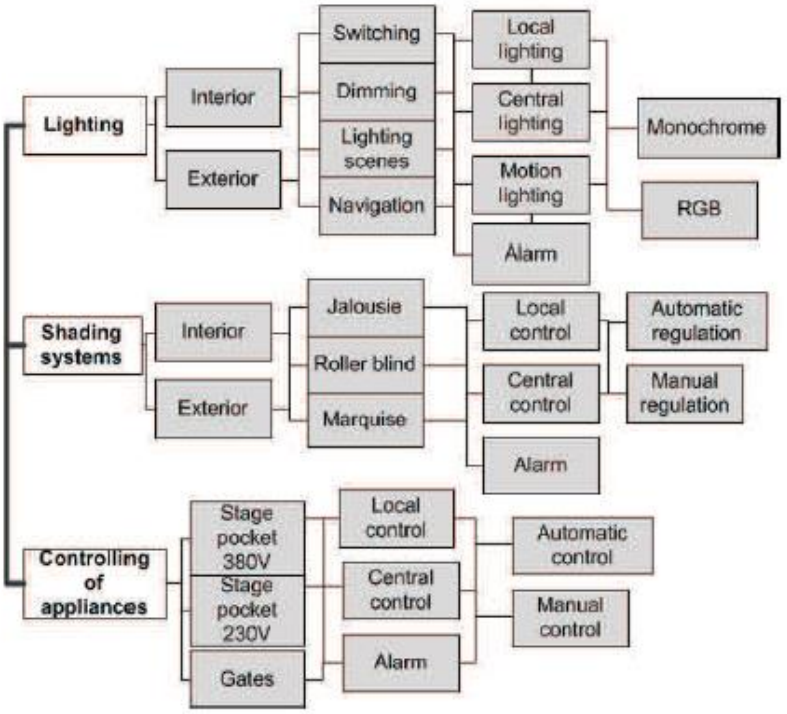
In the same article the author proposed a more concrete and detailed division of the groups functions, divided according to their application in the Smart Home:

- Lighting, that includes: local lighting, central lighting, navigation lights, emergency lighting, lighting scenes.
- Shading system: shielding elements of the interior or exterior, to provide a comfortable temperature and also to ensure the security and privacy. E.g. jalousie, roller blind or marquise.
- Controlling of appliances, that can be automatically or manually and let a two-way communication with the device.
- Heating, ventilation and air conditioning, that are important functions that make up a significant part of Smart Home functions. They provide thermal comfort.

- Safety functions.
- Multimedia, e.g. home cinema, hi-fi system, digital images, Voip phone, intercom or piano, that allow to control and monitor the Smart Home.
- Health, e.g. lift used for disabled people, GPS systems, exercise programs, smart toilette
- Kitchen, which facilitate the preparation, control and order food
- Irrigation system
- Clean, to ensure user comfort
- Control: intelligent control of the house is possible by phone, touch panels, remote controls, and switches, connecting via the internet or by voice.

According to the theory presented, all this functions can be organized in a three-dimensional structure:

- the standard group (*Figure 4*). It encompasses basic functions which are an essential part of Smart Homes.



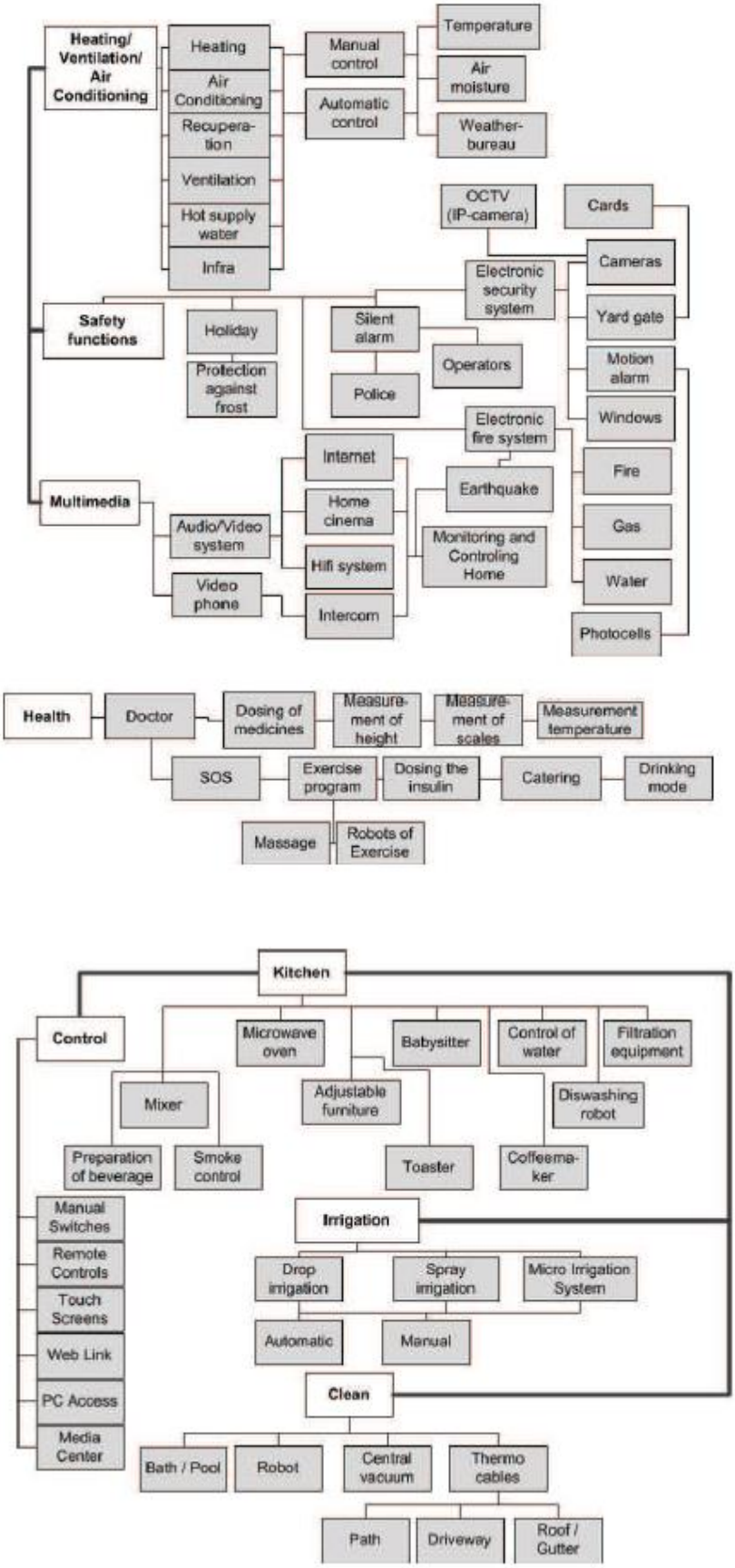


Figure 4: Functions included in the standard group; Hamernik et al. model

- assistance group (*Figure 5*), that includes functions intended for specific users and are like a superstructure of functions in basic group

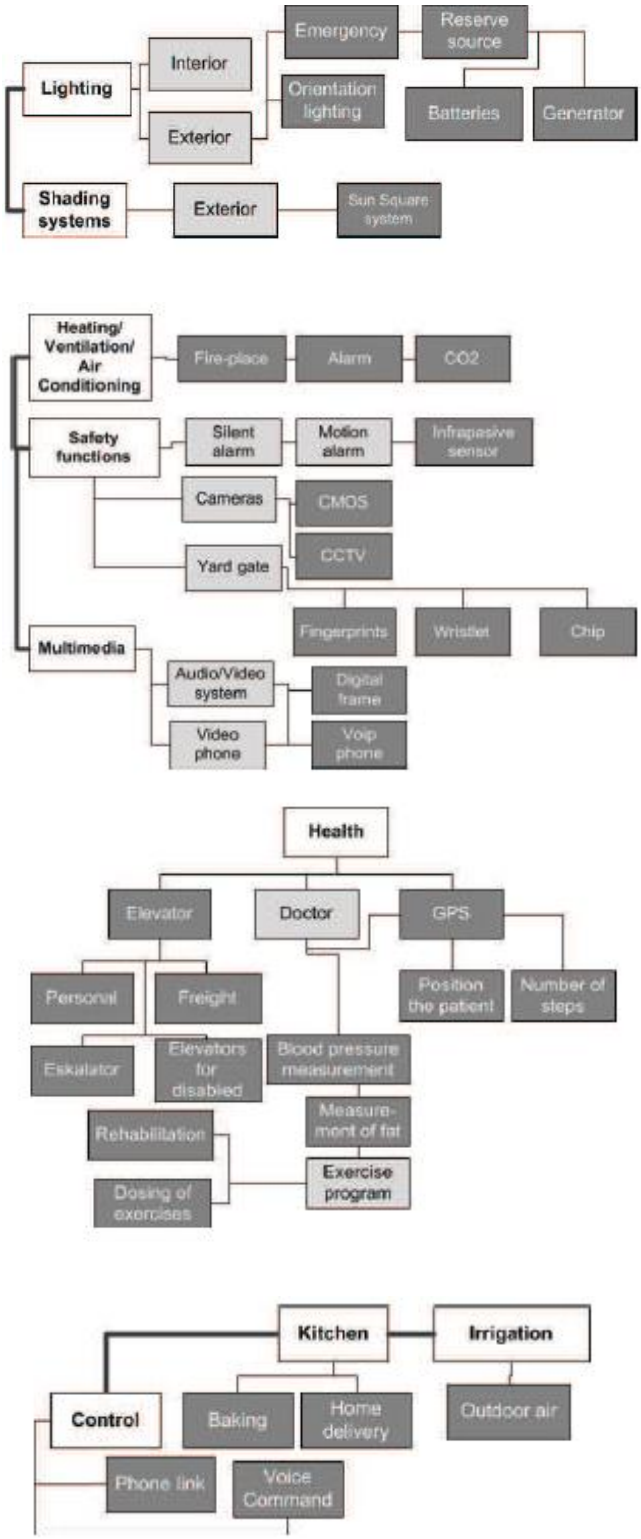


Figure 5: Functions included in the assistance group; Hamernik et al. model

- comfortable group (*Figure 6*), that includes functions not necessarily required to operate the Smart Home and which implementations has a higher cost.

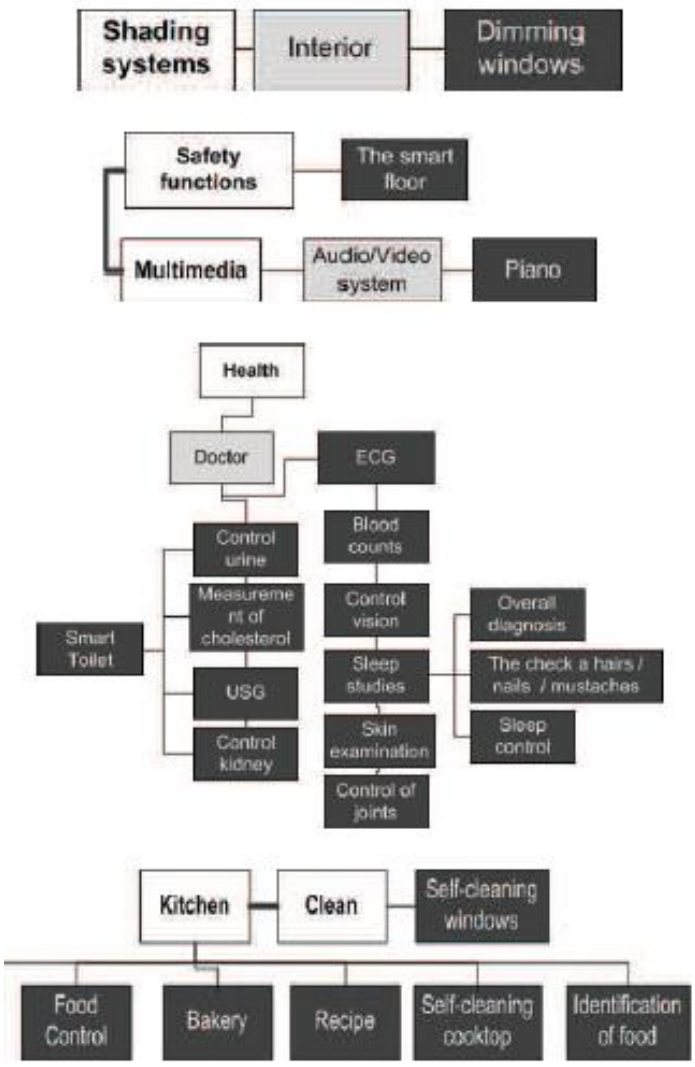


Figure 6: Functions included in the comfort group; Hamernik et al. model

With this original and worthy of attention model, the author categorized the function by level of importance to the operation of Smart Home, provide a concrete summary of the functions of each category and make it easy to choose the function according to the type of Smart Home user. From my point of view this is very important, since it stress on the concept of flexibility and adaptability of the same functions to the specific requirements; the resulting optimal solution depends on the type of user that has to select the home functionalities.

Taking into account the literature analysed and the state of the art of the market, from my point of view the key features of a Smart Home can be explored from below four perspectives:

- Accessibility

The Smart Home devices should be easy to access and use, also remotely. Many cases of utilizing accessibility benefit can be found in safety function and into the field of environment management, for example with detecting devices for pollution.

- Inclusion

There should be no limitation in terms of age, gender, and ability (disabled, people with motor difficulties) of end users of the Smart Home, since anyone can use the devices or can be helped remotely.

- Availability

It should be always possible to operate, monitor, control the Smart Home, anytime and anywhere.

For example, decide when and how to set the temperature of the building, lock/unlock doors, switching on/off the lighting, irrigating the garden.

- Sustainability

Smart home technologies, such as smart appliances and smart meters, enable an easy and optimized energy management system. Addressing it into a larger social scale, Smart Home can be considered the basic component actively contributing to the smart city, enabling a better energy management and reducing pollution emissions.

1.3 Enabling technologies

The aim of this paragraph is to explore the fundamental principles and concepts of the key enabling technologies for the Smart Home appliances. This pervasive and cooperative computing technologies perform a central role for handling the challenges of Smart Home diffusion. Below an overview of the most commonly used.

- *Ethernet*

It is a standard that was born to connect network resources together in a simple and efficient way. It was created in the mid-70s in the Xerox PARC labs by Robert Metcalfe and his assistant David Boggs, with the original goal to obtain a transmission capable of 3Mbps using a coaxial cable in low traffic conditions capable of tolerating occasional load peaks well. With the passage of time the interest of the companies in the sector increased more and more; in 1985 there was the publication of the first version of the IEEE 802.3 standard, which was based on the original Ethernet specification. Subsequently, the Ethernet standard was completely abandoned in itself, but the term continues and is in use almost as if it were a synonym of IEEE 802.3, even if, the two standards do not completely coincide. The limited costs and high reliability, but above all the growth of the Internet, have favoured a considerable diffusion of this protocol which has become the most used in LAN networks, it has also had a good diffusion in the industrial field, where it is used for the control and monitoring of plants and systems. Also for what concerns the home automation field it is a widely used standard thanks to its versatility and the great variety of compatible devices and applications available on the market.

- *Bus*

It is an open standard for fieldbus, developed in 1989 by a number of companies which founded the following year the Bati-BUS Club International. Each communication packet sent is composed of a fixed number of control bytes which are used to indicate the receiving device, or are used for error control or address, plus a variable number of bytes of data which contain instructions or commands. Nowadays, after the convergence

process with the EIB and EHS standards, the BatiBUS is agreed in the new KNX standard (Konnex) which aims to become the European reference system for home automation.

- *Wi-Fi*

Wi-Fi is one of the most widespread standard protocols for the transmission of information in digital format, both in houses and industries. The name Wi-Fi stands for the IEEE 802.11 standard used for wireless local area networks (WLAN), which are short-distance personal networks without thread.

It was built in 1999 with the intent of replacing Ethernet using wireless communication over unlicensed bands. Its goal was to provide off-the-shelf, easy to implement, easy to use short-range wireless connectivity with cross-vendor interoperability. Wi-Fi is an obvious choice for IoT connectivity because in-building Wi-Fi coverage is now almost ubiquitous, however it is not always the appropriate choice. Data transfer requirements for IoT vary from small, intermittent payloads like utility meters to large amounts of continuous data such as real-time video surveillance. Range requirements can span from very short distances for wearables to several kilometres for weather and agriculture applications. Wi-Fi has limitations: high power consumption, moderate range and spectrum congestion. The IEEE addressed these shortcomings by publishing specifications for 802.11ah and 802.11ax.

- Wi-Fi HaLow (802.11ah) technology is based on the IEEE802.11ah standard ratified in October 2016. It was introduced specifically to address the range and power concerns of IoT. 802.11ah provide extended range with low power requirements. It allows for station grouping to minimize contention and relay to extend the reach.
- HEW (802.11ax), High Efficiency Wireless (IEEE802.11ax) standard also adds a number of IoT friendly features. It retains the targeted wake time and station grouping features from 802.11ah to allow the clients to be power thrifty and avoid collisions.

- *Bluetooth*

This technology is a technical-industrial standard for WPAN (Wireless Personal Area Network or personal wireless networks) which represents a method standard, cheap and safe to exchange data between different devices using a short range radio frequency. This specification was developed by Ericsson and later formalized by SIG (Special Interest Group); the purpose of the SIG was to put on the market an economic standard, using the radio system, which operates at frequencies of about 2.4GHz with a maximum achievable speed of 1Mb/s relative to a distance of a few tens of meters. Today it is present on billions of products. In order to be compatible with Bluetooth, an IoT device must have a microprocessor that can handle Bluetooth, as well as a second device to pair with it. The Bluetooth protocol actually has two different versions commonly used by IoT devices that cannot directly communicate with each other: Bluetooth Classic and Bluetooth Low Energy (BLE), which is designed for devices that need to consume low amounts of power. The easiness of use and the low cost represent its two main advantages.

- *ZigBee*

Zigbee is a standards-based wireless technology developed in 2003 by the ZigBee Alliance to enable low-cost, low-power wireless machine-to-machine (M2M) and internet of things (IoT) networks. Zigbee is an open standard, for low-data rate, low-power applications; in contrast to Wi-Fi networks used to connect endpoints to high-speed networks, Zigbee supports much lower data rates and uses a mesh networking protocol to avoid hub devices and create a self-healing architecture. On the market there are three Zigbee specifications: Zigbee PRO, Zigbee RF4CE and Zigbee IP. Zigbee is used by a variety of cable and telecommunication companies, by vendors for Smart Home products (thanks to the ZigBee technology consumers can control LED figures, lightbulbs, remotes and switches in home and remotely to improve energy management), by utility companies in their smart meters to monitor, control, inform, and automate the delivery and use of energy and water. Recently, the Zigbee Alliance rolled out "dotdot," a program to extend its interoperability technology beyond Zigbee. Dotdot, a universal language for the internet of things, lets smart objects work together on any network, unlocking new markets for members and unifying the fragmented IoT.

- *Z-Wave*

The Z-Wave protocol is a wireless, radio frequency (RF) based communications technology designed particularly for control, monitoring and status reading of household applications. It was developed in Denmark in 2001 and become over time a relevant international standard. Z-Wave supports full mesh networks, enabling numerous Z-Wave devices to communicate with each other simultaneously. Z-Wave allows for secure and low power consuming communication between approved Z-Wave devices. Due to its interoperability, Z-Wave encompasses a broad ecosystem of intelligent products that work together between brands and models. Today, over 50 million Z-Wave products have already been sold worldwide.

- *Insteon*

Insteon is a home automation protocol designed to bridge the gap between wired (AC power-line) and wireless protocols as it can use both. It is one of the most complete solutions on the market. So among its benefits, the most important is compatibility. Insteon has a large range of devices with over 200 products currently available. From lighting control to integrated security systems and leak sensors they add remote control and automation to all types of home control applications. Insteon has also partnered with some of the leading accessory manufacturers and platforms, including the Works with Nest and Apple Home Kit programs.

- *Thread*

Thread is an IPv6-based, low-power mesh networking technology for IoT products, launched in July 2014, by "Thread Group" alliance. It is a working group with the companies Nest Labs (a subsidiary of Alphabet/ Google), Samsung, ARHoldings, Qualcomm, NXP, Semiconductors/ Freescale, Silicon Labs, Big Ass Solutions, Somfy, OSRAM, Tyco International, and the lock company Yale in an attempt to have Thread become the industry standard by providing Thread certification for products. In August 2018 Apple joined the group raising hopes it will help popularize the protocol. The Thread protocol specification is available for

free, however this requires an annual membership fee. In 2019, the Connected Home over IP project, led by Zigbee, Google, Amazon and Apple, announced a broad collaboration to create a royalty-free standard and open-source code base to promote interoperability in home connectivity, leveraging Thread as well as Wi-Fi and Bluetooth Low Energy.

1.4 Data valorization

Data analytics has futuristic and hopeful possibilities for efficiency gains and optimization. Analytics involves using algorithms to identify patterns in data that can provide actionable insights. Smart Home objects are equipped with processors, sensors, software and connectivity, favouring an exchange of information between the product and its environment, manufacturer, user and other products and systems. Some product functionalities can exist even outside the physical device, in what is known as a product cloud. Data is the fundamental unit of all these digital processes. With the technologies available on the market, a single Smart Home can generate hundreds of thousands of transactions every day: each smart object can collect an enormous amount of information. Despite this, most of this data remain unused. However, understanding how to exploit these data, how to extract value from them, is crucial to get access to new business opportunities; the more information can be extracted on the state of the environment or on the habits and preferences of the customers, the better the product or the services provided can be. So data is a key element in the Smart Home and it is a competitive success factor. Smart home data analytics solutions are currently focused on customer engagement; however, this is only the beginning of what can be done with residential analytics solutions. Utilities are employing data analytics solutions to provide customers with more information about their energy consumption and specific ways in which they can reduce use and save on energy bills. Hardware vendors are also involved in the Smart Home data analytics market by including free analytics with the purchase of hardware. An example of a company employing this business model is Nest, which offers, with its Learning Thermostat, an app that reveals user energy consumption. The thermostat itself also employs analytics to learn consumer behaviour patterns for automatically adjusting the temperature. Though consumers do not pay for these capabilities directly, companies generate revenue for these analytics services through the initial price of the device.

Below is presented a spectrum of emerging application for data analytics such as automation in the Smart Home *(Figure 7).*

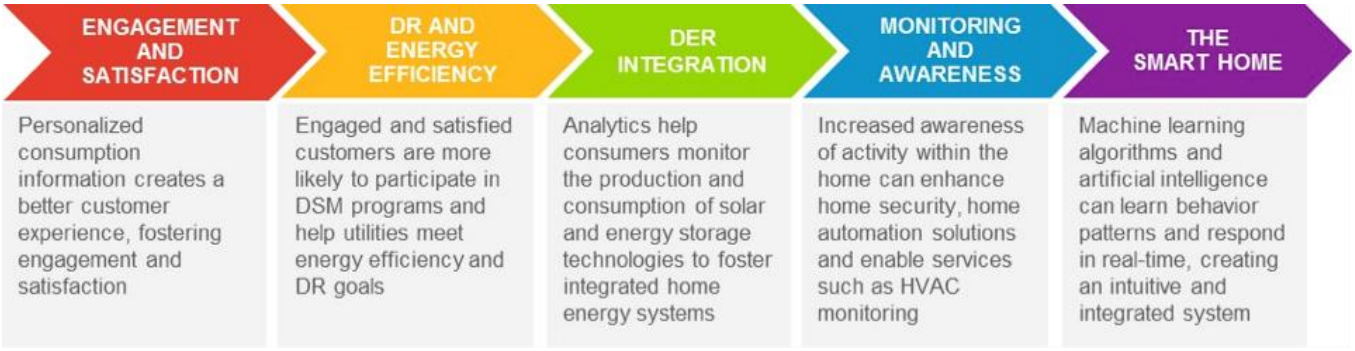


Figure 7: Applications for data analytics; Souce: Navigant Consulting

Though the market is still emerging, analytics in the Smart Home can offer in future lots of other opportunities and have the potential to be used for much more advanced applications. However, there are still many challenges for the Smart Home data analytics market to overcome. The two biggest barriers are:

- Data privacy and security; there are strict laws protecting consumers' data, but these also prevent companies from experimenting with data to create new services and from exploring how to add value to existing solutions.
- Lack of interoperability among Smart Home products; this inhibits market growth. In the connected home, devices that cannot communicate with each other due to incompatible protocols and communicating technologies result in disparate and inaccessible streams of data that cannot be used to create value.

So far, the strategies of data valorization enabled by the IoT are not so developed; however, Big Players like OTT are starting to explore them. This aspect will be fundamental for the further development of the sector *(IoT Observatory, Politecnico di Milano, 2016).*

1.5 Current state of the market and growth forecast

The Internet of Things (IoT) applied in the context of a private household, commonly known as a Smart Home, is one of the hottest topics when it comes to digitization and disruptive changes to traditional industries as pointed out by one of the latest report of the IoT Observatory of Politecnico di Milano (2019) and also testified by the consistent presence of Smart Home devices at the last CES (International Consumer Electronics Show) in January 2020. In 2019, the global Smart Home market was valued by Statista at EUR 73,719 billion. The main countries involved, that generate a considerable part of the global market value are:

- U.S.A. with EUR 24.486 million
- China with EUR 18.500 million
- Germany with EUR 4.272 million
- United Kingdom with EUR 4.258 million
- Japan with EUR 4.233 million

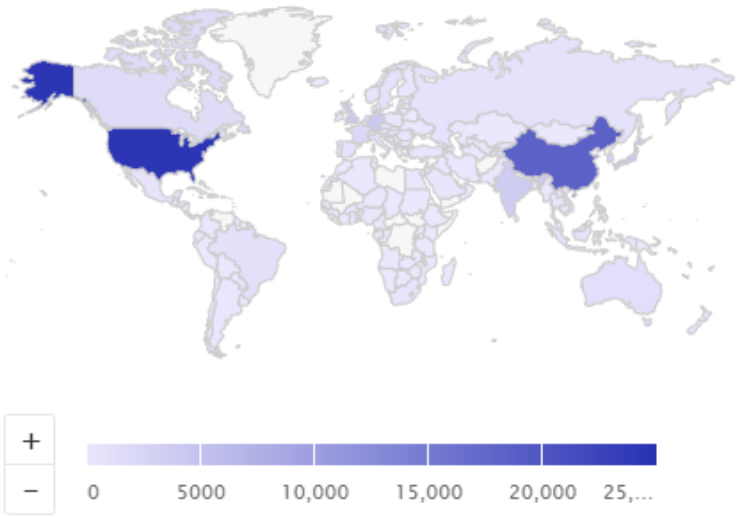


Figure 8: Revenues generated by the Smart Home market around the word; Source: Statista

Smart Home devices cover many market segments based on their functionality.

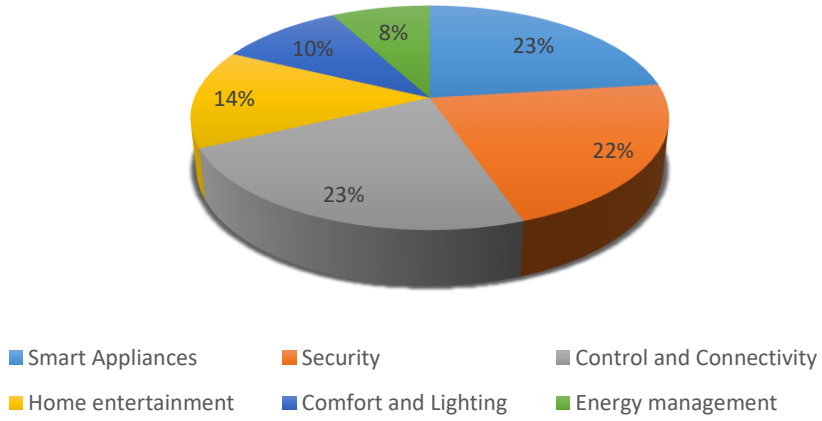


Figure 9: Global percentage distribution of the different Smart Home market segments

The most important sector is Control and Connectivity. In 2019 the amount of revenue is US is $17.161 billion which correspond to 23.27% of the global market. The segment provides the infrastructure for the connection of Smart Home IoT devices. The products from this segment enable communication between devices as well as between humans and devices. It includes smart speakers (Amazon Echo, Google Home, etc.), central control and communication units (hub/gateway), programmable control buttons (e.g. wall switches and adjustable dials) and smart plugs for the control of non-smart devices. A considerable amount of revenues are also generated from services that support these hardware elements such as control apps and connectivity services. Smart Appliances segment ranks second with US $16.972 billion which correspond to 23.02% of the global market. They are specialized equipment programmed to run from a central system. Any domestic device can be a smart appliance and, though they are not cheap, many times they can be leased

instead of bought in order to cut down on the price. Plus, they could also be hooked up to the manufacturer as well, so, for any kind of problem, the manufacture can get an immediate notice of the problem and estimate of the repair. The attractive point is that the users gain more control, giving up control, since Smart Homes think for themselves. In third place there is Security with US $15.930 billion which correspond to 21.60% of the global market. A Smart Home security system is effectively a burglar alarm with motion sensors and wireless camera in one (in the basic case), with the ability to connect to smartphones or tablets. This means that the user can watch footage from the connected wireless security cameras and be alerted if a motion sensor detects an intruder, even when if he is located miles away. On the market a wide range of different sensors-room, door, window and outdoor/ indoor cameras are available, depending on which hub is used. Many systems offer "starter kits". The fourth place is occupied by Home entertainment with a US $10.474 billion revenue which correspond to 14.20% of the global market. Home entertainment is the application of technology and the arts for private amusement and enjoyment. The proliferation of the microprocessor and digital media has produced a wide variety of innovative technologies for home entertainment. People also increasingly use personal computers networked to the Internet for games and chats. Electronic "toys" such as the Sony AIBO robotic dog, high definition television (HDTV), music keyboards and synthesizers and digital video recorders such as the Philips TiVo, are becoming increasingly popular sources of home entertainment as well. Comfort and Lighting is in the fifth place. The worldwide revenue is of US $7.339 billion which correspond to 9.95% of the global market. This segment comprises devices for the general improvement of the living atmosphere and lighting in a Smart Home. This includes products like smart bulbs, window- and door-sensors as well as garage door controls. At least there is Energy management. The worldwide revenue is of US $5.840 billion which correspond to 7.92% of the global market. This segment covers the sale of products and services for the control and reduction of energy consumption. For many consumers saving money is one of the main arguments for buying Smart Home solutions. The main product category are smart thermostats in combination with AC and radiator controls, build by more and companies, such as Google Nest, Bosch, Hive, Honeywell or Samsung. Moderately rising energy prices and a decentralized energy provision are still the main global drivers. While the first Smart Homes were high-value mansions, new plug-and-play solutions drive prices down and thus open the market for middle class households. While Smart Homes now focus on preserving energy, we can also expect a shift towards energy storage and production.

The Smart Home market is expected to grow in the next years as reported by Statista ***(Errore. L'origine riferimento non è stata trovata.****9).* The growth of the system is driven by various factors, such as: a large base of internet users and increased adoption of smart devices; rise in the awareness of fitness and healthy lifestyles owning to the high disposable income in developing economies; high importance of home monitoring from remote locations; rise in the need for energy-saving and low carbon emission solutions; cost reduction measures enabled by market; rapid proliferation of smartphones and smart gadgets; existence of

market players focusing on expanding their adoption in Smart Home product portfolios; and widespread concern about safety and security; increasing adoption of entertainment and other control systems; lighting control solutions; smart speakers and home system appliances are driving the growth of the market for Smart Home market.

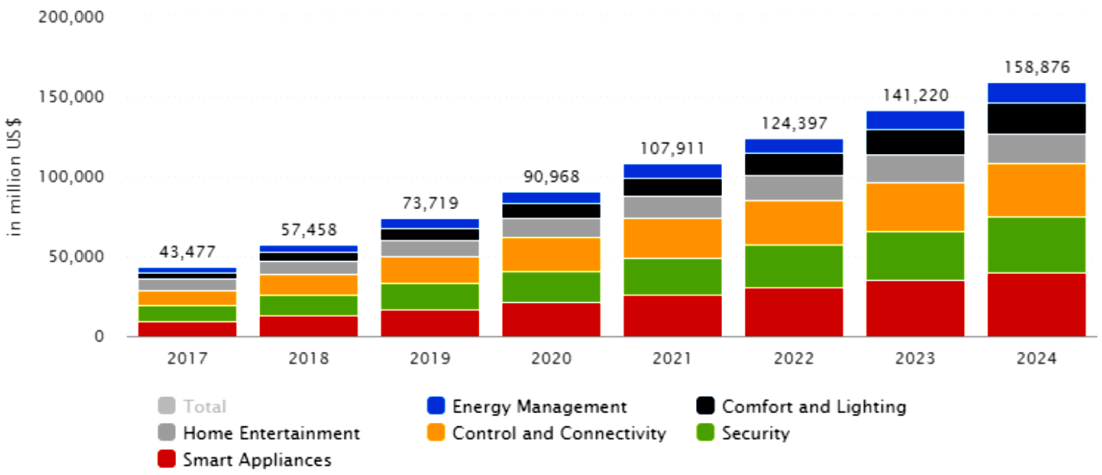


Figure 10: Growth forecast of Smart Home market; Source: Statista

Below in the graph *(Figure 11*) it is shown the growth forecast of each individual sector, from the 2019 till the 2024.

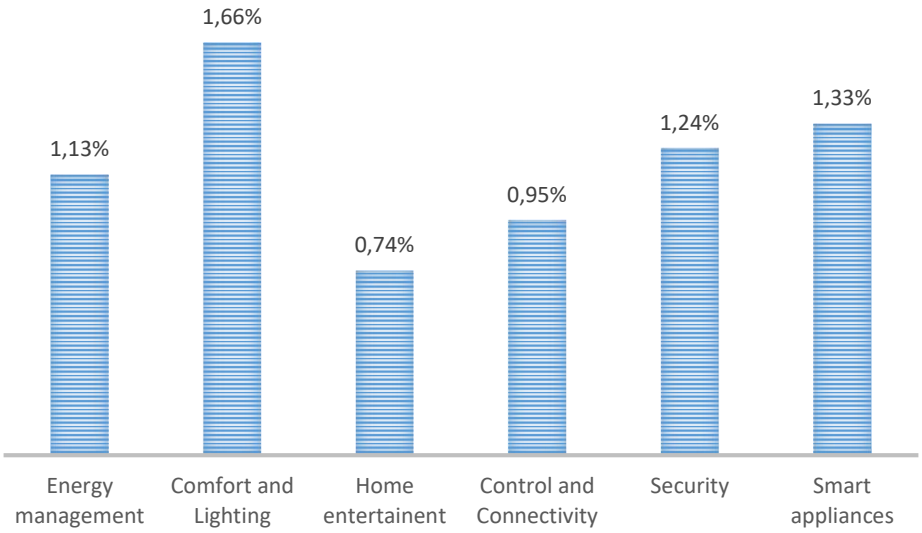


Figure 11: Growth rate till 2024 of each Smart Home sector

Regarding to the geographical distribution of growth worldwide, the area with the highest growth forecast is APAC. Factors driving the growth of the market in this region include strong economic growth, increased population, and improved standard of living, and rapid urbanization that leads to a sophisticated infrastructure. China is likely to account for the largest size of the market in APAC in 2019. However, with the growth of the Smart Home industry and large-scale implementation of hardware and software solutions in

China and Japan, the market in these countries is expected to grow at a higher rate during the forecast period. APAC is considered as a huge market for Smart Home system because of the considerable rate of implementation of various products such as lighting controls, HVAC controls, security and access controls, among others, in the region of Smart Home market.

1.6 A deeper overlook on the Italian market

Looking at the evolution of the Italian market during the last years, it is possible to highlight a positive trend *(Figure 12).* The Italian Smart Home market in 2019 reached a value of 530 million euros, with an increase of 40% compared to 2018. Revenue is expected to show an annual growth rate (CAGR 2020-2024) of 13.6% (*Statista).*

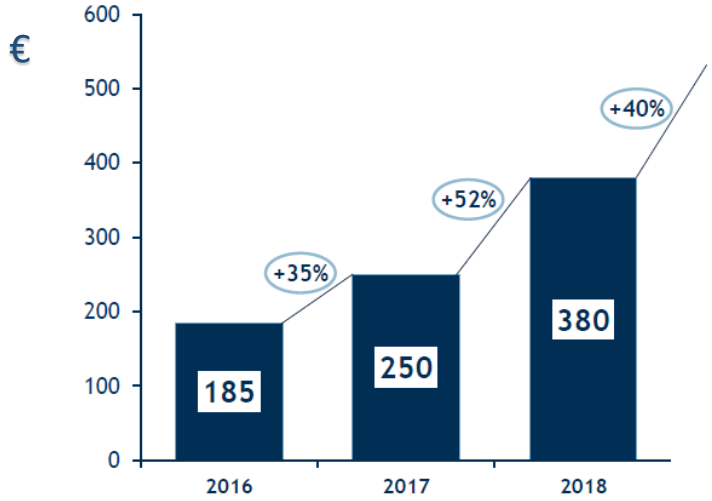


Figure 12: Growth of the Italian Smart Home market in the last years; Source: IoT Observatory of Politecnico di Milano

The growth trend is comparable to that of the main European countries, although the gap is still large compared to Germany (2.5 billion each) and France (1.1 billion). The absolute value is also lower if compared to the one of UK and USA *(Figure 13).*

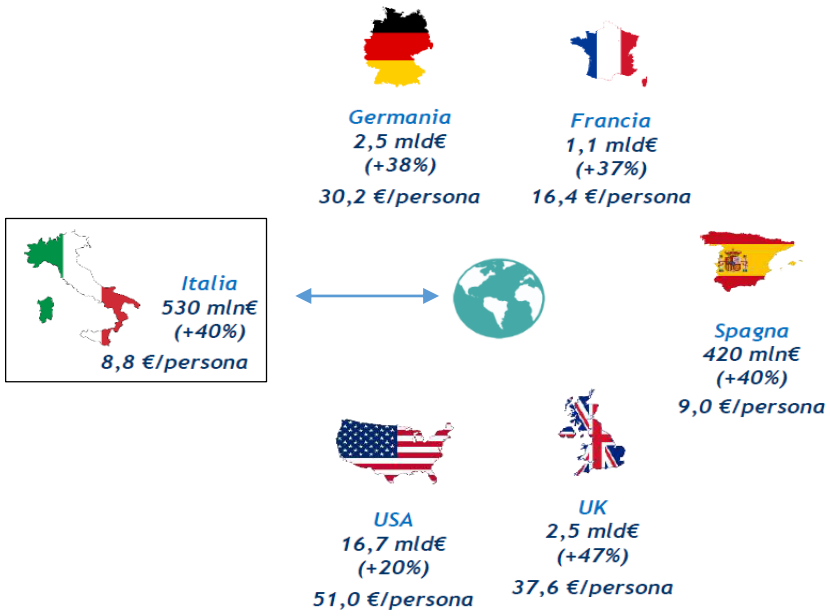


Figure 13: Italian and world countries Smart Home market value comparison; Source: IoT Observatory of Politecnico di Milano.

The market is driven by the following sub-domains: security, Smart Home speakers and household appliances, which together cover over 60% of the entire market. In terms of market share, security solutions occupy the first place, with a value of 150 million euros, corresponding to 28% of the market share (+ 15% in 2019). In the second place there are the Smart Home speakers, which cover a market share of 18% (+ 58% in 2019), with a value of 95 million euros. Connected appliances rank third, with a value of 85 million euros, equal to 16% of the market (+ 55% in 2019). Another strongly growing sector is the one related to the management of heating and air conditioning, with a total value of 65 million euros, representing 12% of the market (+ 44% in 2019); indeed, sales of boilers, thermostats and connected air conditioners increase, benefiting from the progressive integration with voice assistants, the offer of services related to maintenance and the possibility of increasing energy savings and convenience. Follow the audio speakers (with a value of 50 million euros and a market share of 9%) and the connected bulbs (with a value of 35 million euros and a market share of 7%).

As far as the distribution channels are concerned, traditional distribution chain, e-retailer, retailer, insurance, telco and utility have been analysed. The last category is new on the Italian market (it resent from 2017). In the last year it can be observed the advance of new sales channels on traditional ones. The market is driven by e-retailers and multi-channel retailers which reach a total value of 250 million euros, equal to 47% of the market. The traditional supply chain (made up of producers, distributors and installers) maintains an important role (39%) but loses market share. Telco, thanks to simplification of the offer (solutions managed by apps and monthly payments), thanks to the opening of new services (devices for monitoring pets and wearables) and to integration of the traditional offer with new smart objects, grew 140% compared to 2018, reaching 10% of the market. Utility and insurance, on the other hand, still have a limited weight (4% of the market).

Together with the market, consumer awareness and the spread of smart objects in homes are growing too. The Household penetration is 9.5% in 2020 and is expected to hit 18.7% by 2024 (statesman). Moreover, the number of consumers able to independently install the purchased smart objects, without the help of a professional and able to use the smart features, is also growing too.

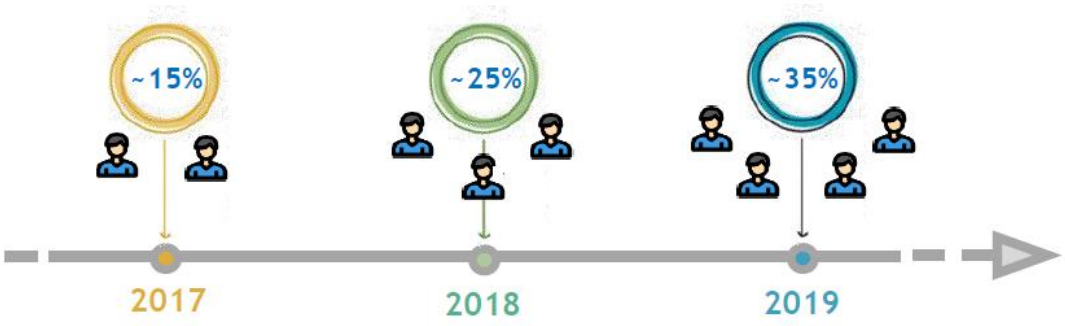


Figure 14: Growth of the Italian users' awareness about the Smart Home theme; Souce: IoT Observatory of Politecnico di Milano

However, there are still few consumers who declare that they are interested in purchasing products for the Smart Home in 2020. Only 37% of the consumers claim to be interested in buying products for the Smart Home in the future, with only 11% of them planning to do so in 2020, and 26% in the next three years. The most frequent reasons that still slow down the use are: excessive complexity (18%), lack of perception of the benefits (10%) and the difficulty in using the Apps for management (6%). Moreover, there is citizens' fears about the risks related to cybersecurity and privacy violation: 54% of Italians are reluctant to share their personal data (+ 3% compared to 2018).

1.7 Barriers and challenges

The Smart Home market is evolving at a rapid pace, as emphasized also in literature: the future home's biggest competition are normal houses *(Groven, 2018).* Still, it is a fairly new field of study and there exists several common barriers to its adoption and spread, analysed below. Adoption is defined by Sathye (1999) as "the acceptance and continued use of a product, service or idea". Consumers go through a process of awareness, interest, evaluation, trial and then make the decision to adopt or reject a product. The attitude towards adopting a technology is generated by consumers' primary beliefs about the consequences of adopting the technology, in addition to an evaluation of these consequences. This paragraph will serve as a classification of the key obstacles to the large-scale development of the Smart Home.

The barriers individuated in the analysis of the literature are divided into: *situational-topic barriers* and *individual traits barriers*. Situational-topic barriers refer to barriers the ones found in the IoT and Smart Home literature (security and privacy, dependence, intrusiveness, price, ease of use, value perception, novelty). Individual traits consist of optimism, innovativeness, discomfort, and insecurity, peculiar to each individual person.

Topic barriers:

- *Privacy and security*

Privacy and security are argued to be the most prominent issues, as they are the heart of trust, relationship building, and exchange (Weinberg et al., 2015). Previously, in non-electronic environments, individual privacy was easier to protect because of the relative inefficiency of communication channels (Hsu & Lin, 2016). This highlights the importance of addressing privacy and security issues, as it gets harder to protect consumers' personal information. Weinberg et al. (2015) argues that privacy issues will have greater or equal importance as the marketing mix elements have in traditional marketing. A lot of Smart Home devices and services can collect sensitive data, such as locations, personal and medical data. Absence of privacy protection may therefore cause serious privacy leakage. This raises many privacy issues as the data can be used in both a positive and negative way (Gubbi et al., 2013). Consumers will consider and act on the trade-off associated with the conveniences offered by IoT and the cost and losses in privacy (Weinberg et al., 2015). Hsu and Lin (2016) further argue that the greater the perceived control of personal information is for the consumer, the

lower risk he or she feels. EU has also implemented a legal regulation: the General Data Privacy Regulation (GDPR) with the aim to protect the data and privacy for all individuals in EU, by giving control to individuals.

- *Price*

Price refers to consumer considerations of which monetary sacrifice is appropriate of the product in question (Mani & Chouk, 2016). However, Balta-Ozkan et al. (2013) pointed out that consumers are concerned not only with the purchasing cost, but also with cost of installation, repair, maintenance, learning, and savings. All this factors make price, in the broadest sense of the term, one of the most important factors to evaluate when the consumers buy a Smart Home product or service. Also Accenture's 2016 report states that price is one of the top barrier of IoT adoption; in particular, the 2016 Accenture Digital Consumer Survey of 28.000 consumers in 28 countries found that consumers price perception differs depending on where consumers are in the diffusion of innovation model. Early adopters of IoT and early majority are less concerned about price than late majority and late adopters. Also Mani and Chouk (2016) found in their research that perceived price is one of the core reasons why consumers resist Smart Products, at the introduction stage of the product life cycle. So there is evidence that high price keeps many new consumers from trying services they are not sure about. However, if the perceived value of the devices is improved, consumers will be more likely to accept the financial risk.

- *Ease of use*

Ease of use refers to consumers' perception of how difficult a device is to understand and use. It represents a barrier when the effort of using the device outweigh the performance benefits of usage. Taking into account the Accenture's study in 2006, it was found that 64% of respondents experienced a challenge when using a new IoT device. Mani and Chouk (2016) stated that when consumers feel confident about their ability to understand the use of Smart Products, they tend to show less oppositional reactions.

- *Value perception*

Value perception refers to the degree consumers perceive the usage of a given smart object as beneficial to them. Marketers continuously struggle to find the right value proposition to communicate to consumers. The success of any new Smart Device depends on consumers perceived value. Perceived benefits may be seen as directly linked with the improving of the quality of users' lives; for instance, smart cooktops that automatically turn the heat down when a pot boils over. Consumers will embrace solutions like this because they provide better cooking, less mess, increase safety. Moreover, value perception could be linked to novelty, that is a fundamental characteristic of any innovation. The perceived newness of the idea for the consumer determines their reaction to it. Mani and Chouk (2016) analysed this possible barrier and found a significant negative impact of novelty on consumer resistance to smart products. Since consumers perceive Smart Products as different and unique, they are less resistant to adopt these innovations.

- *Interoperability*

This barrier refers to the lack of common standards and therefore the difficulties in integrating different software for the different smart devices. Interoperability is a recurring topic in literature. Porter M. and Heppelmann J.E., 2014 pointed out the difficulties that individual developers encounter in making their products interact with others coming from different market players. W. Keith Edwards and Rebecca E. Grinter (2001) stated interoperability as a Smart Home challenge: Smart Home must not consist of many single functionalities but rather as a single one in which the different technologies work together smoothly. Therefore, there is the necessity to design new connectivity models which are not just common communication protocols. Greenwich consulting (2013) claimed the lack of standardization of data transmission, collection and storage technologies that do not allow a specific ecosystem to impose on others. So the negative impact that the lack of interoperability has on the development of the Smart Home is significant, creating an environment where introducing innovations is difficult.

- *Adaptability*

House which are not specifically designed for smart application need to be upgraded to "welcome" these technologies (W. Keith Edwards and Rebecca E. Grinter, 2001). In 2013, Balta-Ozkan et al. pointed out as a major barrier to Smart Home devices adoption "fit to current and changing lifestyle"; technology must fit with home structure, not just in term of suitability and integration but also aesthetically.

On the other hand, there are individual barriers, widely used to explain innovation resistance. These psychological barriers d mostly arise through conflicts with consumers' prior beliefs and are greater among mature consumers than younger consumers (Mani & Chouk, 2016).

- *Tradition*

The tradition barrier arises when consumers have a favourable attitude toward the products they are currently using and may be unwilling to replace the old products with new marketing offerings;

- *Imagine*

The image barrier relates to problems that arises from lack of information and stereotyped thinking;

- *Dependence*

This barrier refers to consumers' degree of dependence on a certain internet and computer-related technology which often creates psychological resistance on the part of the consumer. Mani and Chouk (2016) found evidence that dependence is a predictor of privacy concern, previously analysed in the topic related barriers.

- *Intrusiveness*

Smart devices may be seen as intrusive since they have the ability to perform actions autonomously and without the permission of the consumer (Mani & Chouk, 2016). For instance, some consumers may find the act of capturing the flow of electricity into one's home, and the manner in which it is used over a period of time intrusive. Mani and Chouk (2016) found in their research that privacy has a positive effect on

intrusiveness, because, the more consumers feel sensitive about their privacy, the higher the level of perceived intrusiveness of the Smart Device will be.

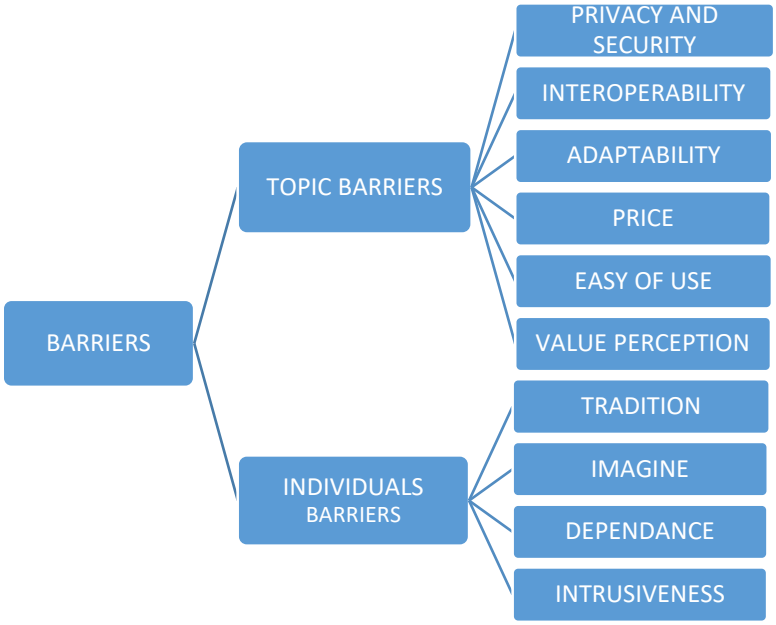


Figure 15: Barriers to the adoption of the Smart Home

CHAPTER 2: RESEARCH QUESTIONS AND METHODOLOGY

The aim of this chapter is to report the purposes and questions this thesis is conceived to answer to. Together with this, the approach and methodologies applied are described and the boundaries of the research are defined. The thesis falls in a broader research context conducted by the Internet of Things Observatory of Politecnico di Milano, that, since 2011, investigate the state-of-the-art of IoT applications, area in which the Smart Home, core of this work, falls into.

2.1 Research questions formulation

Having assessed the importance that the field of Smart Home is reaching worldwide and the huge range of applications available, the thesis has the aim of evaluating the actual offer and the key factors that each firm is taking/ should take into account in its business model in order to bring benefits and create value. The presented introduction led to set out two research questions, presented below.

RQ1*: What is the state of the art of the Smart Home supply solutions in the international arena and in Italy?*

To understand the Smart Home world supply, it is essential to study the state of the art of the market and the characteristics and peculiarities of the offer, understanding how the market has changed in recent years and getting insight about its future direction.

RQ2*: Which are the critical factors in the business model of a firm working in the Smart Home ecosystem that allow to create added value?*

Being the Smart Home a quite recent field of research, it is essential for a firm to understand which are the factors that lead to value creation, in order to encompass and enhance them in its business model and strategic decisions.

2.2. Methodologies

In order to pursue the aforementioned objectives, many methods, following illustrated, have been exploited:

- *Analysis of existing literature*: it has been the first step in order to tackle the Smart Home topic. This analysis has been useful for an in-depth study both of the current Smart Home ecosystem (characteristics, functionalities, barriers to its adoption, challenges, new technologies enabling progresses) and the competitive scenario (strategic directions of different companies, data centralities and value network, positioning framework). The academic materials have been found through online databases for scientific publications: Scopus and Google Scholar.
- *Analysis of secondary sources*: besides literature, then there was an analysis of secondary sources, useful when it was necessary to narrow the focus according to the chosen theme to develop. The types of sources analysed were: reports, articles found in reliable websites, white paper studies dossiers, industry reports, digital market outlooks and consumer market outlooks about the topic, producers and retailers' websites, companies' reports (reports provided by Statista or consultancy companies like Accenture). All these sources have been found through the Google search engine.
- *Qualitative framework,* some coming from the work of other authors, others created during the work.

To sum up, in the following ***Errore. L'origine riferimento non è stata trovata.*** it is graphically explained how the different methodologies have been used in order to accomplish the objectives.

	Analysis of existing literature	***Analysis of secondary sources***	***Qualitative framework***
RQ1	x	X	
RQ2	x	X	X

Table 2: Methodologies- objectives matrix

CHAPTER 3: CURRENT STATE OF THE ART

In this chapter it is presented at a macro-level a snapshot of the Smart Home solutions available on the market, with the aim of understanding how the offer is structured. The analysis is based on a database that has been realized in collaboration with the IoT Observatory of Politecnico di Milano. It contains 698 solutions that are already available or are coming soon in the market, mapped according to several variables, following

illustrated. In the first part of the chapter the structure of the database is presented, while in the second part an analysis of the data collected is done in order to describe the current situation of the market and to identify the main trends.

3.1 Description of the structure of the database

The database has been an important instrument for the realization of this thesis since it has provided a double support: on the one hand, the data collected has been used to obtain complete information on the current situation of the products offered to consumers in the Smart Home market and to perform a macro-analysis; on the other hand, it has given some insights on the possible future evolutions. In the following section are described the parameters that appear in the header row of the database, judged interesting to monitor. The information collected are used in the following paragraphs to analyse the Smart Home market and obtain some final conclusions. In the following analysis the database has been divided into column clusters that that take into account the different aspects of the solution.

- ***Cluster 1: General information***

In this first section general information about the product/ service analysed are provided.

Company name, Product/Service name

In the first two columns general information regarding the company's name and the product/service offered are provided; in case of startups, the product's name often coincides with that of the company.

Description

Brief description of the mapped solution. General features, the description of how the product or service works are presented. There are also indicated facts that have given a particular relevance to the case, if present (e.g. the acquisition of a startup by a big player).

Geographical area

Continent where the company is headquartered. The macro-areas considered are: Europe, America, Asia, Middle East, Africa and Oceania.

Country

Specific country where the company is based.

Company type

Four different kind of firms have been considered: Startup, Big Player and SME (Small and Medium Enterprise). *Startup* is referred to a company that was born as a result of the development of an individual innovative product or service; since it does not have a sustainable business model, it receives funding. The category *Big Player* comprehend a well-established and leading company, with a strong brand and a large portfolio of products. *SME* defines a small or mid-sized company that, unlike startups, do not receive any longer founds from external actors to implement their solutions.

Industry

In this section is better specified the field in which the company considered operates. Some macro categories have been considered, taking into account the type of product/service provided (furniture, personal care, home automation, household appliances, consumer electronics, electrical equipment, platform, robotics, sanitary, sensors, security systems, utilities) or the class into which the company falls (e-Commerce; retailer; MMR- e.g. Mass Market Retailer; OTT- Over The Top, e.g. all those media companies that offer services and content directly via the Internet, bypassing traditional distribution systems; telco; insurtech).

Year

The year taken as reference is the one in which the solution was launched in the market. In case it was not possible to find out the exact launch date, the first available solution review was taken as a reference; In case of products not yet available on the market, the expected launch date was reported.

Application sub-domain

All the solutions are obviously inherent to the Smart Home ecosystem; however, several sub-sectors have been used to classify the different solutions analysed, with the aim of underline the application detail and the final aim of the product or service within the Smart Home. In the analysis the following sub-sectors have been identified:

- *People Assistance*: it includes solutions aimed at assisting people to guarantee physical integrity and well-being. Among these solutions are therefore included all the products that assist and protect vulnerable or needy people (e.g. children, elderly, disabled); it also includes all the types of solutions related to health monitoring (e.g. collect and monitor vital signs).
- *Cooling/Heating*: it includes smart devices to manage heating and cooling system remotely (e.g. thermostat or air conditioning system able to learn customer habits and behave autonomously basing on that).
- *Consumption management:* it includes products aimed at identifying the main sources of energy consumption (e.g. household appliances) and above all the main sources of wastes, in order to intervene where necessary and reduce bills costs. This category includes three subcategories:
    - *Energy consumption management: products focused on the* energy consumption control;
    - *Electricity consumption management: products focused on saving electricity;*
    - *Water consumption management: products focused on the reduction of water waste.*
- *Entertainment*: it includes products for leisure, such as audio and video equipment (e.g. music played by integrated sensors into the walls and manageable remotely, by smartphones).
- *Environmental parameter monitoring*: it includes sensors measuring environmental parameters such as temperature, humidity, concentration of polluting gasses (e.g. carbon dioxide level), in order to ensure better living conditions.

- *Home appliance management*: it includes products that permit to make smarter, more accessible and automatized the household activities (e.g. oven able to receive information via wi-fi directly from smartphone or tablet).
- *Lighting*: it includes smart lighting system that can have both the aim to reduce waste of energy (e.g. smart bulbs that automatically switch off if there are no people in the room) and increase home comfort (e.g. light bulbs that change colours according to the household mood or to the moment of the day).
- *Scenario management*, solutions that allow the integration and management of multiple products in just one interface and at the same time.
- *Security:* it includes solutions to protect the home from any break-in and thefts (e.g. cameras or sensors that detect the opening of doors/ windows and immediately send an alert the owner's smartphone).
- *Smoke, flood, fire monitoring:* it includes smart sensors able to detect problems inside the house and immediately communicate to the owner the state of alert (e.g. presence of fire or flooding).
- *Watering management:* it includes all the smart devices useful for the remote management of irrigation of garden and plants.
- *Animal monitoring:* it includes smart appliances (e.g. sensors, cameras) used to better monitor pets.
- *Others:* this category includes different sub-domains that are less widespread or less consistent with the research purposes.

Secondary application sub-domain

This column is used to map a secondary purpose of the product/ service analysed. Some solutions can belong to two different domains and satisfy more than one application scope.

Next to the columns dedicated to the application sub-domains, a further column named "Notes" can be found. It reports, if necessary, any clarifications or peculiarity regarding the sub-sector identified. For example, in the case of "Other", the exact functionality is indicated; or in the case of wide sub-areas (e.g. Entertainment) the specific area of interest can be specified (audio, video, travel, etc.).

- ***Cluster two: Business model description***

After the initial section, there are some columns dedicated to the description of the company's business model in order understand the strategy and the methodologies used by the company to create value for the consumers, to get profits and to operate into the market.

Physical device sale

In this field the availability for sale of the product/service analysed is certified or not. In the first column is specified if it available on the market or no (two possible choices: *yes* or *no*).

In the next column named “notes” the various possibilities are better explained: not available, available from, the production approach (built to order, make to order, etc.), if it is comprehended in a package, the components of the solution, etc.

App

In this column it is indicated if an App is associated to the product analysed and identifies, when possible, whether it is free or not.

Service

It is clarified if the offer includes a service associated to the physical product or an independent one.

In the next column named “Service notes”, it is better explained the type of service, if it requires a mandatory or optional fee.

Smart speaker

This column clarifies if the product/ service analysed is compatible or not with a smart speaker; in particular, if so, it is indicated whit which one (only Google Home and Amazon Echo has been taken into account, since the widely used).

Type of offer

This column has been used for indicating if the product analysed imply the selling of a hardware or/and software solution. Moreover, it has been indicated if the service is included or not.

Communication

It is indicated the protocol used by the device analysed (the possible types have been further described in chapter 1.3)

Main channel

In this column the possible channels of distribution are mapped; among them, the following has been taken into account:

- *e-Commerce*: online sales. This is the most accessible channel for customers all over the world
- *Retailers:* sales on the shop of a retailer (the product is physically available on the shelves of the shop);
- *Installers*: sales from professional installers. This distribution model happens when the products are complex and the installation cannot be done directly from the final customers, but specialized personnel is necessary.
- *Mass market retailers (MMR)*: the product is available on the shelves of the world's largest retail stores, e.g. supermarket, mass merchandise, warehouse chain.

In some cases, these different distribution modes coexist. In order to have a complete analysis of the real situations, it is also considered the possibility to have a combination of the previous channels (“*e-Commerce and Retailers”, “e-Commerce and Installers, “Installers and Retailers”,* etc.).

"Not available for sale yet" is used for the classification of products/services already presented on the market, but not yet available for sale.

Presence in the manufacturer e-Commerce

The name of the column is self-explanatory: the content of the cell allows to understand if the solution is on sale on the manufacturer's e-shop. If so, it is filled with "yes"; also the peculiar possibility to pre-order it is taken into account.

Presence in general e-Commerce websites

This column identifies the possibility to purchase the product/service from general e-Commerce websites. In the next column is possible to indicate the names (e.g. Amazon, ePrice, BestBuy, etc.).

Presence in Italian Retailers

This column is related to the Italian market and let us understand if the products/services are available on the shelves of Italian retailers and, if so, the specific name is reported (e.g. Euronics, Trony, Mediaworld, Unieuro, etc.).

Pricing

Three options of pricing system are identified in this column:

- *Una Tantum:* the product/service is paid in just one solution. The customer realizes only one payment at purchase moment
- *As a Service:* the offer consists in a subscription. Customers pay a periodic fee, required for the use of a service;
- *Una Tantum + As a Service:* this is a combination of the two previous methodologies. In most cases, the *Una tantum* payment is required for purchasing the hardware, while the subscription fee to obtain an additional service (e.g. the acquisition of a camera is done with a lump sum payment; the video cloud storage or the access to advanced function is offered as a service and so paid through a subscription).

In the next columns are required: the value of the price *Una tantum* or *As a service*; the type of currency used and the conversion in dollars. It is also present the column "*notes*" in order to give further explanation about the pricing policy if necessary.

- ***Third section***

This last session contains the sources, e.g. the websites links where the information about the mapped Smart Home solutions have been found. For most of the products, the company's website has been the primary source, then integrated with other sources such as articles, reviews, e-Commerce sites.

3.2 Reference sample analysis

In this paragraph a detailed description of the sample is provided. 698 products/services have been taken as a reference in this thesis. The solutions cover a time range from 2000 to the first two months of 2020. It is important to underline that during the mapping process some information were not obtainable; in this case,

cells have been left empty and the analysis has been performed taking into account only the available data; in the caption underlying each chart it is always specified the number of solutions analysed on the total solution available (Sample: x/698).

3.2.1 Geographical distribution

The first aspect analysed is the geographic one, considering both the continent and the country. In *Figure 16* a general classification based on the continent where companies are based is provided, while in *Figure 17* the analysis takes into account the single countries.

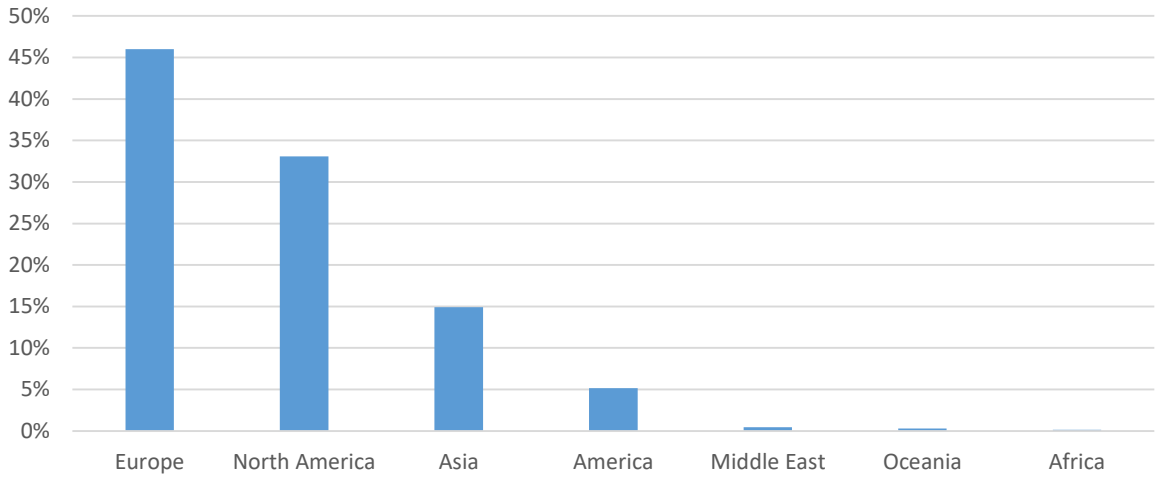


Figure 16: Geographical distribution by continent; Sample: 698/698

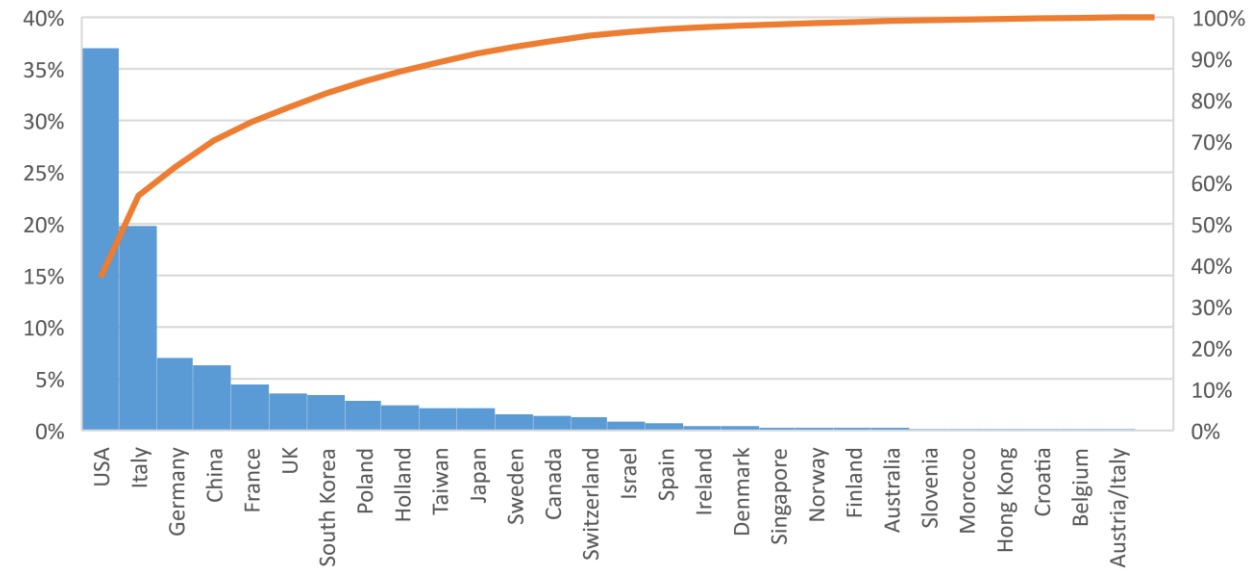


Figure 17: Figure 13: Geographical distribution by country; Sample: 698/698

As can be seen, the greatest part of the monitored solutions come from Europe (about the 46%) and America (about 38%), with 33% of them concentrated in the North of the continent, that was the earliest adopter of Smart Home products/services globally and that in past years has been the preferred nest of many startups, that move their headquarters particular in the Silicon Valley, where growth opportunities and possibilities were generally greater. By looking at *Figure 13*, indeed, it can be see that the USA alone gives home to about 37% of the analysed solutions. What triggers more is the position of Europe: one of the factors that surely explains this high percentage (about half of the analysed solutions) is the increasing number of companies/ startups that started to focus on Smart Home solutions in the latest years. Moreover, it should be underlined that during the analysis a strong focus has been kept on our country, Italy, in which 20% of the solutions have been mapped. The other two European countries giving home to the highest number of Smart Home solutions are *Germany* (7%) and France (5%). *Asia* is worth the 15% of the Smart Home solutions mapped in the database, so has not a negligible position. In particular, 6% of them are mapped in China. Indeed, China, with just four others countries (USA and the European countries above mentioned), account for 80% of the entire Smart Home worldwide market.

The remaining three areas (Middle East, Oceania and Africa) represent less than 1% of the market, so actually offer very few of the analysed solutions and do not play an important role.

3.2.2 Company type

Another aspect considered in the analysis, is the distribution of the offer among different types of company: *Big player, Small and Medium Enterprises (SME*), *Startup (Figure 18)*.

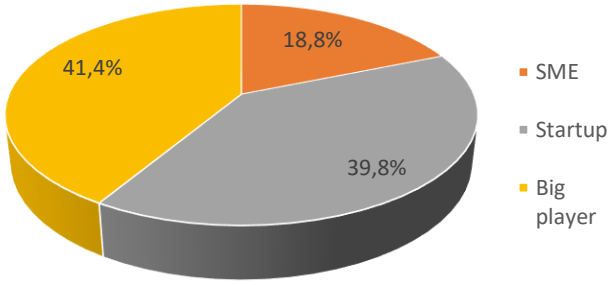


Figure 18: Distribution of the analyzed Smart Home solution by company type; Sample: 698/698

It is evident that the majority of products/services are offered by Startups and Big Players. The former has shown since the beginning greater interest in the Smart Home Market, raising and investing funds for innovative solutions. In past years, Big players constitutes a smaller percentage compared to Startups (as can be seen in *Figure 19*).

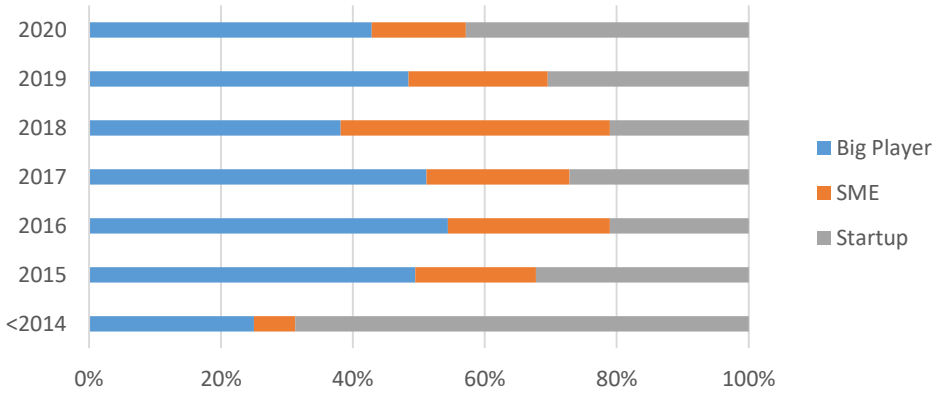


Figure 19: Diffusion over time of the different company types; Sample:698/698

However, with the raise of popularity and of the size of the market, established companies started to launch more and more solutions on the market. For what concerns SMEs, they are more and more understanding the potential of the market, but are still a small portion in the sample considered. It is important to point out that the link between giants and startups is tightened due to the potential that the latter can offer to the big players: the number of acquisitions and partnerships signed are growing. Just to give some examples of the recent acquisitions: Amazon's acquisition of Eero (a startup specialized in routers), Ring (an American manufacturer of "smart bells" and internet-connected video cameras); Apple's acquisition of the American startup Pullstring to strengthen the potential of its voice assistant Siri; Google's acquisition of the Israeli startup Alooma, specialized in data migration. As far as collaborations and partnerships are concerned, these are even greater. Just to mention the recent ones: General Motors partnership both with Amazon to enable the tech company's Alexa voice assistant in its vehicles and with Google to install the tech giant's voice assistant and apps, including Google Maps, into GM vehicles beginning in 2021; Vodafone V-Home, developed in partnership with Samsung and Zurich Italia; Google partnership with tech retailer b8ta to let people demo Smart Home products. In *Figure 20* the number of significant mergers and acquisition done by the Big Five tech giants, or "FAAMG"—Facebook, Amazon, Apple, Microsoft, and Google (Alphabet) are represented; mergers and acquisitions have become a key tactic in maintaining their strong grip on tech supremacy.

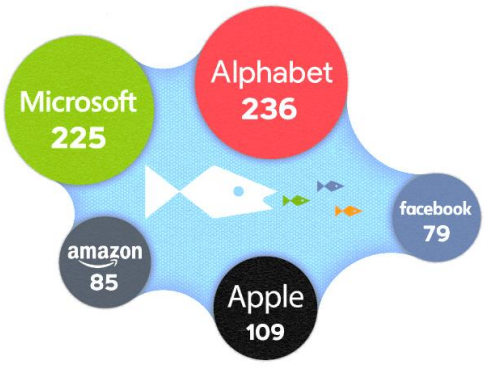


Figure 20: Number of mergers and acquisitions done by the companies; Source: CruchBase

A further analysis is carried out considering company types in relation to the geographical areas (*Figure 21*).

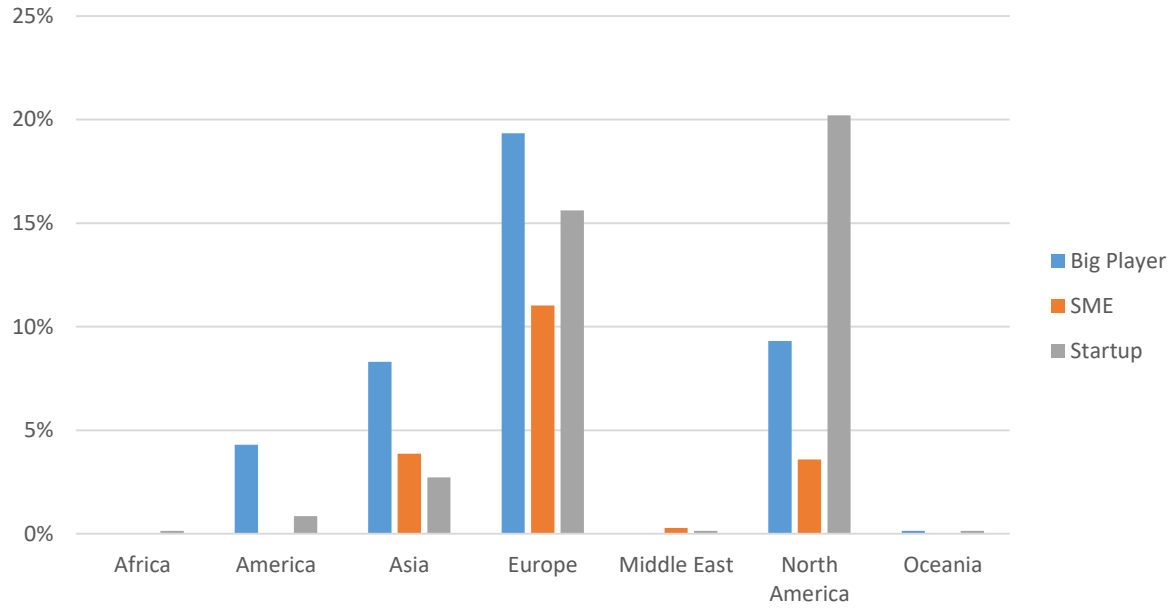


Figure 21: Company type distribution of the mapped solutions; Sample: 698/698

It can be easily seen that in the European market the contribution of Big Players is fundamental, while the startups play a second role; on the other hand, in the area of America, especially North America, the startups dominate the market, for the reasons before explained in Chapter 3.1, followed by Big Players, but with a huge gap in between. *Asia* shows a path similar to the *European* one, with *Big players* pulling the market, but followed by SMEs. This probably because the firms that provide solutions are mainly local, while startups do not find a fertile soil, due to licensing and censorship issues. *Africa* and *Oceania* are a negligible part of the sample.

3.2.3 Analysis of the industry

Another aspect considered is the one related to the industry to which the mapped solutions belong, taking into account the type of product/service provided (furniture, personal care, domotics, household appliances, consumer electronics, electrical equipment, platform, robotics, sanitary, sensors, security systems, utilities) and the class into which the company falls (e-Commerce; retailer; MMR – Mass Market Retailer; OTT-Over The Top; Telco; Insurtech).

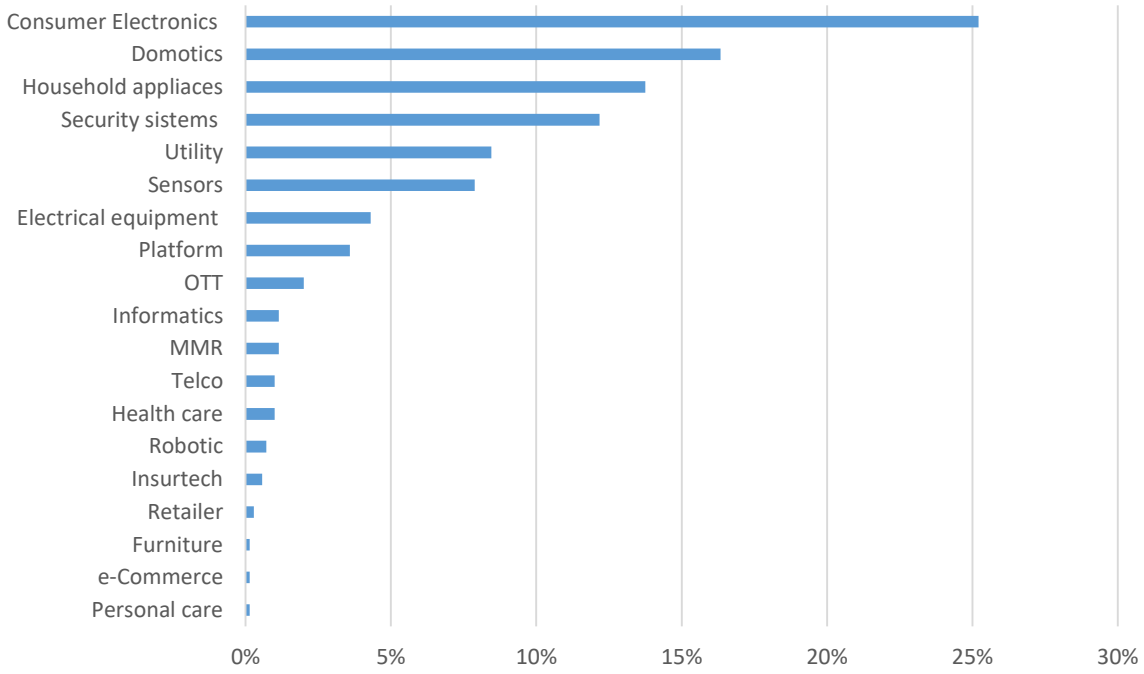


Figure 22: Industry to which the mapped solutions belong; Sample: 698/698

As can be seen in *Figure 22* the driving sector is represented by "Consumer Electronics", followed by "Domotics" and "Household Appliances". This distribution is verified for the whole world market, as can be seen in *Figure 23*:

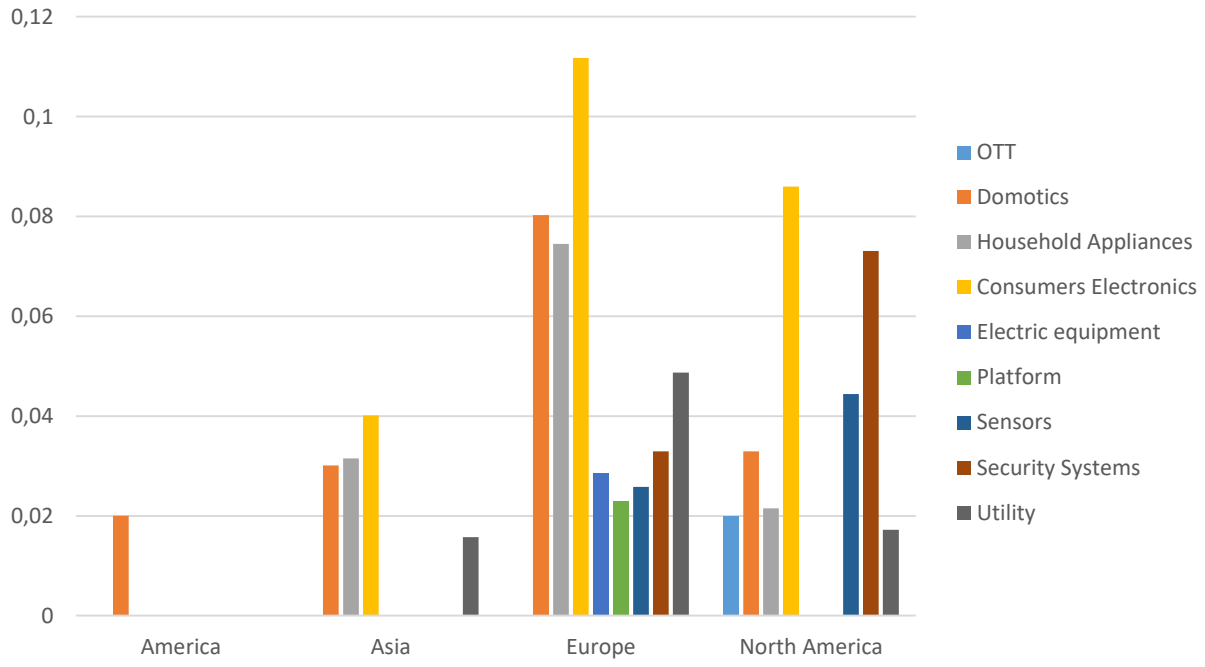


Figure 23: Geographical distribution of the mapped solutions by industry type; Sample: 698/698

Both in America, Asia and Europe the results are quite aligned. The reason behind this huge success of the first category (consumer electronics), especially in Europe, is due to the launch and big diffusion of the Smart

Speakers; indeed, by analysing the diffusion of the different types of industry over the years *(Figure 9*), we can see that the huge leap occurred in recent years, between 2017 and 2019, with the "Domotics" sector advancing more and more. It is worth underling that the last column of *Figure 20* is just representative, since for 2020 only the first two months have been considered, so a different time span has been taken as reference.

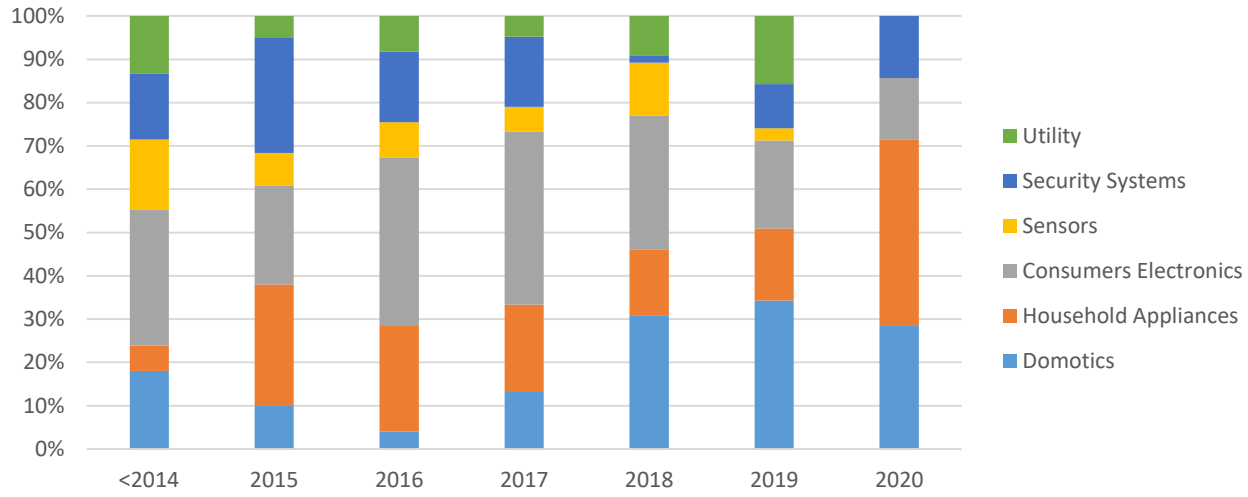


Figure 24: Diffusion of the different types of industry over the years; Sample: 585/ 698

3.2.4 Application sub domain analysis

The analysis of the sample continues mapping the application sub-domain of the database solutions.

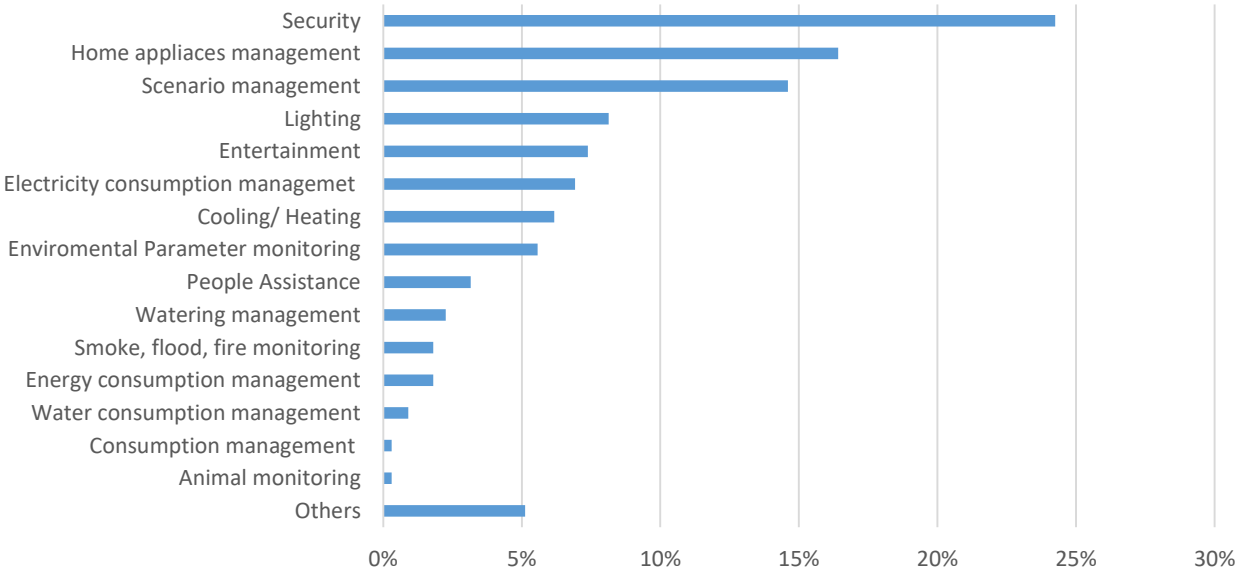


Figure 25: Application sub-domain of the mapped solutions; Sample: 698/698

As can be seen in the graph of *Figure 25*, *Security* is the sub-domain which is more widespread (23%). The solutions categorized in this sub-domain include digitally connected devices for burglar prevention and other security issues, so they are so widespread since respond to a primary need of people: protection; among the

most common devices there are motion sensors, sensors for doors and windows, indoor and outdoor cameras, often sold in kit solutions. The new trend concerns smart locks remotely manageable. Netamo, a manufacturer famous for its range of smart products dedicated to security, at CES 2020 proposed the smart lock and key system, which allows people to customize the keys, activate or deactivate a copy with a single click from the App. The system allows also to send an invitation with an access key (this let other people to access the house while you are away). The second sub-domain for diffusion on the market is *Household appliance management* (16%). Household appliance manufacturers are enriching their mix with smart and connected products: washing machines, dishwashers, refrigerators, ovens that not only can be controlled remotely but can also learn. As propsected at CES 2020, this will be the new frontier: continuous learning systems that improve their performance. One demonstration among many is the new LG ThinQ washing machine previewed at CES 2020, equipped with an artificial intelligence system aided by sensors, which detects the weight and volume of the load of clothes and identifies the type of fabric inserted to set the type of washing. The third most common sub-domain, with 14% of solutions, is *Scenarios management*. Controlling every device through a single hub/app is crucial to customers and nowadays it represents one of the biggest limit of the Smart Home solutions. Other sub-domains, such as *Lighting, Entertainment, Cooling/Heating*, follow, with a market share between 7% and 8%. They encompass innovative, basic and low price products that generate curiosity from customers. As far as the devices for consumption management, appliances for *Water consumption monitoring* are the most diffused ones *(7%),* while *Energy consumption monitoring* and *Electricity consumption monitoring* reach the 2% of products/services mapped. *Environmental conditions monitoring* devices have 6% of diffusion. Probably their diffusion is due to the innovativeness and easiness of installation of the devices, that have built- in elements for the monitor of temperature, humidity, light, CO_2 or air pressure. The domain *People assistance* is noteworthy, since alone cover the 3% of the market; applications of Smart Home for aging in place are becoming more and more common: pet robot that can navigate people to bathroom during the night and return them safety to bed, sensors to monitor vital functionality and detect unusual pattern in order to send a notification to neighbour, family or relevant caregiver are just some example. Lower common are the solutions for *Animal monitoring, Watering management and Smoke, flood, fire monitoring* with a market share between 1% and 2%.
The group *Other* includes all the products that cannot be classified in the sub-domain analysed (5%).

3.3 The actual market

The aim of this paragraph is to give an overview of the actual Smart Home market by analysing: the offer model, the pricing model and the channels used for the mapped solutions.

3.3.1 Offer analysis

The different offers available on the market and the analysis of the availability of a dedicated application represent the starting point for the analysis.

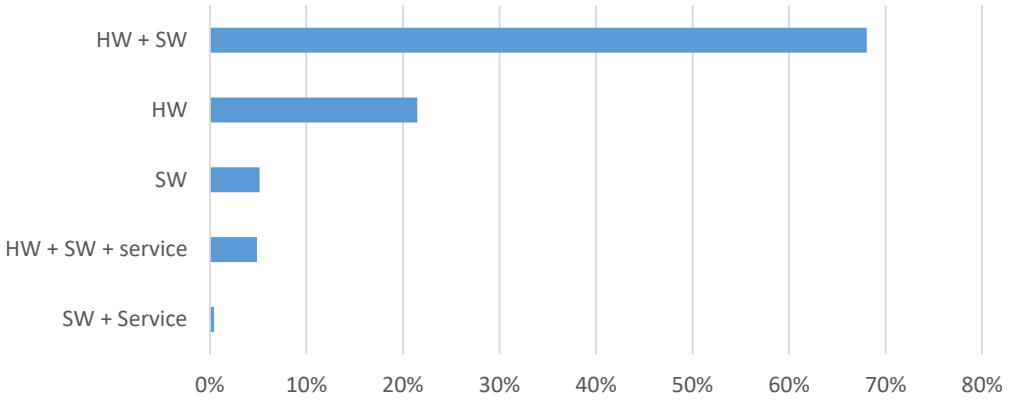


Figure 26: Type of offer; Sample: 698/698

As can be seen from *Figure 26*, most of the solutions analysed offer both a Hardware (physical device) and a Software. However still huge part of the companies (21%) has their business model based only on the sale of a physical device.

The presence of dedicated app through which it is possible to manage remotely the products or the implementation of a service, becomes increasingly important for all the types of companies and in every industry analysed (*Figure 27*). From the analysis has emerged that most of the app are given for free, or their price is included in the offer; 0,5% of the app are paid.

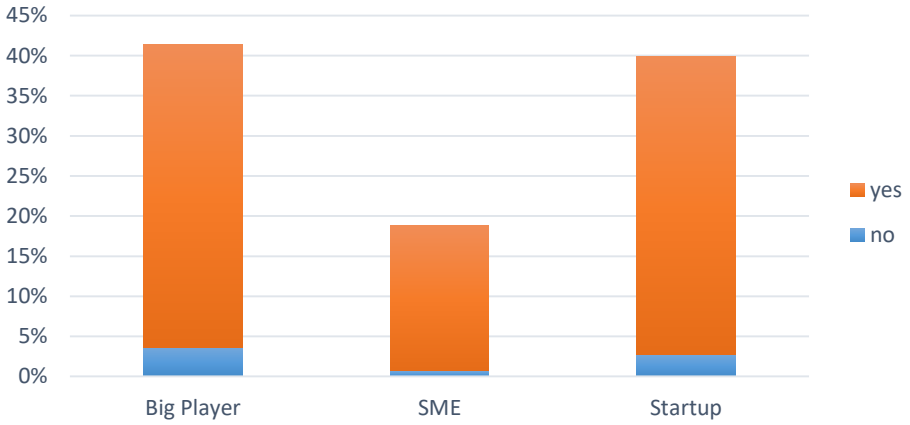


Figure 27: Presence of a dedicated App in the offer for company type; Sample: 698/698

The same considerations can be done taking into account the services offered (*Figure 24*).

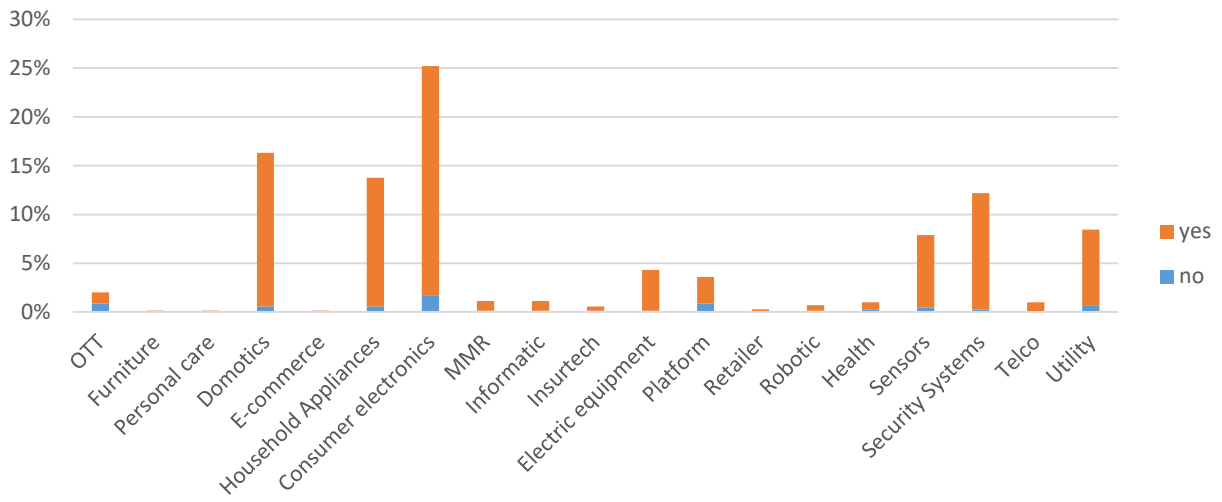


Figure 28: Presence of App in offer for industry type; Sample: 698/698

By the analysis of the database it can be seen that 65% of the mapped solutions have an additional service available for the consumers (percentage calculated excluding the *NUL* cells, for which data are not available). There is an increasing attention in giving to the customers the possibility to add a service to the offer. Only in this way, in an over-crowded market, companies can create added value and increase their sales; in recent years the collaboration between companies increased also to allow the creation of supplementary functions and services (for free or with a fee).

Taking into account the column "*service notes*", *Figure 29* shows the additional services mainly available. These services include information on consumption, registrations, storage, notifications, control of other devices, alerts, cloud, etc. and are just some examples through which companies tried to create value through the experience of the users. The results were obtained through a word cloud, a method used for all those fields that cannot be analysed in the classical way as they have been filled in with unstructured variables (as in this case, text fields). However, the word clouding algorithm used in the resulting graph could make words appear smaller, to be de-contextualized with respect to economic analysis.

Figure 29: Word cloud for type of services; Sample: 119/698

Further insights can be observed by analysing the presence of services in the offer of the different industries *(Figure 30*).

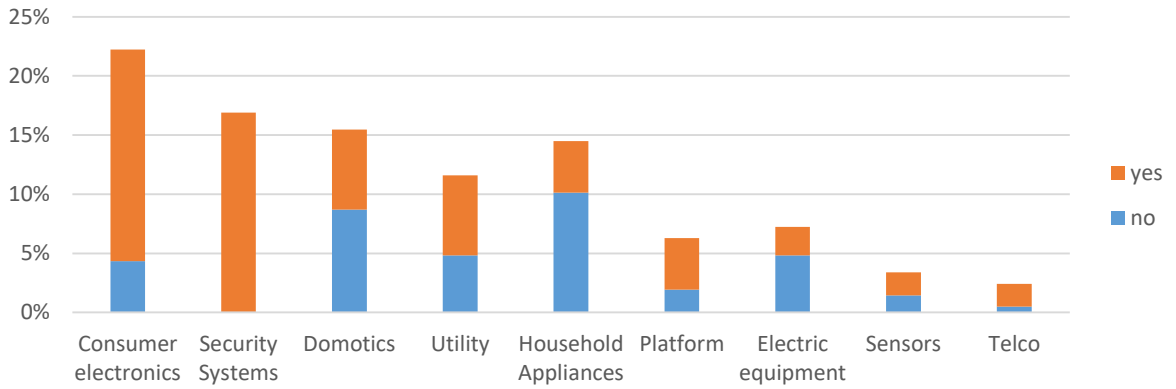


Figure 30: Presence of Service in the offer for industry type; Sample: 216/698

Consumer Electronics is currently the field in which the services are most present (for example, the real-time intervention in the event of irruption), followed by *Security* and *Domotics*, that, as previously seen, are the domains that have a higher marker share and for which the presence of dedicated applications becomes of fundamental importance in order to remotely control the devices.

3.3.2 Pricing models analysis

Another factor taken into account for the market analysis, is the pricing method that allow to estimate the way the householders pay for the product/service.

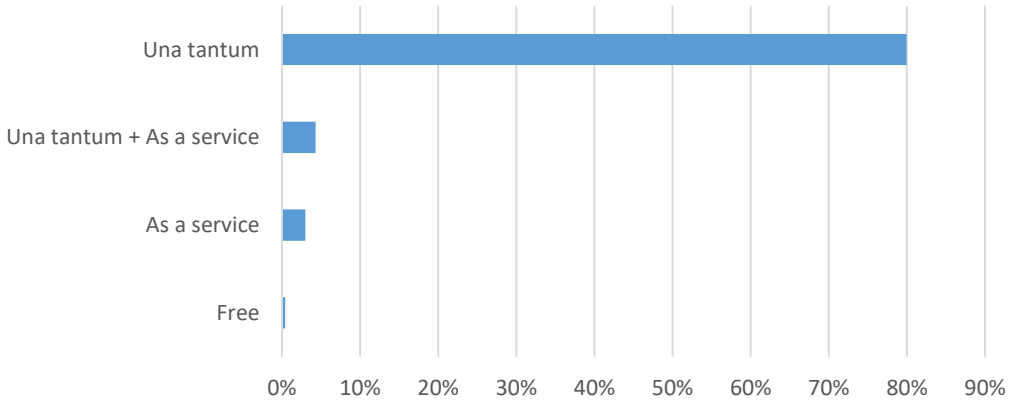


Figure 31: pricing model adopted; Sample: 612/698

As can be seen in *Figure 31*, the 80% of the solutions analysed uses the *Una tantum* pricing model, in which the customer pays only at the purchase of the product/service. The issue of this model is that, after the transaction, the company has no longer any contact with the consumer. Nevertheless, this continue to be the solution most used by all the types of company (*Figure 32*); probably this is due to companies' need (e.g. Startups need to maximize revenue in the short run in order to support their business; Grand Players and

SMEs do not see the necessity to change their business strategy) and/or to consumers' cultural and psychological barriers.

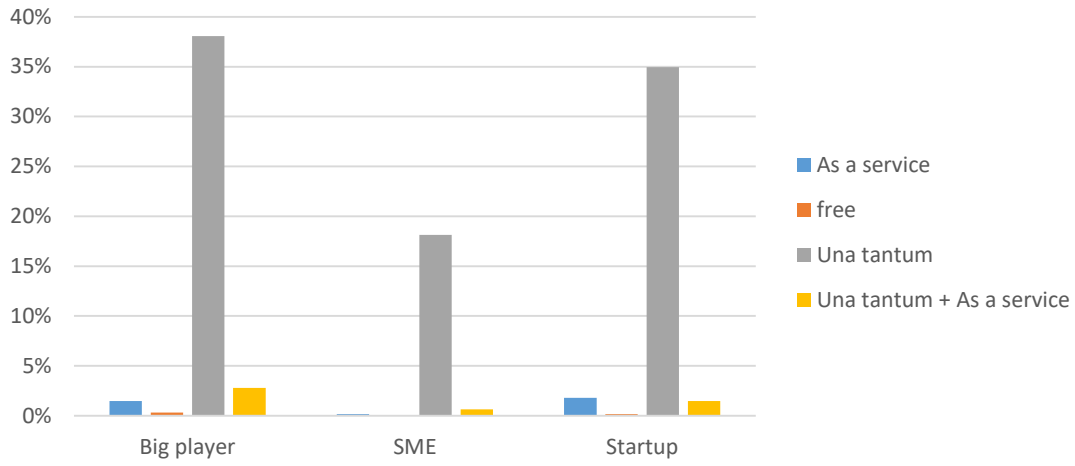


Figure 32: Pricing model adopted by different types of company; Sample: 612/698

The *Una tantum + As a service* model is used when there are products sold with operational services; it consists in paying for the physical product at the time of the purchase while the payment of the services is spread over a period of time (usually a subscription is needed); this type of pricing model is widely used in the security field; for example, buying a security kit, the consumer pays the physical product (e.g. camera/ sensors) at the purchase time and have then the possibility to pay a periodic fee for the additional service, e.g. cloud storage. An example is the product line *Myfox security* offered by Somfy. Some companies can decide to apply the model *Una tantum or A Service*, although in the sample analysed there is not a consistent number of solution that adopt this policy. This model offers the consumers both the payment option: single payment or as a service; so the customer can decide whether to buy the product or rent it. An example among the product analysed is *Smart MEM* by Acotel, an innovative solution for measuring energy consumption and for monitoring photovoltaic systems. The *Smart MeM* can be purchased by paying at once or by instalment payment at no additional cost or by paying an annual fee to take advantage of the service.

The "*As a service"* model consist in paying a periodic fee to use a service; an example is Homeflix, by Zurich Connect, an online home insurance with 24h assistance service. With this last two alternatives, much less common, profit should not be simply generated by a surplus on the sale price but may be recurrent over time thanks to the services, subscriptions and applications. It is important to underline that this types of approaches, although still have small numbers, are going to face a huge growth in the next years, thanks to the diffusion of servitization in the sale strategy of most companies. As explained before, nowadays, the *"Una tantum*" pricing model is the preferred solution for all the types of company, so the next analysis take into account only the solutions that adopt this policy (80% of the entire sample).

The analysis of the pricing model went on by considering the medium price of Smart Home products in the different countries (*Figure 33*).

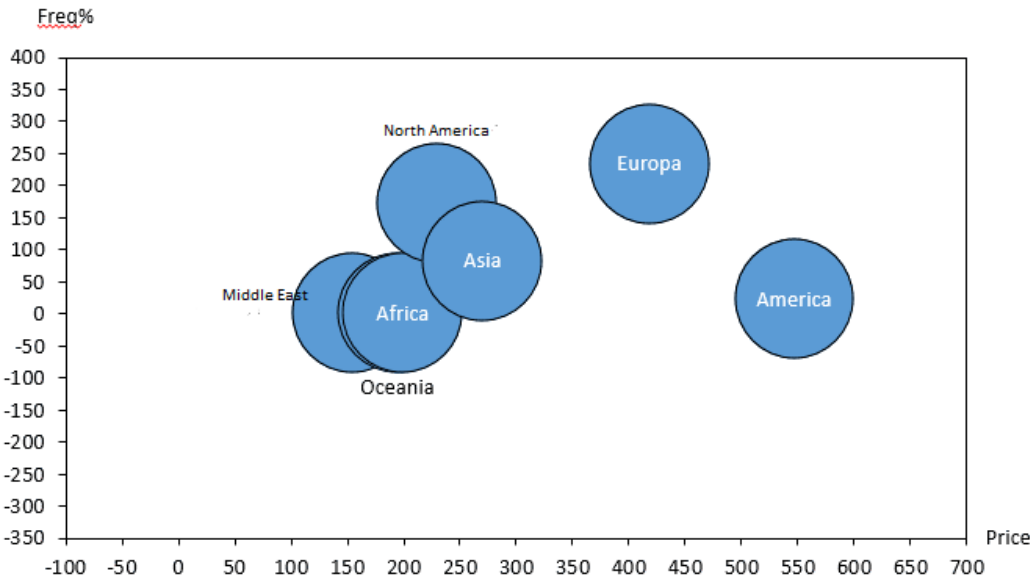


Figure 33: Medium price by Country; Sample: 518/698

As can be seen by the graph, the country that offer Smart Home Product with a higher medium price is Europe, followed by America and Asia. While in Africa, Middle East and Oceania the medium price registered is low. This is probably linked to the maturity of the market: while in Europe the Smart Home market is present from decades and complex devises are sold, in developing countries the market is still in its infancy. *Figure 34* gives a more detailed picture by looking at the single nations; in red, yellow and green respectively the nation that follow into the low (from 0€ to 149,99€), medium (from 150€ to 449,99€), high price (higher than 450€) category.

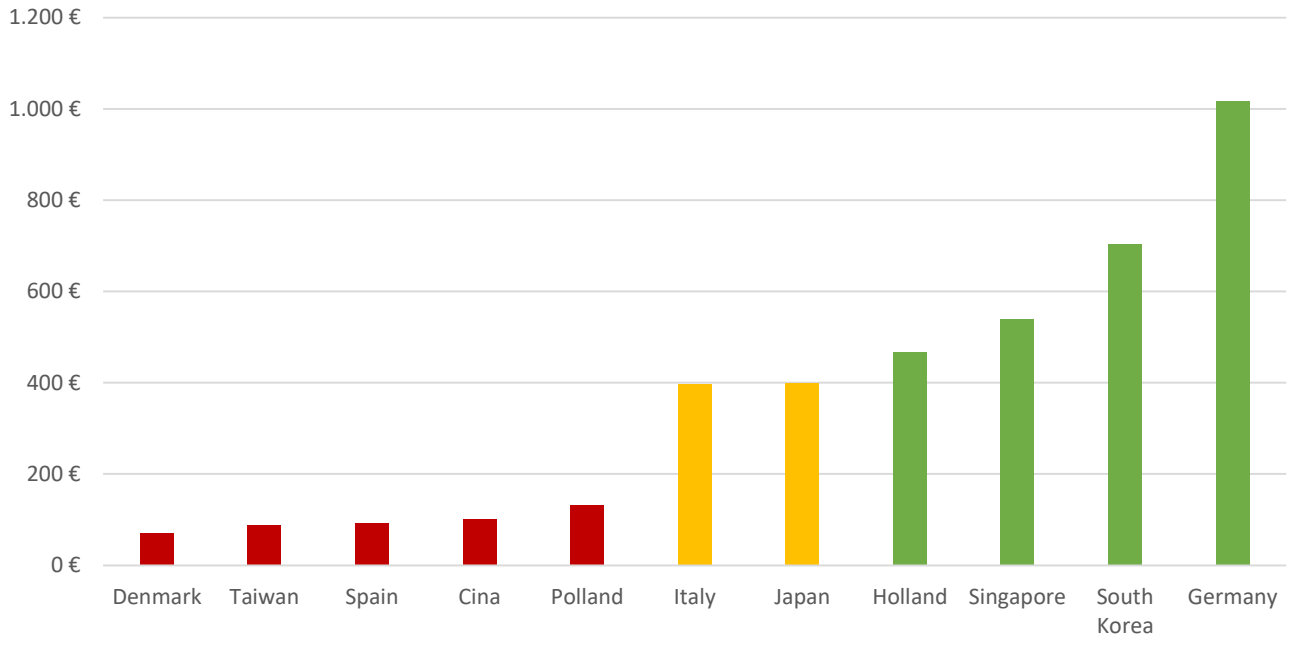


Figure 34: Medium price by Nation; Sample: 518/698

By crossing this analysis with the results regarding the Smart Home Market diffusion over the countries (done at the beginning of this chapter), it can be seen that the country where the medium price is higher are the same in which the market is more mature, probably because the basic products are already present in the most of the consumers' houses (in the years not taken into account in the sample) and consumers now require more complex and expensive solutions (for example, kits rather than individual devices).

To have further analysis on the pricing method, it is interesting to see how these ranges are distributed in the different industres of the Smart Home (*Figure 35*).

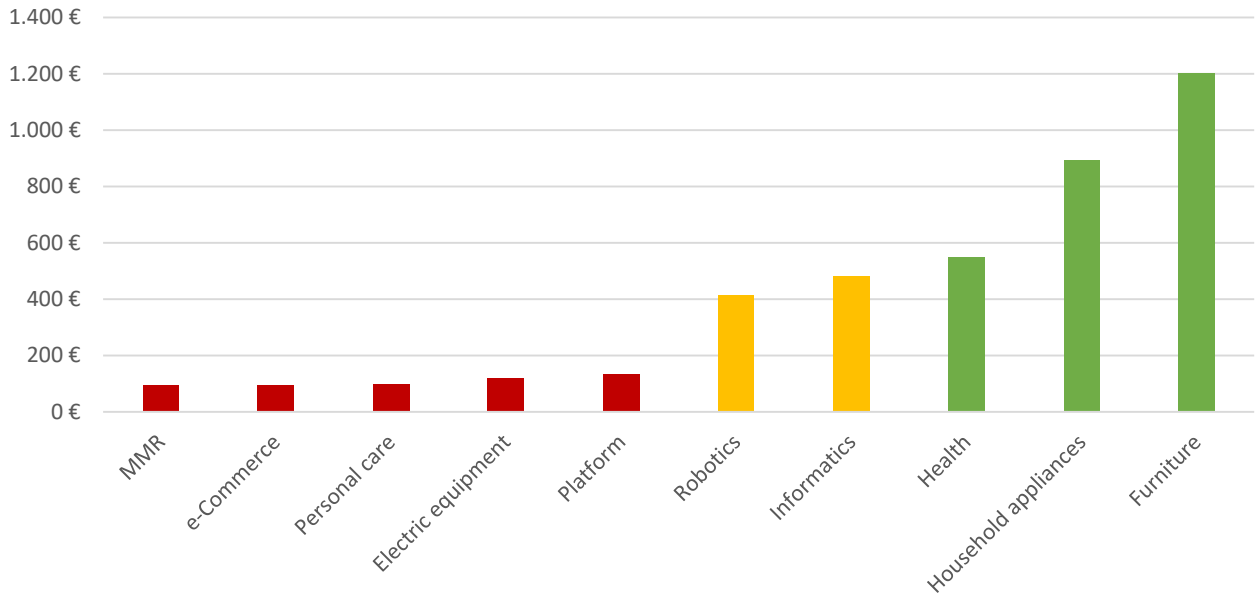


Figure 35: : Medium price by industry types; Sample: 518/698

The analysis conducted show that the low-price range products are present in every country and industry category. The industries that offer low-price products/solutions are the ones that can be linked to products such as sensors, cameras, smart bulb, so products very simple and easy to install. For this reason, low-price solutions are even present in the countries where the Smart Home Market is still in its beginning period (as stated before). It is worth to mention that the price is often related to a single product, thus the total cost of a complete system belongs to the high price range. On the other hand, the industries characterized by higher price are Household appliances, Furniture and Sanitary; indeed, given the volume, complex structure and their many functions, these kind of products cannot be in the low-price range (e.g. washing machines, refrigerators). The medium price category includes products related to the industry of Robotic and Informatic, such as hubs that are used to control the Smart Home.

3.3.3 Distribution channels analysis

The last step consisted in the analysis of the different distribution channels (*Figure 36*).

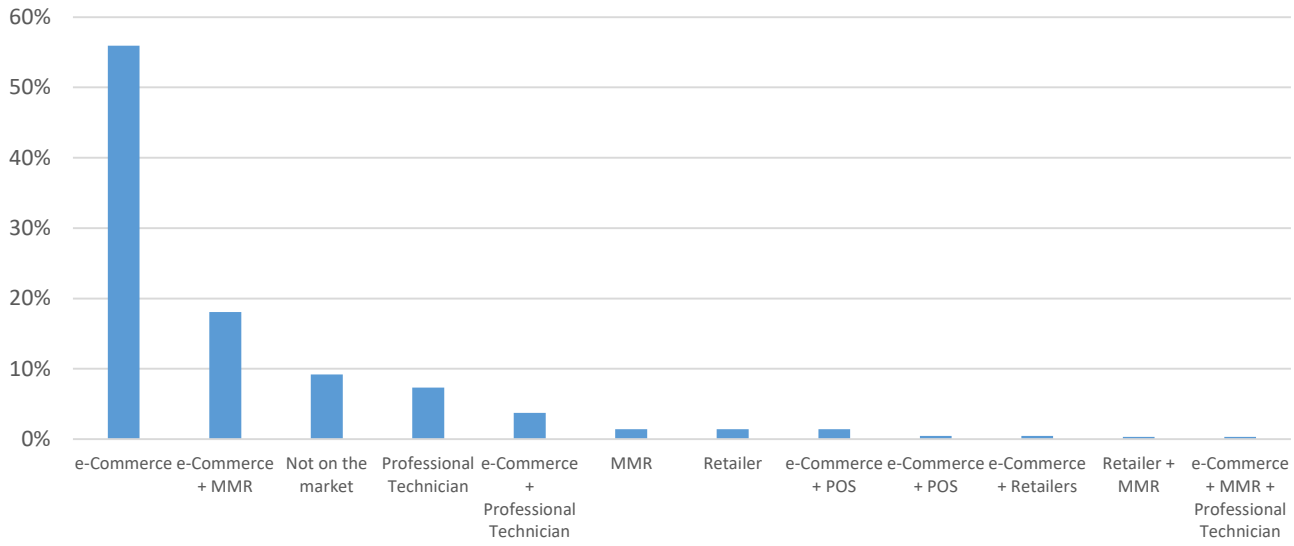


Figure 36: Frequency of the different distribution channels; Sample: 642/698

It emerges that *e-Commerce* is the most used sales channel, being adopted, as a unique channel, in 56% of the solutions and in 81% of the solutions mapped if also multichannel strategies are considered. An important role is also played by *professional technician*, that cover alone about 7% of the market. They are a key figure when it comes to complex solutions; however, thanks to the high number of self-installing/ easy to install products that companies are launching on the market, in the next future their role will be resized. As far as *Retailers* are concerned, their role in the current market is still a niche, in both the single channel and multichannel cases. Mass Market Retailers (GDO) instead result to be more exploited if considered with e-Commerce. As it can be seen in *Figure 37*, the *e-Commerce* channel is the most used channel by all the different types of company.

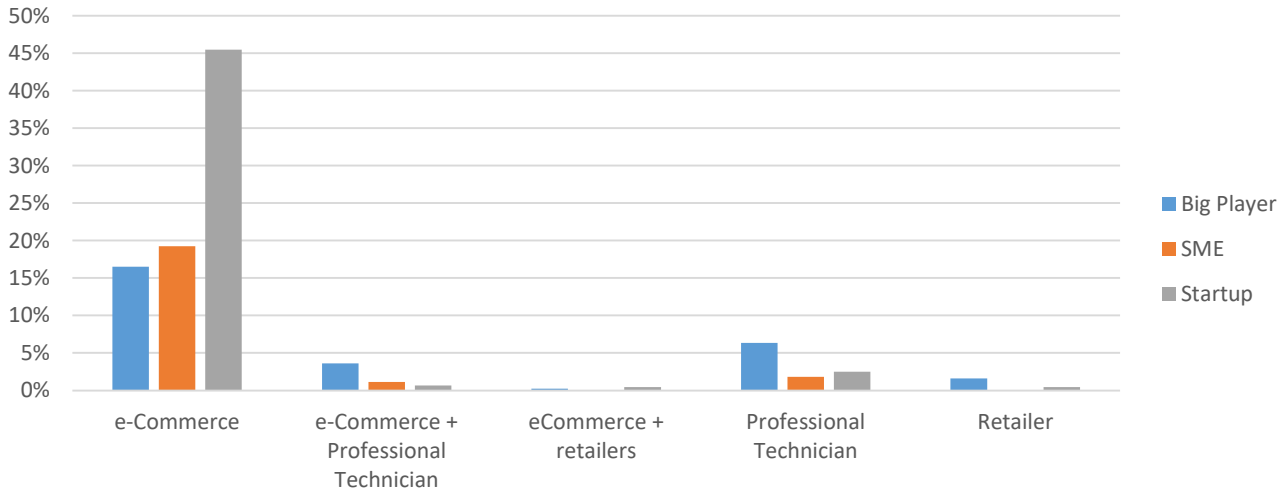


Figure 37: Distribution channels used by different company types; Sample: 642/698

For startups, *e-Commerce* represents almost the only channel used, given the high percentage with respect to the other channels. Startups have the need to directly reach the final customer pushing their products all

over the world, without the intermediation of retailers or professional technicians, cutting costs. This is due to their lower brand equity, range of products and financial capabilities. Also SMEs and Big Player leverage in particular on the *e-Commerce channel, with a frequency of* 19% for the former and 17% for the latter. However, they exploit, surely more than Startups, also the other distribution channels, in particular professional technicians and MMR. Big Players are the only ones that exploit the *retailers channel;* this is confirmed by the partnership between them (e.g. Samsung has close relationships with US retailers in order to promote its offer and, consequentially, to enrich the online purchase). So *Big Players* represent the category that prefer to use a multichannel strategy.

As previously illustrated, the products being analysed are often placed on the market via e-Commerce. This can be done either through the manufacturer's website or through external sites. The last option in particular occurs when these products are developed by small companies, which tend to have a simplified organizational structure, reduced managerial skills and a poorly structured risk approach. As a result, SMEs have greater difficulties in the distribution and market access phase, and therefore need the intermediation of companies such as Amazon and eBay, which have greater economies of scale and experience. These intermediaries also enjoy a brand awareness on which SMEs can leverage to reach visibility in large market segments. The word cloud realized *(Figure 38)* shows that the major retailers in the sector in question are Amazon, eBay, ePrice, Euronics and Monclick. The graph also highlights Amazon's position of economic dominance in this product sector, since it operates both as a manufacturer and as a distributor, with comparatively considerable dimensions compared to the main competitors.

Figure 38: Word cloud analyzing the e-Commerce external site most used; Sample: 612/689

Further insights can be observed by analysing the distribution channels according to the application scope (*Figure 39).* Given the complexity of the analysis, only the most diffused channels and the subdomain of interest for the results drawn have been filtered.

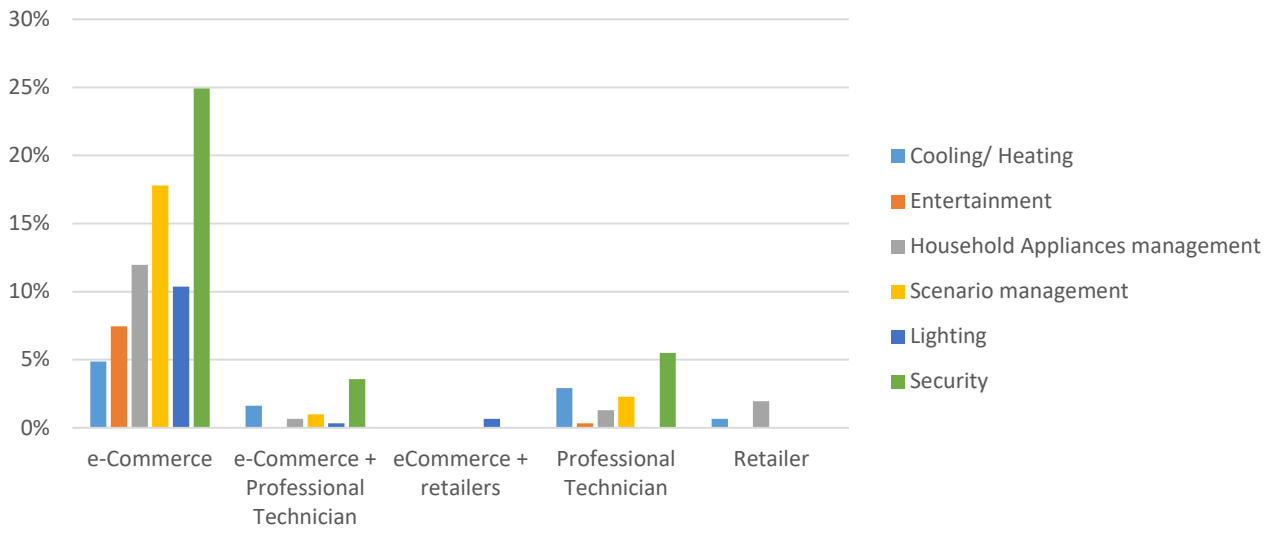


Figure 39: Distribution of the channel strategies for subdomains; Sample: 642/698

e-Commerce, as before explained, is the channel used in most of the subdomain analysed. The retail channel is particularly important for products belonging to the Home appliances management sub-domain: probably, given the economical effort required, consumers prefer to see the product before making the purchase decision. As far as *professional technicians* are concerned, it is clear their importance for Security Systems, Scenario management, Cooling/Heating and Home Appliances sub-domains. Indeed, in the first two cases, complex kits, that comprehends various smart objects, are usually sold on the market; so the final customer need a help for configuration and installation. While in the last two cases, probably this need is due, more than to the technical complexity, to the dimension of the objects to be installed.

Another insight of particular interest is the one related to the availability of the products analysed in the Italian distribution chains. As can be seen from the graph below *(Figure 40),* 68% of the products considered are not available in the main Italian retailers (Unieuro, Euronics, Mediaworld). Conversely, in 17% of cases the availability is positive, and for 15% the answer is not known in the light of the inferable information.

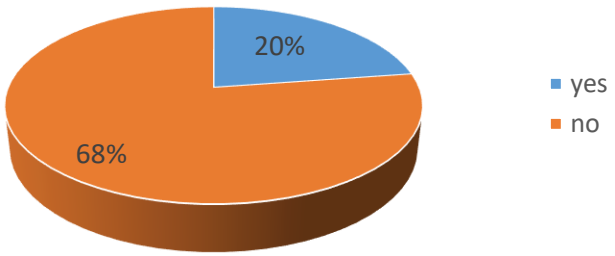


Figure 39: Presence of the products in the Italian Retailer stores; Sample: 583/698

The following word cloud shows that the major distributors of Smart Home products are Mediaword, Unieuro, Euronics, although they only distribute 17% of the products analysed overall.

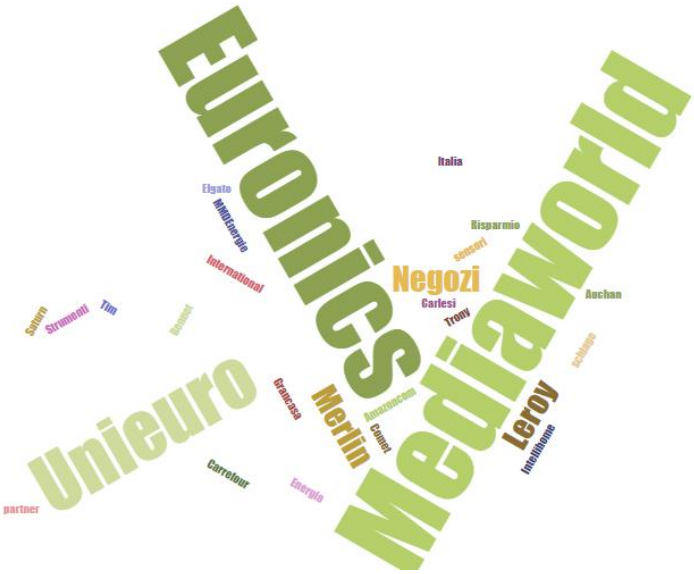


Figure 40: Italian Retailers selling Smart Home products; Sample: 698/698

3.4 Trend analysis

To complete the macro level picture of the Smart Home market, it would be interesting to analyse the evolution of the offer over the years, in order to obtain some insights on the actual and possible future trends. The box plot below (*Figure 42)* allows to identify the time span during which the products in question were placed on the market. The three-year period 2014-2017 brings together the greatest concentration (the boom of the market). The graph also shows some outlier points: the products sold before 2014 were developed by "pioneering" companies in innovation, while those made after 2017 refer to the *R&D* activities still in place.

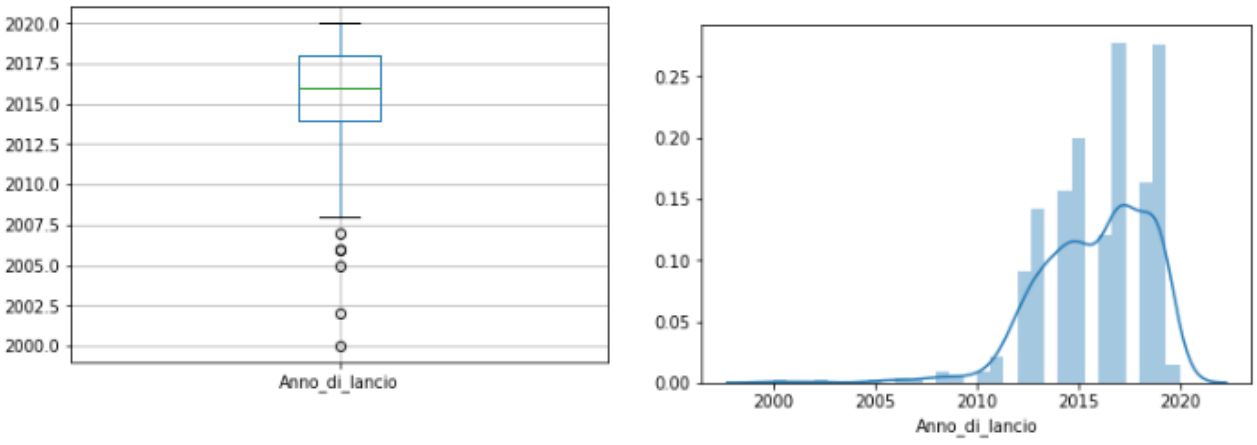


Figure 41 : Evolution of the offer over the years; Sample:698/698

Then the different years of diffusion of the mapped solutions in the different geographical arias has been studied *(Figure 43).*

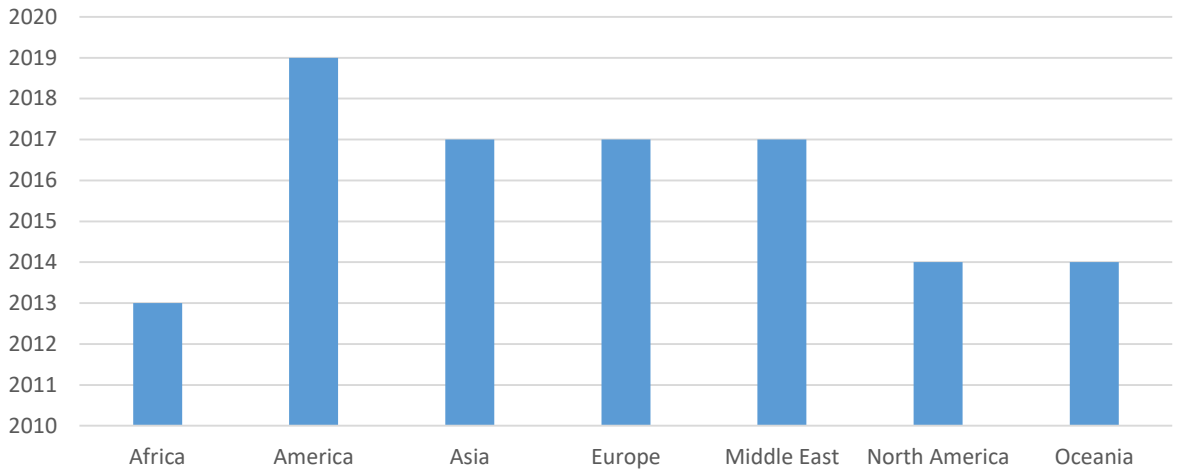


Figure 42: Evolution of the Smart Home market in the world; Sample: 689/689

From the table below *(Table 3)* it is possible to see for every area when Smart Home products started to be sold and the date of the last product to be released. North America has been an early adopter and it is on the market from the beginning to the end of the period observed. Same considerations can be done for Europe, even if with a five years checkmate. Middle East and Asia developed this market only in more recent year and nowadays compete in the world market. As far as Africa and Oceania, instead, the sample analysed let just to draw the conclusion that surely they have a smaller and underdeveloped market.

Area Geografica	*Launch_year_MIN*	*Launch_year_MAX*
Africa	2013	2013
Oceania	2013	2015
Nord America	2000	2020
Europa	2005	2020
Asia	2012	2019
Medio Oriente	2017	2018
America	2017	2020

Table 3: Year of the first and last Smart Home product launched in each country; Sample: 698/698

Important insight can be obtained by crossing the results above with the evolution of prices over time. In the following scatterplot *(Figure 44)* the variables *price* and *time* have been considered. The distribution shows a growing relationship. In other words, the most expensive Smart Home products have been made in more recent years (2014-2020 period).

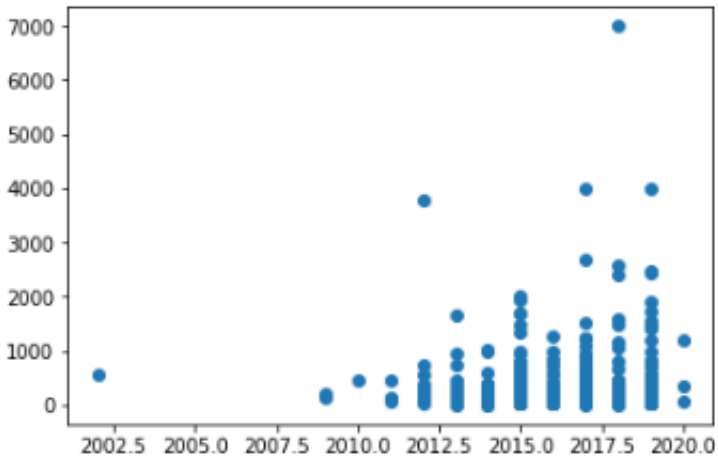


Figure 43: Evolution of the prices over time; Sample: 698/698

This means that the most expensive products are only sold in North America and Europe, where the market is more mature. The increasing price of the offer, however, is not given by the increase in the price of the single devices but rather by the need of the consumer to purchase complete kits, including additional services. This can also be confirmed by studying the distribution of prices among the product analysed.

In *Figure 45* it is shown a curve that is leptocurvic and strongly asymmetrical on the left. The economic interpretation of this distribution refers to the fact that 75% of the Smart Home products are offered on the market at a price less than or equal to 330 euros, and the average price of these products is equal to 335 euros. Conversely, only in some cases the prices have out of range values as shown by the associated box plot (each sphere corresponds to an outlier).

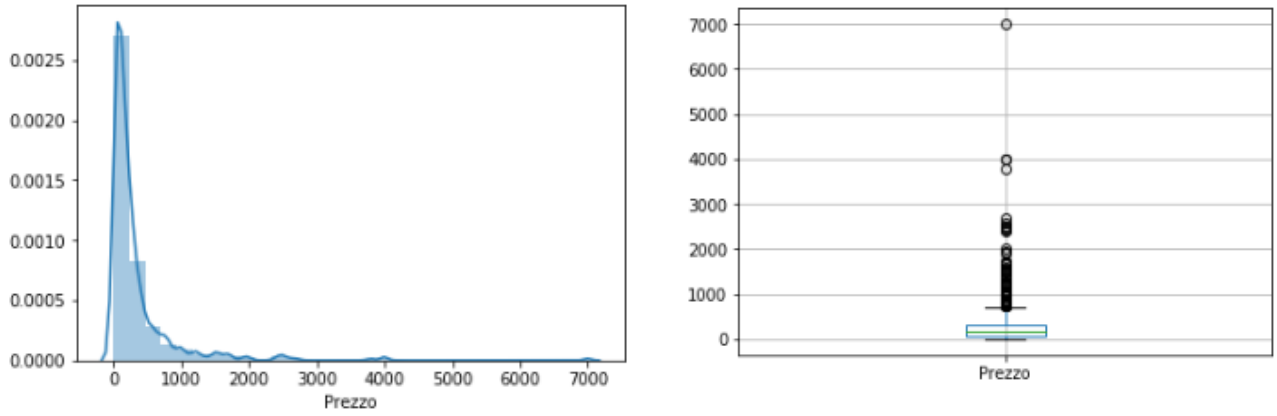


Figure 44: Price of the products; Sample: 698/698

Further insights can be obtained by looking at the application scope distribution over years (*Figure 45).*

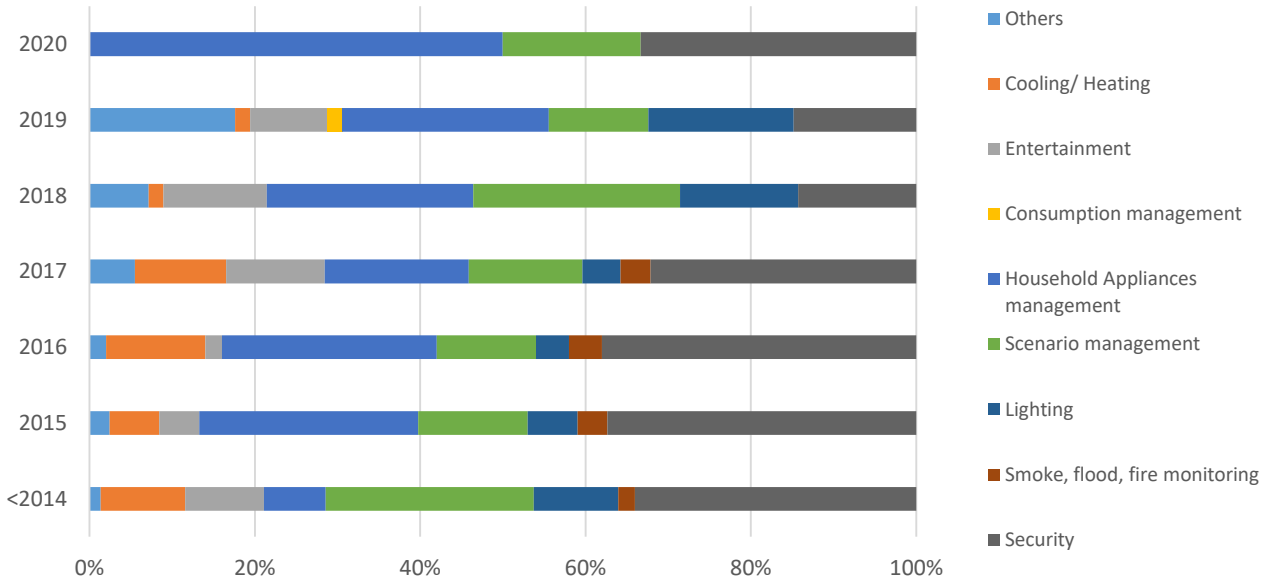


Figure 45: Application scope evolution over time; Sample: 698/698

It is relevant to examine the trend of the most relevant application scope (in terms of offer, before mentioned) over the last five years. Also for this analysis years before 2014 have been aggregated and 2020 takes into account only the first two months of the year. While as far as the Application scope, only the field characterized by significant changes have been plotted. For *Security systems* the biggest peak is reached between 2015- 2016. This field also obtains a superior position over the other fields for all the five years considered, as a confirmation of the importance of *Security* in the Smart Home market, as attested in the previous paragraph. As far as *Home appliances management*, after a peak in supply in 2015, still continues to record a significant share of solutions. The sector is driven by the sale of connected washing machines (IoT Observatory of Politecnico di Milano); the first major break in the market was done by Candy, that in 2014 launched Simply-Fi, the first product line connected via Wi-Fi and controllable remotely by a single application. In this wake than also other company, such as Whirlpool, Bosch and Samsung moved. The third field more relevant in terms of offer, *Scenario management*, had a peak in 2018 but it has always been present, with a good market share in all the years taken into account for the analysis. This constant distribution over time, confirms the importance to offer customers a unique interface for the Smart Home.

Lighting products have always been present on the market, probably thanks to companies like Philips and Samsung that started to launch their first products in this area since 2014; the boom is reached during the 2018, thanks to the general growth of the Smart Home market and the collapse of prices, that made especially the small smart appliances available to everyone. A similar path to the of the lighting can be observed for *Entertainment subdomain*, always present on the market, but which boom in 2018-2019 is evident. For this category the boom can be probably explained with the spread of the Smart Speaker market that led to the production of high-end devices more oriented to the interaction with the final user. Regarding *Cooling/ Heating* appliances, the products have reached their peak during 2016- 2017 and then it is possible

to detect a slight decrease. As far as the remaining sub domain are concerned, it is important to underline that the results might be influenced by the search itself that probably has not included enough existing solutions. For *consumption management*, it is observable a different trend for energy, water and electricity. Electricity consumption management devices had a peak during the first years of the analysis and then it is immediately evident a quick decrease. Water consumption monitoring, on the other hand, presents an opposite trend: this type of products was completely absent before the 2015 but they developed very quickly reaching interesting percentages of diffusion in 2019; this is probably due to the awareness raising on the topic in the recent years. Energy saving, instead, it is totally absent and then present good market shares only in the two most recent years analysed. This can be probably due to the fact that energy saving was one of the founding themes of the Smart Home; after the initial wave happened in previous years (not analysed), there has been a fall (from 2015 to 2017) due to an over-saturated market; while in the last two years analysed (2018-2019) product share has stabilized. The area *Smoke, flood, fire monitoring* had a stable, albeit small, market share during the years 2015-2016-2017, while in recent years they are not so far asked, probably due to a saturation of the market. While for watering management and animal monitoring, there is surely interest for this application but the number of solutions available on the market (at least the portion analysed) is limited. The category *Others*, show a constant increase during the years and it is therefore a domain that will continue to count solutions even in the coming years. The same trends can be confirmed by analysing the diffusion over years of the different industry types. In the analysis only the industries that show an evident correlation with the subdomain analysed have been taken into account.

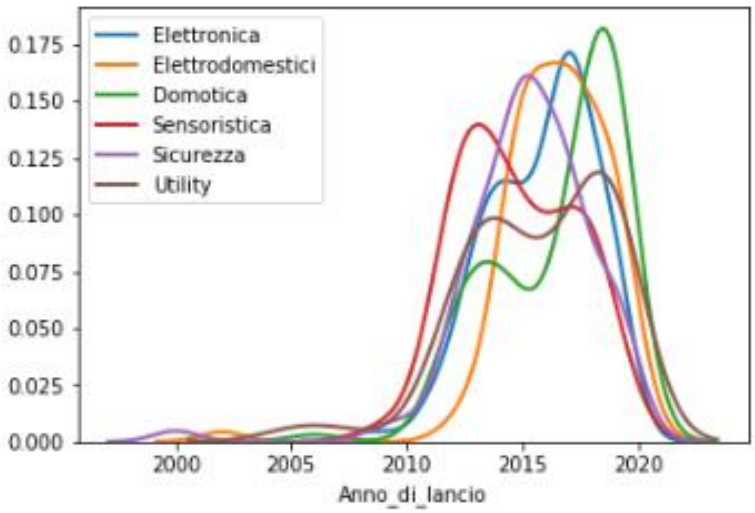


Figure 46: Adoption curve for industry type; Sample: 698/698

As shown in *Figure 46*, all the industries analysed reached their peak in the Smart Home market during the years 2014-2019, while before were totally absent.

Considering this targeted years, the distribution over time has been analysed (*Figure 47*).

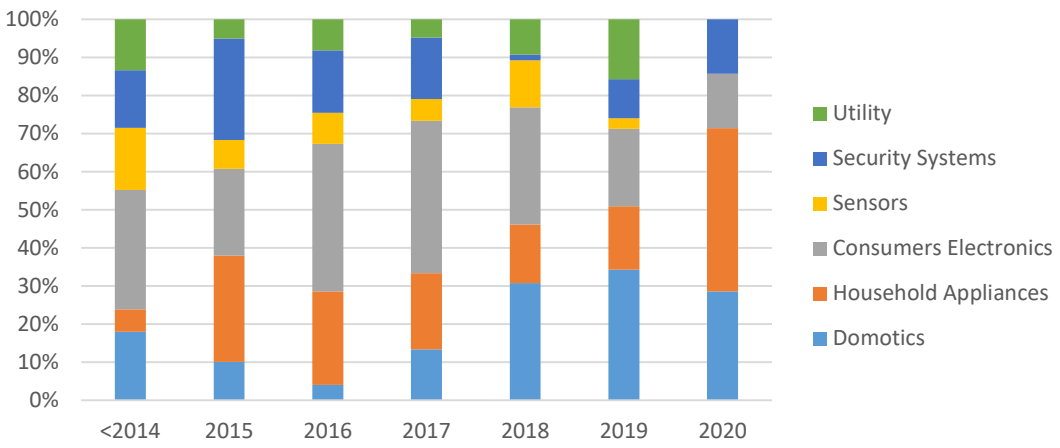


Figure 47: Distribution over time of the type of industries; Sample: 698/698

The *Home Appliance* industry, *Consumer electronics* and *Domotics* industry dominate in the market. The former is correlated to the wide diffusion of *Home Appliances Management* sub-domain (the second sub-domain for market share). The *Consumer electronics* industry can be linked, more than anything else, to the subdomain of *Entertainment* and, in fact, the trend is the same: as previously seen, it has always had a significant share of the market, reaching a peak in 2018. *Domotics industry*, in the broader sense of the terms, has a boom in the more recent years, 2018-2019, probably thanks to the diffusion of Artificial Intelligence and autonomous learning systems, as well as thanks to an improved data analysis and data valorisation optic. *Security industry* follow the path of *Security appliances*, with a peak in 2015 and a normal distribution over time, which confirms again that this field has always had a huge importance for consumers. Sensors industry show a two peaks with a halt in between: the first one during the first year of the Smart Home diffusion (2014) and the second in the year analysed (2019). The same trend has already been see for lighting, consumption management and scenario management sub-domain, that, from the previous analysis, result both to have a higher market share, as Sensors industry shows, and to have been characterized by a fall after a first diffusion due to an over-saturated market. The same considerations can be done for the industry of Utility.

CHAPTER 4: BUSINESS MODELS AND SMART HOME ECOSYSTEM

This chapter presents some companies offering Smart Home applications and describes how they act in the Smart Home market through the analysis of their business model. The companies have been divided into three groups. The first one focuses on the Tech Big Giant: Amazon, Google, Apple, Samsung; the second one focuses on startups and the last one describes small-medium enterprises (SMEs). Before entering in detail and analyse each actor, it is necessary to build the ground for the analysis.

In a highly-technologic, value-intensive and multi-actor sector, as the one of the Smart Home is, in defining a business model of a company it is essential to link the company's activities with the surrounding network:

Business Ecosystem. So the next step consists in defining what an ecosystem is and which are the peculiarities of the Smart Home one. Indeed, it is no more possible to consider just the single actors but there is a call to a real symbiosis of collaborators that work within a broad business community: Business Ecosystem.

4.1 Business Ecosystem and Smart Home

The term ecosystem was introduced for the first time in the 30's by Arthur Tansley, a British botanist, to describe a community of organisms interacting, competing and collaborating to co-evolve and jointly adapt to their environments, catch opportunities and exploit available resources. The concept of ecosystem was applied to business theory for the first time by J. Moore (1993): *"I suggest that a company be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries. In a business ecosystem, companies co-evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations".* Moore underlined the need of an evolution from a company-core-perspective to the concept of extended enterprise and finally to business ecosystem.

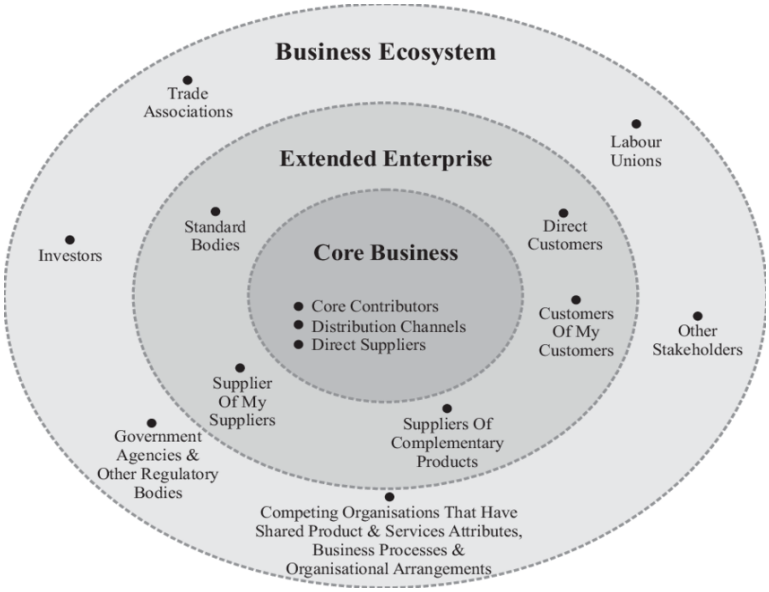


Figure 48: Smart Home business ecosystem representation; J.Moore, 1993

Another insight is given by Peltoniemi M., Vuori E. (2008) who stated "*the system is more than the sum of its parts"*. What he outpointed is that the partnerships are functional only if the final common value is major than the sum of the value deliverable by the single actors.

The more recent definition of Business Ecosystem was given by E. Kelly (Deloitte University Press, 2015): *"Ecosystems are dynamic and co-evolving communities of diverse actors who create and capture new value through increasingly sophisticated models of both collaboration and competition … First, ecosystems enable and encourage the participation of a diverse range of (large and small) organizations who together can create, scale, and serve markets beyond the capabilities of any single organization … Second, participating actors interact and co-create in increasingly sophisticated ways that would historically have been hard to*

formally coordinate in a 'top-down' manner, by deploying technologies and tools of connectivity and collaboration that are still proliferating and disseminating … Third, participants are bonded by some combination of shared interests, purpose, and values which incentive them to collectively nurture, sustain, and protect the ecosystem as a shared "commons." Everyone contributes, everyone benefits".

Applying this general concept on the Smart Home field, the Smart Home ecosystem can be defined as the 'whole' or 'holistic' system of devices that need to work together to achieve all of users' in-home requirements.

4.2 Business models and Smart Home

There are many definitions of business models. One of the most complete definitions was probably proposed by Osterwalder & Pigneur (2005): *"A business model is nothing else than a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and robust revenue streams."* Chesbrough & Rosenbloom (2002) defined the Business Model as *"a blueprint for how a network of organizations co-operates in creating and capturing value from technological innovation".* This concept is also expressed by Haaker, Faber & Bouwman (2006): "*A business model describes the way a company or network of companies aims to make money and create customer value*". Through time, the concept has changed; Porter (2001), underlined that more recently, business models have been related to market structures and the place individual companies occupy within those structures. In the same paper Porter underlined how business models are more and more related to strategic choices companies are making. The implementation of a strategy is increasingly translated into business models, which aim to answer questions regarding the customer needs, the way services are provided, the availability of resources, the way processes are defined, etc. Also Melin L., Naldi L. (2013) observed the shift of the definition from "*what business models are*" to "*what business models are for*". Indeed, a correct business model must start from a clear value proposition and must always take into account the target market of reference. Westerlund M. (2011), outpointed the possibility of having different new or renewed strategies by linking the business models to the relationships with the other firms in the ecosystem. Indeed, it would be limiting and incomplete to just consider a single actor and not the *key partners* that have strong impact on the overall strategy and to forget the central role of customers as co-creator of value.

It is evident the higher complexity in designing business models in a context of multi-sided platforms and ecosystems, which is the case in the IoT paradigm; IoT-based products/services allow for a radical change in existing business models (Porter & Heppelmann, 2014). Nevertheless, still little is known about how the IoT change business models and literature do not exert how business models for the IoT should be constructed. Generally speaking, there are various business model frameworks, at the enterprise level and at the industry level (Sun et al., 2012). At the enterprise level, the most used frameworks are: the Value Chain, the Strategy Map, the Four-Box Business Model and the Business Model Canvas (BMC).

In the analysis done, aspiring to identify scopes and strategies with a high-level perspective, the traditional business model templates and frameworks have been a reference but have not been applied meticulously. Among the different frameworks, the BMC is suggested as a possible framework for analysing Smart Home companies. The "Business Model Canvas" is a model proposed by Osterwalder and Pigneur in 2010. It is a synthetic and handy model, which can be used for all types of business and at any stage of life. It is one of the most used frameworks for business modelling, including digital businesses and the IoT (Sun et al., 2012). It allows to synthetically store essential information, giving a simple and complete picture. It was therefore chosen for its versatility and completeness. The BMC is made by nine building blocks covering the areas of:

- Offering
    - Value proposition
- Infrastructure
    - Key activities
    - Key resources
    - Key partners
- Customers
    - Customers segments
    - Channels
    - Customer relationship
- Finances
    - Cost structure
    - Revenues stream

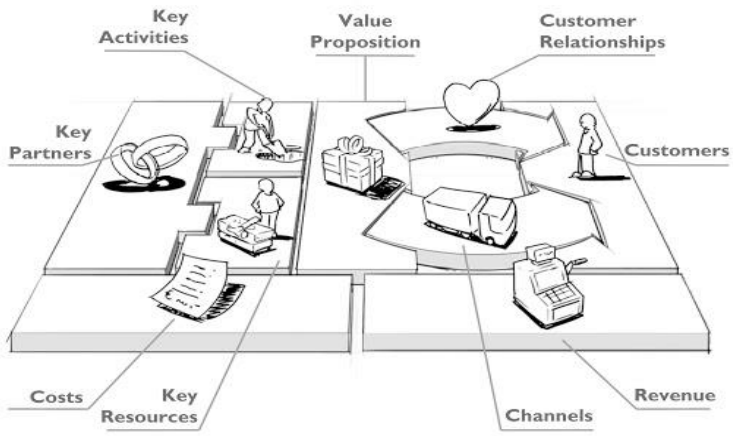


Figure 49: Business model Canvas representation

The financial part of the model will not be covered in the analysis since the information needed to make assumptions about the costs and the revenues stream are outside of my research scope.

4.3 OTT companies analysis

As far as the Over-The-Top companies operating in the Smart Home market are concerned, the analysis is centred on the Tech Big Giant: Amazon, Google, Apple and Samsung.

Generally speaking, these companies are characterized by:

- affordability, thanks to which they are able to create strong partnerships, obtaining the access to broad competences;
- cash availability, that opens to strong acquisition policies;
- ability in collecting and managing data that let them improve their value proposition and increase customers' retention.

These players have a foothold in the majority of the sectors and their entry in the Smart Home field increased the interest of the mass market, thanks to their brand awareness and effective communication.

4.3.1 Amazon

Amazon, an American e-commerce company, is the largest Internet company in the world. In November 2014 it announced a big news for the Smart Home world: Alexa and all the Echo Smart Speakers. Alexa is an artificial intelligence capable of dialoguing with humans and executing voice commands. Among the most common functions: play music, set reminders and alarms, play audiobooks and provide weather forecasts and play other information, even in real time. In the home automation field, Alexa controls the various smart devices and let to manage lights, thermostats, smart sockets and switches by voice, as well as scenarios and routines. The Amazon Echo line has been hugely successful. This huge success is due to the fact that the company has a much broader Alexa-based product portfolio than its competitors, some of which have excellent value for money, and, also to the chronological aspect of the whole issue: Amazon was the first to launch a smart speaker. In Q3 2019, in fact, Amazon is pulling the European market, with over half of the deliveries of smart speakers. Moreover, its acquisition of Ring, best known for selling its connected doorbells, security cameras, and floodlights, in 2018, allows to strengthen its position also in the security and automation sector. More generally speaking, considering the whole offer, Amazon is adopting a cradle to grave strategy (as pointed out by Wolf M., 2016), since it aims at managing all the phases of the product lifecycle, from purchasing to installation and post-sale services.

Figure 50: Amazon logo

Value Proposition

The value proposition changes on the base of the targeted customer segments.

Consumers

Amazon offers its customers a strong value proposition based around these key ideas:

- Price; Wal-Mart displayed it as being the leader in low price category;
- Selection;

- Fulfilment: it provides fast delivery, guidance during the purchase, assistance after the purchasing process, though online chat and additional services (e.g. dash button). It is the earth's most costumer centric company;
- Variety: it offers a wide range of products/ services: consumer electronics (Kindle e-readers, Fire tablets, Fire tv, Echo); low end products (e.g. USB cable) under its bran Amazon Basic; it is the world's largest provider of cloud infrastructure services (Iaas and Paas); Amazon music; Prime instant Video;
- Innovation.

Sellers and installers

The aim that Amazon let the producers/ installers of Smart Home products to reach is greater visibility; for the former this led to customer awareness and increased sales; for the latter this led to become part of a wide network and to increase the customer base. In both cases, Amazon let them to scale up global their business.

Key activities

Amazon focuses on the most diverse activities:

- merchandising, that is the heart of the business;
- platform/software development and maintenance;
- logistic and distribution, a sector in which Amazon is an example worldwide;
- R&D for what concern both new products/services to offer and the way to deliver them;
- Human resources;
- Customer service, since as said, Amazon is obsessed on a customer centric view.

Key resources

The company exploits both physical and intellectual resources to deliver its best value proposition. Among the physical ones, the more important are: logistic assets (warehouses and distribution network), IT infrastructure, robotic systems. Among the intellectual ones: human resources, e-commerce strategy, strong brand awareness, recommendation algorithm, patents (e.g. speculative shipping).

Key partners

Among the most significant partnerships, these can be underlined:

- suppliers and manufacturer; Amazon coverts its potential competitors into partners that help to generate value; e.g. the decision of open-sourcing Alexa is going towards this direction;
- network of sellers;
- logistics providers;
- mergers and acquisition;
- subsidiaries (e.g. Beijing Century Joyo Courier Services).

Customer Segments

Amazon targets three different customer macro-segments:

- *Mass market consumers* (everyone who buy products from Amazon for personal purposes.
  This segment can then be split taking into account customers' behavioural basis.
  The usage of Amazon broadly mirrors technological adoption trends: where people are connected, technologically advanced, time poor and price-sensitive, they tend to use it more. This happens especially in the urbanites;
- *sellers* (everyone, producer or wholesalers, who want to give visibility to its products and sell them through Amazon; they can be little producers, developers or large e-commerce sellers that use Amazon in addition to their own websites);
- *installers* (everyone who offer installation services that can be bought through Amazon, independently or to be added to the purchase of a product);

Channels

The channels used to reach the customers are: websites (witch products/services can slightly vary on the base of the country); mobile App; a wide logistic and distribution network; social media; Amazon Go stores, pioneered in 2016, which are contactless physical stores with humans involved.

Customer Relationship

Amazon focuses on B2C and B2B relationship. It also let a C2C relationship through the Amazon marketplace. Amazon main leadership principle is customer obsession. Amazon customer relationships are based on:

- automated services;
- co-creation (e.g. customers leave reviews and recommendation on products/services purchased);
- community;
- timeliness (e.g. same day delivery race);
- customer experience;
- partnership and alliances;
- innovation (e.g. Amazon suggest or send things before the customer orders them; Twitter users can link their accounts to Amazon and automatically add items through the tag #AmazonCart).

4.3.2 Google

Google became aware of the opportunities of the Smart Home market in 2014, thanks to the acquisition of Nest, a Smart Home appliances maker. Then this business acquired more and more importance. In 2016, after the launch of Amazon Echo, Google launched on the market Google Assistant, a virtual assistant, that firstly came as a function of Google Home in 2016 and then was brought also to the core of Nest's offer. In this way Google started to strongly affirm its position in the Smart Home market.

Figure 51: Google logo

Value Proposition

As far as the Smart Home field is concerned, Google strategy is "being the thread that ties together the Smart Home world" (Kastrenakes J.,2016). Google makes users' life easier in innumerable ways: multiple hardware

products (Home smart speaker, Wi-Fi mesh wireless router, Daydream View virtual reality headset), AI with Google Assistance, Google Shopping that allow users to compare prices among different online vendors, content platform (music and video), cloud services, Marketplace, hosted web-based Google Apps, services designed for work and productivity.

Key activities

Among the different key activities, the most important one are R&I and R&D, indeed Google is committed to both the development of new technologies, features and the improvement of existing ones. Others key activities are the maintenance and management of massive IT infrastructures and products and services, data analysis and indexation, software development. Separately from this, there is work done on marketing and sales, strategy and alliances.

Key resources

Key resources for Google are both physical and intellectual. The physical ones include datacentres, servers and other IT infrastructure, IPs. Among the intellectual ones: staff talent, the corporate philosophy ("you can make money without doing evil", "you can be serious without a suit", "work should be challenging and the challenge should be fun"), company culture, its innovation model. Other resources include patents, licenses and proprietary material, platforms, Android mobile operating system and last, but not least, the brand (with its popularity and ubiquity, Google has become the verb to describe "search for something online").

Key partners

Key partners for Google comprise suppliers, content creators, stockholders, distributors, the Open Handset Alliance and original equipment manufacturers (OEM), developers' community, hardware manufacturers, major electronic manufactures, acquisition and partnerships. Among the different partnership, it is worth mentioning the one with utilities: an example is the "Rush Hour Rewards", a program through which the users get paid by the energy provider to use less energy during peak periods. To sum up, Google has partnerships with the most varied types of actors and so, it shows to take advantages from the Smart Home ecosystem.

Customer Segments

Google customers are segmented into three categories: the users segment: people (single consumer or enterprises) who use in convenient ways Google products and services; the advertisers: people who have a cost-effective way to display online and offline ads to customers; Google Network Members and other Content Providers (web publishers, Ad agencies). Another extended segment may include mobile device users and makers along developers.

Channels

Channels used to reach customers include google.com, google affiliate websites, global sales and support teams, Google Apps, Android devices, public relations and events.

Customer Relationship

In order to build a positive and strong relationship with customers, Google adopts a problem solving approach, fast, flexibles and with high standards. It provides customers with sales and support services, personal assistance both online and in stores, possibility to share opinions and ideas in the community (co-creation), automated services and online tools, dedicated apps. A particular attention is dedicated to large groups of users: Google offers dedicated teams and adopts economies of scale.

4.3.3 Apple

Apple, born as a US company producing operating systems, computers and multimedia devices, since 2011 has been one of the largest companies in the world by share capitalization. Apple has entered the Smart Home market thanks to its HomeKit framework. Apple's requirements for HomeKit support are extensive, meaning that the list of devices supported under HomeKit pales in comparison with both the Amazon and Google equivalents. However, in 2011, Siri, the digital assistant developed by apple in 2012 has also access to HomeKit, allowing a voice base control and lead to the ecosystem becoming broader.

Figure 52: Apple logo

Value proposition

The Apple Value Proposition revolves around three core concepts:

- Think different; Apple aims to an identification of the user with Apple's brand values, so it aims to create a strong link between brand and status. People who use Apple devices are creative, hipster, people who "Think different".
- Tech That Works; Apple technology is seamless and integrated. Apple, in contrast with the other big players, controls the software, the hardware and the content. This results in a far easy experience for users. The efficiency component both in products and service delivering is deeply related to Apple value proposition. So convenience and usability are the core of Apple value proposition
- Your Privacy is Safe with Us; Apple sells Software and Hardware and builds all of its products into a single consistent eco-system (walled garden). It doesn't sell advertising or make a market in data. This creates a core value proposition that separates them from the other big tech giants analysed.

Those components can be applied to the whole Apple offer: devices, services, operating systems and accessories.

Key activities

Apple has two key activities in its business model that differ from the other companies' analysed and led to create value proposition: design, branding and marketing. Apple is fundamentally about associating their products and services with emotional feelings in its users; users should feel successful, different, special. The marketing efforts of Apple are highly unique. Obviously there are many other activities which has led to create value proposition: R&D with a strong focus on innovation, hardware and software development, app development, quality control.

Key resources

Apple relies on physical, intellectual and human resources. The most important for the company are the intangible ones: its "think different" ideology, the corporate culture, a consistent focused philosophy of saying "no" (Apple only makes a product if Apple can do it better). These led the company to be the world's largest IT company by revenues. Apple is also the world's largest company by total assets. Important resources for the company are also the "best in class" employees in every role, intellectual property, hardware and electronic manufacturers, its operating system.

Key Partners

The Key partners of Apple includes: manufacturers and suppliers, Telco companies, wholesalers and retailers, authorized resellers, mergers and acquisitions. They do a variety of activities for Apple, including: provision of row materials, provision of assembly services, provision of manufacturing facilities, selling of company's products, software development. Among the top ten partners there are Foxconn Technology Group (world's largest electronic manufacturer), Intel, Wirtek (supplier of touch screen), Toshiba (supplier of LCD panels).

Customer segments

Apple is a company operating in the global consumer market, thanks to the wide variety of products/ services offered. However, it can be noticed a ditch of the Mass market and a deeper focus on business, richer, brand loyal segments.

Channels

The most important channels used include: Apple Stores, that, though the genius bar layout, make a statement in a way that their competitors do not; Apple's websites, through which Apple controls the distribution of its products; Third-party stores that have their brand and image tightly controlled. For this company it is worth to mention the marketing channels, most of all the word of mouth (users need and want to talk about their ownership of an Apple product or group membership).

Customer Relationship

The company performs a number of activities for maintaining good customer relations, such as: establishment of Genius Bars, heavy advertisement to provide information to both existing and potential customers, product warrantees and guarantees. What makes the biggest difference in Apple's customer relationships is that Apple is a product-led company; customer support, although being an important part of customer relationships, is seen as a failure of product design (consumers contact support when something goes wrong. If you can design out failures, then you need far less customer support).

4.3.4 Samsung

Samsung, the biggest electronic company of the world, officially entered the Smart Home market in August 2014, thanks to the acquisition SmartThing, that was a fast-growing home automation startup. SmartThings cofounder and CEO Alex Hawkinson stated:

Figure 53: Samsung logo

"From the beginning, our goal has been to make a platform every human being could use—and to make

every home a Smart Home". Working on this path, SmartThings developer community created a platform, composed by a hub and a "smart apps" that allow various devices to sync up and talk to each other. Collaborating with Samsung, the company leveraged the global scale and reach a much bigger number of customers more quickly.

Value proposition

Samsung value proposition is: "Inspire the World; Create the Future". The company aims at creating superior products and services that contribute to a better global society. The Samsung offer in the Smart Home field is based on the SmartThings, a complete and open ecosystem. Samsung offer is composed by SmartThings cam, SmartThings hub and sensors, SmartThings Wi-Fi, SmartThings trackers. Samsung offers also a wide range of connected products: appliances and accessories (smart washers, refrigerators, air purifiers). Most of the products are DIY (Do-It-Yourself) products; they are easy-installable products that let the users to easily customize the Smart Home. Another feature that should be pointed out is the commitment of the company to produce "green products".

Key activities

Being an innovative company, Samsung is focused on R&D for improving existing products and developing new ones. Others important activities are: manufacturing, distribution, repair services, consultation, IT infrastructure management, quality control and marketing.

Key resources

The company exploits different kinds of resources. Among them, the existence of a trusted and solid brand is the most important. As far as the physical resources are concerned, the solid infrastructure of R&D and IT sectors should be mentioned, since it let a huge products and services diversity and innovation, essential to enlarge the customer base. Among the intellectual resources, integrity and know-how are the more important.

Key partners

The main partners are suppliers, component manufactures, developers (the heart of the SmartThings platform), Google (for the Android OS), joint ventures (Toshiba, Sony, etc.), affiliated companies, mergers and acquisitions.

Customer segments

Samsung is a multi-industry company that target the *mass market*, trying to make Smart Home devices diffused in every home and thus reaching high sale volumes.

Channels

To reach the customers, Samsung uses: its own online channel, reseller and distribution channels, third party websites, retail stores.

Customer relationship

In order to strengthen the relationship with customer and/or enlarge the customer base, Samsung points on: customer personal assistance (either online or in the retail shops), automation of services, co-creation, community sense, brand loyalty, dedicated showrooms (e.g. the Samsung District in Milan and other showrooms at retail stores where customers can have a live experience of the Smart Home products).

4.4 Startups analysis

As far as the analysis on the startups is concerned, the choice fell on AICO and FIBARO. These companies are present in the Database analysed with their flagship product, respectively, SmartEgg and Swipe that catch the attention for the high level of integration, innovation and originality.

4.4.1 AICO

AICO Technologies is a startup founded in 2014 that operates in the home automation field. Its flagship product is Smart Egg, a universal remote able to control any infrared home device, allowing to manage them from mobile phone and to create different home scenarios. The object connects to the smartphone via Bluetooth 4.0 with which it interfaces via the appropriate AICO App, while the connection with smart devices is via infrared technology.

Figure 54: AICO logo

Value proposition

AICO aims to satisfy a need that today could be contingent with the increase of electronic devices present in every house: being able to control all of them through a single device, making them collaborate and creating scenario, automating some processes that are performed regularly every.

Key activities

With the aim to prove a product easy to use, able to manage in an easy way the large number of smart objects present in our houses, AICO teams are specialized in software development, hardware integration, R&D activities and design.

Key resources

The most important resources inside the company are the intangible ones: kickstarters campaign (e.g. platform that gives startups the opportunity to be supported, especially in terms of finance), FCC and CE certifications (e.g. certification mark employed on electronic products manufactured or sold, respectively, in the United State and in Europe), human resources; while as far as the physical ones, they are still weak, e.g. the company does not have a strong logistic network (it is physically present only in Singapore and, with branches, in the last years also in China and USA). The strongest point of the company is a huge and constantly growing database, which contains all the codes of the various products that can be interfaced with their system.

Key partners

AICO partners both with the big companies on the market (Google, Apple, Amazon) in an open innovation perspective; it was also able to reach 2,000 Backers in 65 different countries.

Customer segments

As far the targeted customers, their offer is meant for the mass market and they struggle to reach it. Potential customers are scattered all over the industrialized world. The product is compatible with the majority of the Smart Home products and has an accessible price (Smart Egg can be purchased on Amazon at the cost of $ 89). The persona targeted is the one who likes technology, innovation, who is time lacking and wants to minimize routine actions that could be easily automated.

Channels

The company aims to reach customers through various web channels. AICO has its own blog and advertise its product most of all on Amazon. It does not have large communication channels. In fact, customer acquisition is difficult.

Customer relationship

The company aims both to increase the customer base and the customer loyalty. For the first point, it is developing a scalable business, expanding also the physical presence in the world; for the second point, AICO constantly enrich its product with new features and let it interface with an increasing number of devices, so it is developing a good retention method.

4.4.2 FIBARO

FIBARO is a global brand operating in the Internet of Things sector, which provides building automation solutions. It was born in Poland in 2010 and in just a few years, FIBARO has settled on six continents, becoming one of the most advanced, wireless Smart Home systems in the world. The company has nearly 400 employees. Since July 2018, the brand has been part of the Nice Group. FIBARO's mission is to enrich people's lives all over the world by creating a comfortable, friendly and safe home space. The MVP consists in an App that can be downloaded on smartphones and tablets and that enables the control of the entire Smart Home scenario. The company targeted the latent problem of the management, already tackled by others, also in a totally innovative way: through the interpretation of the gestures of a hand. SWIPE is the intelligent device that detects simple moves and combinations of moves as well, in order to tackle commands, avoiding the customer even to pick the phone up.

Figure 55: FIBARO logo

Value proposition

According to FIBARO, the most reliable companies are those who are able to offer customers the most comprehensive solutions and minimize the number of installed apps. So the company's focus is to combine essential knowledge of other entities and merging technologies between manufacturers via FIBARO system. The company is driven by courage and creative. The company, above all, supplies the control units that manage building automation and are the basis of the entire intelligent system. The company's offer also includes sensors (such as movement sensors, devices to

control humidity, smoke, the presence of CO in the air), actuators (e.g. the intelligent electrical outlets and the thermostatic heads that regulate the temperature of the radiators) as well as products that control access to the building. This wide range of products are characterized by complementarity and user-friendliness.

Key activities

FIBARO activities are focused both on hardware and software development. The company gives particular importance to R&D and QA. There is also a strong focus on marketing and sales, as well as strategy and alliances, in line with its value proposition.

Key resources

The intangible resources are the most important: experts, company's culture, innovation as well as awards, certificates (e.g. product design award, European Business Award), copyrights and patents (more than 150). Among the physical resource, it is worth to mention FIBARO Technology Park, a space of more than 4,000 sqm, equipped with professional and modern production lines.

Key partners

The company has decided to establish new cooperation with industry leaders having their technology perfectly integrated with FIBARO System, in particular with Samsung SmartThings and Apple HomeKit. The company also announces to join subsequent brands to its distribution offer, since third-party brands opens up new and very attractive opportunities.

Customer segments

FIBARO products are meant for B2B and B2C purposes. The products offered target distributors, installer, architect, developers and third party brands. Reaching the mass market is the company's aim. The targeted persona is certainly young, passionate about technology and futuristic; a person who is not afraid of technological innovations and wants to introduce revolutions in everyday life.

Channels

The most diffused channel is the e-commerce one, both its own marketplace and third sites. Moreover, FIBARO expanded its market presence by appointing Alloys (one of the leading companies on the global Smart Home market) as its Master Distributor. Alloys provides a non-traditional approach to distribution with multistate warehouses, showrooms, in-house trainings, plus technical, sales and marketing support.

Customer relationship

Their customer relationship is based on the reliability of the offer and the continuous improvement of products' usability, thanks to the vast range of products that can be interfaced with FIBARO system.

4.5 Small and Medium Enterprises analysis

For the analysis of the SMEs, Homey and Eve have been chosen. These two companies are emerging in the market and seem to me to have adopted a quite opposite strategy, making different choices. Homey focuses

on integration; on the other hand, Eve, although operating in a wide range of sectors, is open up only to Apple. Below a more detailed description of their Business Model.

4.5.1 Homey

Homey is a proven unlisted company founded in 2014 in the Netherlands. It operates in the Consumer Electronics, Home Automation, Internet of Things and Smart Home markets. Its motto perfectly synthetizes the aim of the company: "*With Homey, you decide how to make your devices work together to make your home cozy, safe, ecological and fantastic*". So the main problems targeted by Homey are: automation of daily processes; awareness of house consumption and integration, since not all the devices speak the same wireless language.

Figure 56: Homey logo

Value proposition

Through its offer to the consumers, the company aims at making easier the life in the house, thanks to the automation of processes that are carried out on a daily basis (e.g. create customized scenarios based on the hours of the day, automate time wasters), in the easiest way, thanks to its built-in protocol that let Homey to communicate with more than 50.000 other devices. Moreover, Homey responds to the need of management and control: Homey Insights is a data centre that automatically collect, store and analyse data. It is designed to give users the power, flexibility and scalability to get more value from their own long-term data and see the house in a completely different way. As far as the manufactures and installers are concerned, Homey let them exhibit their ideas and reach greater visibility, bringing them into a wider network.

Key activities

The key activity of the company is R&I; it continuously tries to provide increasingly reliable and innovative products and services; it is a head hunter: on their portal there is a section in which all manufacturers can propose their ideas which are then carefully evaluated by the company. Other important activities are: data analysis, marketing, attention for the design.

Key resources

The main resource is certainly the company's know-how; the intellectual resources, guaranteed by its employees; the protocols that allow the most varied technologies to communicate with each other.

Key partners

Homey partnerships with manufacturers, since it is not a direct producer, letting them to gain visibility for their products, retailers and installers. Among its most important partnerships there are: Ikea, for lighting systems; Samsung, for smart TV; Honeywell, for thermostats; FIBARO, for sensors; Siemens, for household appliances and many others.

Customer segments

Homey targets different customer segments: mass market consumers (people passionate about technology who like to analyse the data of their home to take advantage of it, young enough to be able to interact with today's technology), sellers (developers, manufacturers, retail stores) and installers.
everyone who buy products from Amazon for personal purposes.

Channels

The most important channels through which the products are sold are online channels: the company's site and Amazon. However, Homey products are easily available also in physical stores, mostly sites in northern Europe, where the company was born.

Customer relationship

Homey is focused on customer loyalty by continually improving the functionality offered by its products. These functions are divided between software, improving the management and services offered by the system, and hardware, enriching the range of compatible objects. Homey also aims to enrich its customers base (e.g. using paid media as Google search engine).

4.5.2 Eve

Eve is a German company active in the Smart Home and home automation market since June 2018. The brand originally existed, since 2014, as a product line manufactured by Elgato System, a company known for video recorders and gaming products, subsequently bought by Corsair Components in 2018, that renamed itself as Eve Systems.

Figure 57: EVE logo

Value proposition

The features offered by the Eve system are limited to Eve brand products only. As far as the Smart Home offer, the company focuses on the sectors of: energy, by making smart plugs; lighting, by making smart switches and led strips; heating, with thermostatic valves; environmental parameter monitoring, through sensors for air quality and security, by producing motion sensors, vibration sensors for windows and doors, smoke detectors and water leaks; weather station and intelligent sprinklers. The privacy aspect is of great importance for the company: Eve underlines that data analysis and registration is not in its business model, and so it assures no cloud, no registration and no data profiling.

Key activities

The company's key activities are centred on innovation, reliability, quality control.

Key resources

The main resources for the company are the intellectual ones: its employee and its ideology, that makes the consumers feel 'safe' and unique.

Key partners

Eve has only one main partner: Apple.

Customer segments

Eve targets both consumers and entrepreneurs. As far as the last are concerned, the company should have a MFi licensee. As far the customers, since each products interfaces only with Eve devices and with the Eve app available only for iOS systems, the possible clients are already limited by two aspects: have an Apple device to download the app; limited choice of products (only among the Eve ecosystem). So Eve aims at a niche market, in order to give the users the advantage of quick and easy integration and management.

Channels

The unique channels to buy Eve products are online: the main one is its own store. It is not possible to pick products up in a store, neither in Forces Post Offices or PO Boxes. The products are also available on third party sites (e.g. Amazon). Channels are not well developed and widespread: the company does not deliver in British, Dutch and French Overseas Territories, the Channel Islands, Canary Islands and Balearic Islands, Gibraltar, Livigno, Vatican City, Republic of San Marino, Ceuta & Melilla, Andorra and British.

Customers relationship

Eve focuses on make users feeling safe, special and bet everything on loyalty. The company provides a close ecosystem of products and guarantee quality, perfect integration and a user-friendly experience. The company also enhance the importance clients have for it in terms of people: “you are our customer, not our product” and assure them “what happens at home, stays at home”, renouncing to use users’ data and making privacy a paramount.

4.6 General consideration

The BMC, as a "generic" business model framework, has surely helped to business modelling the companies discussed, through the analysis of their value proposition, infrastructure and customers targeted, but it does not let to analyse some topics peculiar of the Smart Home ecosystem. From my point of view, in this new and singular scenario, in order to establish the different roles companies can play on it and how they act in order to create value, we need to improve this existing framework, further analysing some area (such as technological factors) and connecting and exploring the interdependences between each firm and the external ecosystem. The analysis made allows to highlight some factors of fundamental importance for all the companies analysed, regardless of the type of industry to which they belong, so omnipresent: R&I, R&D, technological progress, date gathering and info generation, IT infrastructure, the need to create value through services, the importance of key partners external to the companies. The BMC has made possible to identify these common factors; however, in order to make a real comparison among the companies, to identify to what extent they incorporate them, how they exploit them to obtain a specific position in the actual Smart Home ecosystem, how the ecosystem influence each company and, on the other hand, to what extend it is able to adapt the solution offered, a complementary analysis is required.

CHAPTER 5: INCLUSIVE FINAL SCENARIO

In this chapter the factors that are currently critical for a firm in order to well operate, create value and distinguish itself in the Smart Home ecosystem have been analysed. Taking advantage of the results obtained through the analysis of each company using the BMC and after having underlined how is important to consider not only the firm itself, but the entire environment, it has been possible to extrapolate these factors and to analyse to what extent each of the firm considered incorporate them. In order to give a summary representation, the critical factors identified have been bundled in two groups and in the last part of the chapter, the firms before analysed have been plotted into a bi-dimensional matrix.

5.1 Key factors in the Smart Home ecosystem

All the factors below analysed, that are considered to be of crucial importance for a firm working in the Smart Home field, are linked to the technological/innovation side and to user's habits. Indeed, it is important not only to take into account what a firm develop and spread, but also the usage that a customer can do of it.

- **Disruptive technology**: these are usually defined as technologies that cause major changes within the industry. Disruptive technologies change markets in a fast and unexpected way, as it happened in the past (e.g. with Internet, block-chain). Firms can be swept away or ride the wave of innovation, making the most of it. Generally speaking, disruptive technologies are characterized by a high technology complexity. However due to the high complexity of the technologies, some products result unusable for the average consumer, making the Smart Home diffusion difficult. So each firm should not only invest in the development of advanced, innovative and disruptive technologies, but also find the way to make them accessible and enjoyable, e.g. through support/ installation services.
- **Integration**: this factor is crucial and implies the integration of different technologies, devices and scenarios. Companies from different backgrounds should work together, find synergies, join resources in order to generate and deliver new solutions with added value and make the Smart Home becoming mainstream.
- **Economic impact:** it is important to consider the impact that each device could have on the current economic situation in which the users find themselves. This factor has a direct effect on the spread rate of the new solutions developed.
- **Home type:** it refers to the type of home the consumer is living in. Old or new buildings, already automated home or not, could make the difference and influence the implementation of smart technologies. Each company must be able to break down this barrier, making its offer available and usable in most of the scenarios.
- **Usefulness**: it refers to the degree to which users see Smart Home new technologies as factors that will better their living environment. This strongly influence the market. It is important that consumers

find the new products and services valuable in order to make them viable. The technologies offered should be seen as a necessity.

5.1.2 Driving forces in the Smart Home ecosystem

In this paragraph the key factors before mentioned have been clustered in two groups in order to build a bi-dimensional matrix. The cluster formed can be named *driving forces* since influence the large ecosystem in which the companies operate or could operate in the near future.

The first driving force has been named ***users experience*** and it encompasses the key factors *economic impact*, *usefulness*, *home type*. This driving force indicate how much the firm is able to make its offer appealing for the users. If the firm analysed is able to make people recognizing the added value and make them in the situation of buying its products (e.g. in terms of price, integration with the type of house/ objects already hold), it is making its offer adaptable to the external scenario.

The other driving force is ***technological innovation*** and it bundle the remaining factors *disruptive technology* and *integration*. This driving force explain the need for a firm to be innovative, to represent a disruptive force into the market and, at the same time, to not only focuses on its core sector, but to favour integration (it is for these reasons that the activities of R&I and the partnerships built are becoming more and more important in the business model of each firm).

The higher these factors, the higher the possibilities for the Smart Home companies to bring real innovation and a win-win situation for both firms and users.

USERS' EXPERIENCE
- Economic impact
- Usefulness
- Home type

TECHNOLOGICAL INNOVATION
- Disruptive technology
- Integration

5.2 Scenario framework

By plotting the driving forces 'users' experience' and 'technological innovation' on the axes of a matrix, a scenario framework has been drawn and four different possible scenarios have been obtained *(Table 4)*. It is important to not only look at the extremes of the axes, but to take into account all the key factors analysed, since they add the most differentiation and let to come up with the four different scenarios.

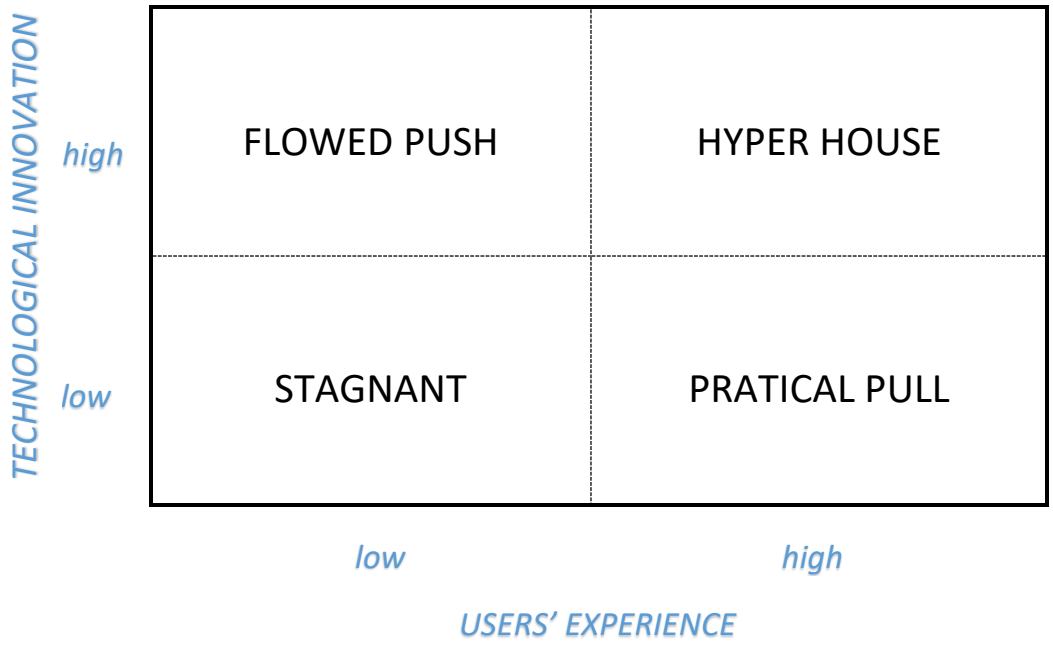


Table 4: Users experience- technological innovation matrix

Below the four sub-scenarios obtained are described.

- **Hyper House (high users' experience, high technological innovation)**

In the top right scenario companies from different areas work together and launch new, disruptive and integrated products that are immediately taken up by consumers. These systems, although are technologically complex, are characterized by usefulness, since the complexity is managed by the system itself. To give a tangible example, it could be an environment with consumers spending more and more on technology, with prices fallen down thanks to the high demand and systems always improving thanks to the collaboration and information exchange. This represents the best case scenario that each company, through its way of operate, can build and work in.

- **Flowed push (low users' experience, high technological innovation)**

In this scenario the Smart Home market grows fast, with companies that collaborate and together push towards innovation. On the other hand, the offer is not absorbed by the demand, as the consumers are not pushed in the direction to adopt new Smart Home products and/or use them in the optimal way. This could happen for the barriers to the adoption (analysed in Chapter 1), for a particular economic situation (e.g. financial doldrums), for an overcrowded market in which the firm is not able to differentiate and make its offer appealing.

- **Practical pull (high users' experience, low technological innovation)**

This scenario can be considered the ghostly of the Flowed push one, before analysed. The product offered are clear, easy to use, financially accessible, but, on the other hand, do not perfectly respond to the need of

innovation and integration. This could happen for variable reason: low pace of innovation and/or different protocols for each company and so low interoperability.

- **Stagnant (low users' experience, low technological innovation)**

In this last scenario both trans-sector innovation and adaptability to the external context are at their lowest point. Companies are neither able to collaborate and come up with innovative technologies, nor are able to assure integration (this could be cumbersome and expensive), and make people recognizing the added value that Smart Home products/services could bring to their lives (this, for example, could happen because the installation of the product in old buildings has proven to be difficult and expensive; the perceived price is too high).

5.2.1 Applied scenario framework

In order to have a tangible representation, the different companies in the previous chapter analysed have been placed into the quadrants of the matrix. To do so, each single factor encompassed into the two driving forces has been evaluate. A representation of this work is synthetize in *Table 5.*

	TECHNOLOGICAL INNOVATION		USERS' EXPERIENCE		
	Disruptive technology	Integration	Economic situation	Usefulness	Home type
Amazon	🟢	🟢	🟢	🟢	🟢
Google	🟢	🟢	🟢	🟢	🟢
Apple	🟢	🔴	🟡	🟢	🔴
Samsung	🟢	🟢	🟢	🟢	🟢
AICO	🔴	🟡	🟢	🟡	🟡
Fibaro	🟢	🟢	🟡	🟢	🟢
Homey	🔴	🟢	🟡	🟢	🟢
Eve	🔴	🔴	🟡	🟢	🔴

🔴 low 🟡 medium 🟢 high

Table 5: Qualitative evaluation of the key factors for each of the company analyzed

Generally, the higher the score assigned, the better the factor analysed is taken up by the company. As far as the first two columns, used to evaluate the "technological innovation", the higher the score, the higher, respectively, the innovation bought into the market and the level of integration offered. As far as the "users experience" is concerned: the higher the score given to the economic situation, the better the offer adapts to the economic needs of a possible consumer (e.g. thanks to its lower and accessible price or thanks to different line of products offered with slightly different features and prices); for usefulness: the higher the score, the more the product is pushed as a necessity, making consumers feel to need it; for home type: the higher the score, the better the products offered fit into any type of home and it is versatile and adaptable.

Amazon

Technological innovation: high

Amazon offers the widest range of products online available, so their technological complexity and innovation is variable, but it can reach high standards. As far integration, Amazon products assure broad compatibility (e.g. with Nest, Samsung, Philips hue, Netamo); Amazon allows makers of smart devices to connect their creation to Alexa and have access to data usage.

Users' experience: high

Thanks to the wide range of products, the offer is customizable, so the range of prices is variable on the base of the product/category considered; also for Alexa there are different versions available (tap and dot is the cheaper one). So the economic situation should not represent a barrier. This versatility is verified also for the 'home type' factors. Amazon is the biggest online channel for DIY (Do It Yourself) products, so most devices are easy to use and is a score at company's favour for the 'usability factor'.

Google

Technological innovation: high

As can be seen by the analysis of its business model, Google strength lies in the continuous research for innovation; so thanks to its powerful physical and intellectual resources, assets, key partnerships, Google continuously bring innovation into the market, always leveraging on new and complex technologies. As far as the integration level, it can be understood by just looking at Google strategy: "*being the thread that ties together the Smart Home world*" (Kastrenakes J., 2016).

Users' experience: high

The same consideration made for Amazon can be done for Google. Thanks to the large products portfolio and the brand awareness created through years, the company perfectly push the demand.

Apple

Technological innovation: medium-high

Apple has a strong focus on innovation and advanced technology development for both hardware and software. So the key factor linked to the technological disruption surely fit at its best the company's strategy. As far integration, however, the offer is highly unique and do not guarantee a high level of integration with the other brands on the market (this is a strategical choice of the company that has always aimed to create a closed circle).

Users' experience: medium

Apple with its strategy has always aimed at creating a brand loyal segment to target. The prices are higher and the versatility of the offer is low: it is difficult to adapt Apple products in a house built on other technological standards (e.g. Android).

Samsung

Technological innovation: high

Samsung SmartThings ensure a high level of interoperability being open to the connection with devices of other brands, indeed Samsung entered the Smart Home market with the object to create a complete and open ecosystem in order to solve the interoperability issues causing a lot of problems to customers. As for the others OTT, also Samsung strength is based on the continuous work on R&D activities, ensuring innovation and high level of technologies on the market.

Users' experience: high

The offer of the company is wide, so it can meet the demand of different types of consumers without any pre-built barriers. Samsung offers consumers a wide selection of DIY (Do-It-Yourself) products, easy to set-up, at accessible prices to build everyone's Smart Home. Samsung give the users the possibility to easily customize their Smart Home according to their preferences and specific needs.

AICO

Technological innovation: medium-low

As the technological level is concerned, the company is not very innovative (e.g. the app used is a very popular and basic); the degree of technological innovation of the device offered is not high: Smart Egg leverage on the infrared and Bluetooth technology, already common and diffused. For this same reason, not integrating other types of technological standards, the integration level is medium-low (it cannot be said it is low, since still a good number of basic devices used in our homes are based on this two standards).

Users' experience: medium-high

Its product generally does not affect the economic situation of the user thanks to its accessible price and do not require major future developments. The product offered is not linked in any way to the type of house but only on the objects inside and IR technology is widespread (remote control). It can be easily used by anyone to easily control a huge range of object.

FIBARO

Technological innovation: medium- high

Most of the products have a good degree of integration as they communicate with all the other Z-wave intelligent household objects, Alexa, Google Assistant as well as HomeKit and SmartThing. As the innovation brought into the market is concerned, the company offer both basic and simple smart objects (plugs, sensors) and innovative products, e.g. Swipe, that, as in the previous chapter explained, is able recognizes and respond to gesture abbreviations.

Users' experience: high

The company offers products that are not influenced by the type of house, thanks to their versatility. As far as the usefulness, the objects must be installed and configured in any case, so there are some operations that should be done before using it, but quite intuitive. The products offered cover most of the Smart Home sub-domain and it is quite easy to find a FIBARO product in a house (e.g. products like swipe are very popular

in families with children thanks to the innovative technology of gesture; sensors to monitor both the environmental parameter and consumption, products for scenario management, etc.).

Homey

Technological innovation: medium-high

Homey has a very high degree of integration (e.g. its Smart Home hub connects with 50,000+ devices from 1000+ brands and that number is growing every day), but the company did not introduce a proper disruptive innovation on the market.

Users' experience: medium

For having optimal performances, to the cost of each single product offered, the cost of the hub should be added, so the economic situation can influence if the entire system is considered. However Homey hub is available in two versions: one from € 300 and one from € 400, in order to target different needs. As far as the usefulness is concerned, products are endowed with lots of functionality, not always fully exploited by the users. So it is up to each single person and his propensity for innovation. As far the type of house, this factor can have an influence: new houses may be equipped with greater automation and so the interface is more direct. However, this does not affect the possibility to use the kit and products offered, maybe with reduced functionalities, in every building

Eve

Technological innovation: medium- low

Since the products offered can only be interfaced with Apple systems and only via Bluetooth, the integration level is very low. Also the technological complexity behind and the innovativeness of the products are medium-low; indeed, taking into account that the company spread into the Smart Home market in 2014, the products offered are quite similar to the already existing ones.

Users' experience: medium-low

The cost of products is very flexible, since also the product portfolio is wide; so the price is customizable. The control software is free. Devices are useful and simple to use (for their usage and control a great dedication is not required). As far as the type of home, since products cannot be interfaced with others of different brands, there could be difficulties to use them even in a latest generation house.

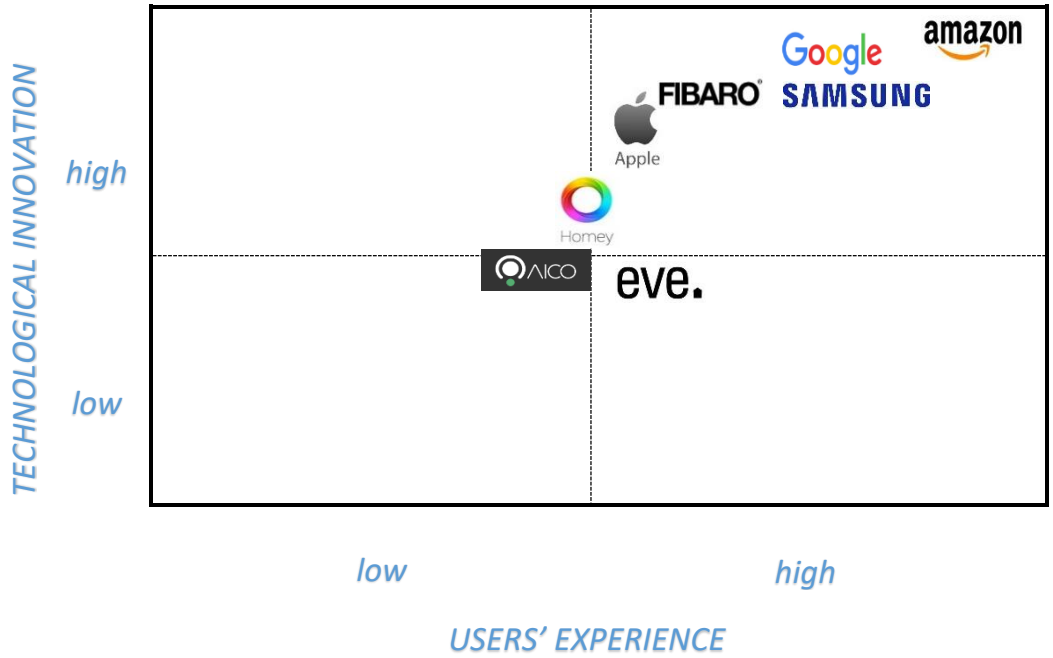


Table 6: Users experience- technological innovation matrix for the analyzed companies

5.3 Final considerations

The OTT, although follow different strategies in the Smart Home business, are in the same quadrant: the *Hyper house*, characterized by high *technological innovation* and a positive (high) *users experience*. Amazon, Google and Samsung cover more or less the same position: the highest mark both on x-axes and y-axes. Amazon has the absolute position. Those industries push the entire Smart Home market, collaborate both among themselves and with a huge number of third parties, have a very high number of partnerships with different actors, enable new and innovative services; all of this, especially thanks to their mergers and acquisitions and their brand awareness. However, it is needed to specify that in the actual market, a common protocol/ standard is still missing and the collaboration among firms is still weak with respect to ideal case, since each actor still try to dominate the market yet. It would be desirable that in the future these industries move more and more towards the top right corner of the matrix and work together to provide a totally unified experience. As far as Apple is concerned, its position is slightly different from the other OTT: although it pushes innovation and new complex technology, the focus on adaptability and collaboration is still too low. A relevant insight is given by FIBARO, that has a position really similar with the OTT, and so it is positioned in the *Hyper house* quadrant, though being a startup. This company hardly pushes for innovation and integration and deploys huge resources in these fields. Maybe only its lower brand awareness and still not strong structure do not let it to reach the exactly position of the OTT, but the company is moving more and move towards the top right corner, leveraging in the right way the critical factors analysed. The other three companies are in the middle of the matrix. As far as AICO is concerned, it has been positioned in the top right corner of the quadrant 'stagnant'. This choice because the company's flagship and core product is based on

simple technological standards (Bluetooth and infrared); it is not very versatile as its function is ensured only in the 20 meters range and is not compatible with the other more complex technologies that now dominate the market. However, the product is simple to install and use, accessible to the mass market. Moreover, the company, through its value proposition, tries to propose a solution meant to be a control centre for basic devices, present in the majority of houses; for these reasons its position is not completely in the III quadrant, but more shifted towards the centre of the matrix. So AICO and FIBARO, although belonging to the same type of industry, occupy different quadrants and act dissimilarly in the Smart Home ecosystem. The SMEs analysed, instead, give their contribution in a similar way and are both positioned in the middle. Homey, with its hub, is characterized by medium-high trans-sector innovation (and so it is positioned in the upper half of the matrix), since its control centre assure the compatibility with more than 50000 devices and 1000 brands, although the technology behind is not so complex neither innovative. As far as the position on the x-axis, it is in the middle since it has a medium influence on the external context: its offer is available in more versions and has a high versatility. Eve is more shifted towards the quadrant P*ratical pull*. Its position on the x-axis is similar to the one of Apple, but the 'trans-sector innovation' on the y-axis is not so high; this is due to mostly to the low interoperability.

To sum up, the OTT industries, nowadays, are the ones that most contribute to create the best scenario; indeed, they operate and position themselves in the top right quadrant; while startups and SMEs, expect for FIBARO that occupy a position more similar to the one of the OTT, are in the middle, with slight differences. It would be desirable that each company move more and more towards the top right corner, in order to contribute to the creation of a winning, cross-industry and mainstream ecosystem and to not remain excluded from it.

CHAPTER 6: CONCLUSIONS

This last chapter closes the thesis retrieving the main steps that have permitted to solve the two research questions. The key findings are highlighted as well as the implications that they could have in the near future. Finally, a guideline for possible future studies is provided.

RQ1*: What is the state of the art of the Smart Home solutions in the international arena and in Italy?*

A detailed study of the Smart Home offers is provided, starting from a database, realized in collaboration with the IoT Observatory of Politecnico di Milano, consisting in 698 solutions already available or that are coming soon in the world market. Generally speaking, the supply analysis has shown that companies have great interest towards the development and launch of the Smart Home solutions. However, there are differences in terms of geographical distribution of the supply, application areas and business models adopted (type of offer, channel used, pricing model).

Geographical distribution of the supply

The greatest part of the mapped solutions come from Europe and America, with the first one having the primacy, enclosing about half of the analysed solutions. The factors that explain this high percentage are, firstly, the increasing number of companies/ startups that in the latest years that started to focus on Smart Home solutions in Europe and the strong focus that during the analysis has been kept on our country: 20% of the mapped solutions comes from Italy.

As far as America is concerned, it should be underlined that North America was the earliest adopter of Smart Home products; in particular, many startups based themselves in the Silicon Valley where growth opportunities were generally greater. Analysing the geographical distribution of the mapped solutions by country, it can be seen that, respectively, Italy, Germany and France give home to the highest number of Smart Home solutions in Europe. While, for American countries, the USA alone gives home to about 37% of the analysed solutions, gaining the first position. An important role is also played by China, that together with the aforementioned European countries and USA, account for 80% of the entire Smart Home worldwide market. However, the actual Chinese market size is still limited compared to the huge population; but at the same time this country has huge possibilities of growth both on the demand and the offer side and it is reasonable to forecast that China is the only country that could face USA dominance in the long run.

Application areas

Among the wide existing application areas, the offer is focused mainly on Security (23%), representing a primary need of people, followed by *Household appliance management* (16%); this last subdomain, as prospected at CES 2020, is growing more and more, thanks to the application of AI and machine learning that allow the diffiusion of continuous learning systems. The third most common sub-domain, with 14% of solutions, is *Scenarios management*, relevant due to the importance of interoperability whose lack represents one of the key barriers in the development of the Smart Home.

Type of offer

Most of the solutions analysed offer both a Hardware (physical device) and a Software. However still huge part of the companies' business model (21%) are based on the sale of a physical device. For all the types of companies and in every industry analysed it is important the presence of a free dedicated app, through which it is possible to manage remotely the products or the implementation of a service, via smartphones or tablets. There is also an increasing attention towards the possibility to add a service to the offer; this also confirmed by the increasing partnerships among companies as well as mergers and acquisitions, in order to increase the value of the offer. These services, thanks to the collaboration mostly with utilities and insurance companies, include information on consumption, registrations and storage of data, notifications, control of other devices, alerts, support services 24/24 in case of problems, cloud.

Channel used

e-Commerce is the most used sales channel, being adopted, both as a unique channel and in multichannel strategies. In particular, startups use it almost as their unique channel, having the need to directly reach the

final customer, cutting costs. As far as *retailers* are concerned, their role in the current market is still a niche; this is confirmed also in the Italian distribution chain: most of the analysed products are still not available in the main in the main Italian retailers (Unieuro, Euronics, Mediaworld). *Retail* channel is more exploited by companies offering solutions related to the Home appliances management sub-domain, probably because consumers prefer to see the product before making the purchase decision, given the economical effort required. An important role is also played by *professional technician*, that are a key figure in the Security, Scenario management, Cooling/Heating and Home Appliances sub-domains, when it comes to more technologically complex solutions and installations. However, it should be specified that, thanks to the high diffusion of DIY products (self-installing and easy to use solutions), on which companies are shifting their focus, in the next future their role will be resized.

Pricing model

The *Una tantum* pricing model, in which the customer pays only at the purchase of the product/service, is the most widespread and the preferred methodology mostly used by all the types of companies (OTT, startups and SMEs). This is probably due, as far as startups are concerned, to the companies' financial capability: startups need to maximize revenues in the short run in order to support their business; as far Grand Players and PMI, probably to the inertia in changing the traditionally most used model and the lack of request and need to do so: consumers themselves prefer this model, although its downsides, due to their cultural and psychological barriers. The *As a service* approach, although still less common, is going to face a huge growth, thanks to the diffusion of servitization in the sale strategy of most companies. Indeed, if considered in combination with the *Una tantum* pricing model, it is still the second preferred method. Considering the *Una tantum* pricing technique, it was possible to get insights on the price ranges (high, medium or low). Generally speaking, prices fall into the medium-low category, confirming the trend according to which Smart Home is becoming a mainstream domain, accessible to the most.

Europe, followed by America and Asia are the countries where the highest prices have been registered. By crossing this analysis with the results regarding the Smart Home Market diffusion over the countries, we can say this is probably linked to the maturity of the market: country where the medium price is higher are the same in which the market is more mature, probably because the basic products are already present in the most of the consumers' houses and consumers now require more complex and expensive solutions; indeed the industries characterized by higher prices are Household appliances, Furniture and Sanitary, given the volume, complex structure and many functions of the products offered. While in Africa, Middle East and Oceania, developing countries where the market is still in its infancy, the medium price registered is low, since more basic products are offered.

Future trends

Looking at the whole thesis work, insights about the future development of the Smart Home market can be derived. Thinking about how the offer can evolve in the near future, different aspects can be pointed out:

Smart Home devices are becoming more affordable, more intelligent, and more valuable to consumers, which will help expand the addressable market for device companies and service providers; partnership among different actors are gaining importance, as the huge number of mergers and acquisitions done in the most recent years confirm; data gaining and analysis is a critical activity to which always more companies are focusing on; there is a clear shift towards servitization: services, enriching the customer experience, can bring customer retention and can ensure constant revenues; DIY products, easy to use ad install, represent the new frontier in the Smart Home supply.

***RQ2**: Which are the critical factors in the business model of a firm working in the Smart Home ecosystem that allow to create added value?*

It is extremely important to know which variables can influence, and in which direction, the value creation using a viable and robust business model. Having pinpointed the lack in the identification of a business model that underline a sustainable path to create value in this new industry, key factors and pillars that should be taken into account for business modelling firms working in the Smart Home field are suggested.

- Analysis of the business ecosystem

The business model needs to be thought considering the entire Smart Home ecosystem and not only the individual firm.

- Value proposition and offering

Is important to define clear value propositions considering customers' needs, profile and level of familiarity with the technology. Moreover, the shift towards a less tangible value proposition is a key aspect: each firm should evaluate the convenience provided by the services related to smart products.

- Firms' Internal capabilities (key activities, key resources)

The firm needs to make a realistic assessment of its assets and capabilities to develop smart products. In particular technology Infrastructure needs to be carefully considered in business modelling Smart Home and more in general IoT applications, because strongly influences the value proposition and the forms of value capture.

- Partnerships

The firm needs to develop partnerships and the capacity to manage them. Partner selection is crucial, since represent a powerful instrument to penetrate the market and get a competitive advantage.

In the Smart Home environment, companies are increasingly partnering with actors both internal and external to the IoT world. Companies, mainly big players, are trying to collaborate and create a shared ecosystem in which standardization and cooperation dominate. For every type of firm, partnering can represent a strategic choice.

- Interoperability and integration

Interoperability among devices and integration are essential and can be generative and profitable in new business models based on the IoT. Companies from different backgrounds should find synergies and work together to make real an integration of different technologies, standards, devices and scenarios.

- Disruptive innovation

In order to distinguish itself in an over-crowed market, each firm should invest in the development of advanced, innovative and disruptive technologies, making the most of them.

- Customer centred approach, in order to enhance the users' experience

Developers should comprehend the interrelationships between Smart Home offer and users (in terms of their demands, values, and behavioural patterns). Shift the design approach to a user-centred approach leads to a higher adaptation of smart technologies with users' needs and preferences in real life and, consequentially, to generate higher value and revenues. Indeed, assessing the effects of new technologies on people's lives and adapting them to the real users' needs is essential for domestication of Smart Homes. Each firm should be able to make its offer appealing to the users, in terms of price, adaptability (e.g. with the type of house/ objects already hold/ external scenario), inclusion and usefulness (users should see the solution offered as a necessity). Moreover, it should provide an increased positive user experience, working on the higher level of quality for the services offered, easiness in the access, use and installation (DIY products are the most required), availability (e.g. being able to provide a multichannel experience or 24/7 services).

6.1 Research shortcomings and suggestion for possible future developments and researches

The current work has clearly shown that the Smart Home area is dynamic and fast evolving. So the analysis of the offering done is an up-to-date photography which needs to be continuously upgraded in order to underline how the offer will evolve year after year and to detach the newest trends. Moreover, many research limitations could be underlined; in this regard, possible ways to overcome them and develop future related researches are suggested. One of the main short-come is the relatively small size of the dataset and its structure: there is a clear prevalence of made in Italy solutions; from the database analysis, in fact, Italy appears to be the dominant country in Europe, but, although the Italian Smart Home market is well positioned, in reality, as the latest market research points out (IoT Observatory of Politecnico di Milano; Statista), Germany and France dominate the scene in the European context with a much higher market maturity than Italy. Secondly, we should underline that this study chooses a high strategical level of analysis. Future research could aim at providing clear paths for the implementation of a defined mission. Furthermore, the nature of this work is explicitly qualitative. Successively, more quantitative studies could be assessed. Also deepening the business models building blocks can furnish improvements; in the research the financial aspects of the BMC have not been covered, so it could be useful to form a research project based on a financial model, e.g. in order to calculate the profitability of certain strategies. An additional upgrade to the model could be made by supplementing interview data collected, focusing on Smart Home entrepreneurs and/or on users; in this way, by asking further information to the user, such as their age, occupation,

households composition or level of technological knowledge, it would be possible to better understand users' habits and needs, that are extremely important to deliver valuable solutions. It would be also interesting to deepen analyse the barriers to the adoption and the triggers introduced by the employment in this field of the new technologies such as AI and robots (e.g. studying the implication in bioethics). Another interesting insight to explore is the effect of the Smart Home objects quick diffusion and brands proliferation: as CES 2020 shows, more brands than ever are creating Smart Home devices; but could this sheer proliferation of options paralyze consumers' Smart Home purchase journey? These raised questions have been composed taking into account the Smart Home studies, literature and some of the aspects that, going beyond the purpose of this thesis research, have not been deepen; however, they are not limited to the Smart Home only, but could be applied to future researches encompassed around technology-intensive products, services or innovations.

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APPENDIX

AN INTRODUCTION TO THE IoT PARADIGM

The appendix is dedicated to a general overview on the Internet of Things paradigm, that had a radical influence also on the way people live in their homes.

Initially it is presented a general description of the technology and historical events that led to the birth of the paradigm and to its exponential growth. Subsequently, it is given a more detailed description of the main features of the connected objects and the available technologies supporting the Internet of Things market (IT infrastructure required). At the end, the several and different application areas are summarized.

Internet-of-Things definition

In order to provide an adequate definition of the IoT paradigm, the ones provided by the most accredited expert bodies on the subject in the Italian, European and international fields were taken into consideration:

The first has been proposed by the Internet of Things Observatory of Politecnico di Milano which is one of the most relevant IoT research centres in Italy:

"The expression "Internet of Things" indicates a path in technological development on the basis of which, through the internet, potentially every object of our daily experience acquires its own identity in the digital world. It is a structured route, characterized by countless fields of application and from different - for variety and dynamism - enabling technologies." (IoT Observatory - Polimi, 2015).

The second comes from the European Research Cluster on the Internet of Things (IERC), an organization that, supported by the European commission, facilitates knowledge sharing on the IoT and supports best practices and new business models in this regard:

"A dynamic global network infrastructure with self-configuring capabilities based on standard and interoperable communication protocols where physical and virtual 'things' have identities, physical attributes and virtual personalities, and are seamlessly integrated into the information network." (IERC, 2014).

The third comes from the Internet Engineering Task Force (IETF), an international organization founded in 1986 and formed by an open community of network designers, operators, vendors and researchers interested in the technological evolution of the Internet:

[...] IoT will connect objects around us (electronic, electrical, nonOelectrical) to provide seamless communication and contextual services provided by them." (IETF, 2010).

The last analysed was proposed by G. Sachs, one of the worldwide leaders in global investment banking:

"The Internet of Things connects devices such as everyday consumer objects and industrial equipment onto the network, enabling information gathering and management of these devices via software to increase efficiency, enable new services, or achieve other health, safety, or environmental benefits." (Goldman Sachs, 2014).

Sachs in the same paper summarize the differences between the Internet of Things and the traditional Internet, presenting the so-called S-E-N-S-E framework: Sensing, Efficient, Networked, Specialized, Everywhere *(Table 7).*

S-E-N-S-E	What the IoT does	How it differs from the Internet
Sensing	Leverages sensors attached to things (e.g. temperature, pressure…)	More data is generated by things with sensors than by people
Efficient	Adds intelligence to manual processes (e.g. reduce power usage on hot days	Extends the Internet's productivity gains to things, not just people
Networked	Connects objects to the network (e.g. thermostats, cars, watches)	Some of the intelligence shifts from the cloud to the network's edge
Specialized	Customizes technology and process to specific verticals (e.g. healthcare, retail)	Unlike the broad horizontal reach of PCs and smartphones, the IoT is very fragmented
Everywhere	Deployed pervasively (for example on the human body, in cars, homes, cities, factories)	Ubiquitous presence, resulting in an order of magnitude more devices and even greater security concerns

Table 7: Key attributes of the IoT and how it differs from the regular Internet; Goldman Sachs, 2014

The reasons that led to the diffusion of the IoT paradigm

Several relevant innovations and technology changes have driven the IoT diffusion, making it becoming mainstrem. Among them, it is interesting to mention the following:

- Sensors and batteries have seen great improvements in performance, miniaturization and energy efficiency and their price has dropped;
- Smartphones have reached impressive percentages of diffusion and are becoming the personal gateway to the IoT;
- The so called Big Data Analytics that help managing the large amount of data generated by the IoT system and allow to extract value from them;
- The new IPv6 Internet registration system, that allows to activate trillions of trillions of new IP addresses, each associated to a single device;
- The new protocols, designed to provide greater information security, which make easier to pass a device between different networks and allow servers to automatically delegate and address without the need for IT support.

All these factors have made the connected objects cheaper, more affordable, both technically and economically, for both enterprises and consumers (Goldman Sachs, 2014; Porter M. and Heppelmann J.E., 2014).

Historical background and developments

The starting point in the history of Internet of Things is represented by RFID technology (Radio Frequency Identification). RFID is the easiest technology through which an object can enter the IoT world. It is based on the ability of small tags (or transponders), consisting of a chip and an antenna, to store information coming from the outside that can then be read by other objects, called readers, at distance, using radio waves. The first experiments on RFID technology were conducted during the 50s and 60s by scientists and researchers from US, Europe and Japan, with the scope to remotely identify objects through the radio frequency energy; several companies began to apply RFID tags for anti-shoplifting purposes. Between the 60s and 70s, the Cold War and the nuclear arms race between the United States and the Soviet Union pushed the development of RFID technology even further, creating the foundations for the birth of the Internet. The early 90s were another significant period: Tim Berners-Lee made the birth of the World Wide Web. In that period, IBM engineers developed for the first time an UHF RFID system (ultra-high frequency) with better reading skills and a faster data transmission. However, the development of UHF RFID became faster only in 1999, when the Uniform Code Council, EAN (European Article Number) International, Procter & Gamble and Gillette decided to finance and create the Auto-ID Center at the Massachusetts Institute of Technology (MIT) to study how to exploit low-cost RFID tags for tracking purposes along the entire supply chain. Kevin Ashton, director for many years of that research centre, coined the new word “Internet of Things”, neologism in a publication of the International Telecommunication Union (ITU) in 1997. Nowadays RFId (Radio Frequency Identification) is used in particular in logistics, pharmaceutical production, retail, etc. Since 2003 the RFId was one of the most used technology used in the IoT market. In September 2003, the EPC (Electronic Product Code) Executive Symposium taking place in Chicago (Illinois, USA) marked the official launch of the EPC Network. It is an open technology infrastructure allowing computers to automatically identify objects and track them from the distribution centre to the stores. This was a big revolution for the identification of the “things” nearly in real time. It was also a deterrent for the counterfeiting of products, in particular in those industries with high value products. The concept of IoT was then extended thanks to the introduction of wirelessly sensory technologies, which had extended the sensory capabilities of devices and consequently improved the autonomous control and the intelligence characteristics. During the last years, several definitions of the IoT were developed, depending on the technologies adopted. In particular, the concept of “Things” has changed several times. Nevertheless, the main goal of making a computer sense information without the aid of human intervention remains unchanged. A radical evolution of the Internet into a Network of interconnected objects has led not only to harvest information from the environment (sensing) and interact with the physical world (actuation/command/control), but also to use existing Internet standards to provide

services for information transfer, analytics, applications, and communications. (*Li S. et al.*, *2015*; *Sundmaeker H. et al., 2010*; *Gubbi et al., 2013*).

Smart objects and their features

According to the *IoT Observatory of Politecnico di Milano (2017)*, the fundamental elements for the IoT market are the smart objects: devices that belong to an interconnected network; this objects, in addition to their traditional physical components, that materially constitute the object, have smart, intelligent components and connectivity components. The smart components greatly increase the potential and the capabilities of the physical components, enlarging their value. The connectivity components, instead, increase the potential of the smart components, creating a continuous and virtuous circle of incremental value generation.

Smart components

Smart components refer to all the sensors, actuators, microprocessors, data storage systems, software and controls for the user interface that can be found in the device. These smart components enable three product features, not necessarily present all together (*IoT Observatory of Politecnico di Milano, 2015*):

1) Self-awareness, which allows:
    - uniquely identification of theobject (the digital code of a product must be unique) and universally identity in the digital environment (ID should be understood worldwide);
    - localization both in real time, for example through GPS technology, and elaborating the information along the supply chain, “tracing”;
    - check in its operating status (with different levels of detail on the internal systems more or less accentuated), in order to monitor the parameters inside the object and understand if it is performing correctly and if it needs some assistance;
2) Interaction with the environment, through:
    - Data acquisition; this could happen through:
        - Metering ability: it means measuring and automatically recording a flow of information about a specific physical quantity such as cubic meters of water or gas used, kilowatts hour of energy consumed, miles covered;
        - Sensing ability: it means receiving data that are not a continuous flow in time (for example, the perception of movement, the perception of smoke into the environment, the perception of brightness);
    - Execution, the ability to control remotely the devices and execute commands that modify its state, e.g. the opening or closing of a blinds;
3) Data elaboration, that consist in the processing of information obtained from the external environment through predetermined algorithms or that can be implemented later after the acquisition. There could be:

- *Basic elaboration*, the initial analysis of data collected, such as filtering, correction, algebraic aggregation (sums, averages), conversion, cryptography, etc.;
- *Advanced elaboration*, the extrapolation of information from the basic data, for example through statistical analysis, inferences, forecasts, etc.

Connectivity components

Connectivity components refer to antennas, doors and protocols that allow the connection with the device. Generally, the communication can take three different forms, which can be present individually or simultaneously (*Porter M. and Heppelmann J.E., 2014*):

- One-to-one: a single object connects with another single entity (the user, the manufacturer or another object). This form of connectivity can be found for example when a diagnostic machine is connected to an intelligent camera to detect defective elements or update software;
- One-to-many: according to a central-star configuration, a central access point communicates at the same time with more devices continuously or intermittently. For instance, the smart meters installed in Italian homes communicate with the unique central system of the energy supplier that can automatically monitor the situation and manage contracts;
- Many-to-many: more products connect with each other and also to external data sources. For example, public transports that can communicate both with smart traffic lights to improve the city traffic and with a central system for geo-location to optimize the frequency and minimize the average waiting time at the stops.

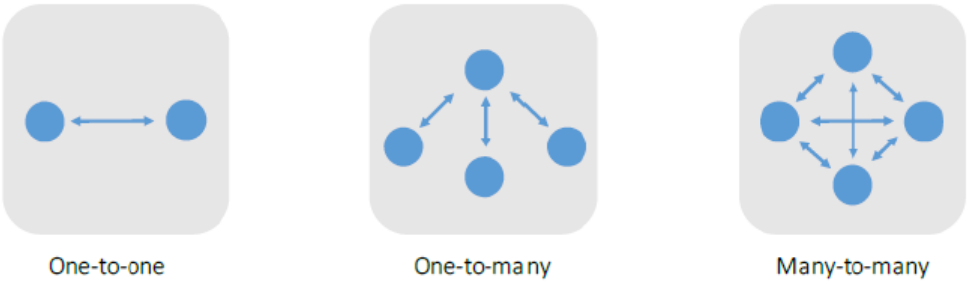

Figure 58: The three different types of connectivity of smart objects; Porter M. and Heppelmann J.E. (2014)

These three forms of connectivity should be implemented together to achieve high levels of product functionality. Generally, connectivity pursues two main objectives. Firstly, it allows the exchange of data and information between the object and the external environment (such as the users, the producer, other smart products, operating systems). Secondly, it makes possible the existence of some external product features in the so called product-cloud, which is a software that runs remotely, in the producer's server or in the server of an external partner.

The key features of the smart objects

The smart and connectivity components have enabled a completely new range of products functionalities and capabilities. It is possible to group them in four main areas (*Porter M. and Heppelmann J.E., 2014*):

- Monitoring: connected smart objects allow the user or the company to comprehensively monitor at distance product's condition, usage and the conditions of the external environment. In addition, the product can send push notifications and alerts in case of changes in the detected parameters;
- Control: software embedded in the product or in the product cloud enable to remotely control the various functionalities. The algorithms on which the software is based, are formed by specific rules that impose the object (and its actuators) to react in case of changes. This feature enables a personalization of the performance, that in the past was not viable or economically possible;
- Optimization: the previous two abilities allow the creation of algorithms that let to optimize the use of the object through preventive maintenance, predictive diagnosis, support and timely repair;
- Autonomy: monitoring, control and optimization, if combined, can allow smart objects to reach high levels of autonomy, that in the past were very difficult to reach. Through embedded sensors and software, the product can become aware of the external environment and make decisions without human intervention. This capability allows the smart object to self-detect problems and to self-diagnose clients' requirements and consequently adapt to them, improving output and efficiency.

Each ability complements and enriches the previous ones.

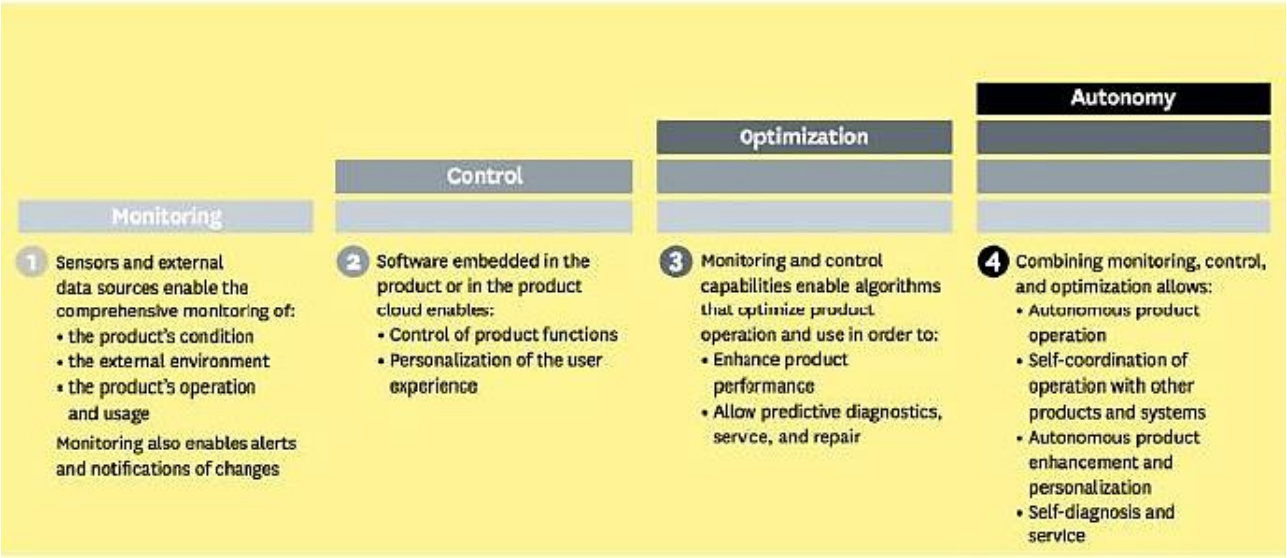

Figure 59: The four capabilities of smart products identified by Porter M. and Heppelmann J.E. (2014)

Technologies overview

As aforementioned, in order to create a "Network of Things", the Smart Object must have a communication capability (wired or wireless) in order to transport the information locally collected to remote applications. In this paragraph it is proposed an overview of the most important technologies developed during the last years, *IoT Observatory of Politecnico di Milano (2017)*:

- *Passive RFId (Radio Frequency Identification):* it is the first technology to be used for the IoT and the easier one. The passive RFId comprehends a tag containing electronically-stored information. The tag is activated through a reader, without needing any type of battery;
- *Active RFId (Radio Frequency Identification):* the active RFId differs from the previous one since it has a battery incorporated in the tag. It is more expensive, but it furnishes additional functionalities. Thanks to the battery, the communication has improved in terms of reading distance. Moreover, it is possible to activate the autonomous running of the tag, without the reader's query;
- *Personal Communication:* it comprehends the standards for the communication in short-term networks, the Personal Area Network (PAN). These technologies were created for consumer applications and are characterizes by narrow communication bands, such as Bluetooth low-energy, ANT, NFC13. In last years the diffusion of Personal Communication technologies has grown considerably, thanks to their integration with most of the last generation of smartphones and tablets;
- *Wireless Bus:* Wireless Bus are all the no-wired standards that represent an alternative to wired solutions, very widespread in the industrial work. Some examples are the Wireless M-Bus, the KNX and the X10. The first one is the most diffused, since it is a protocol that supports the 169 MHz frequency band, in addition to the others. Furthermore, the architecture behind these technologies are not sophisticated, because they replicate the principles of field buses;
- *Wi-Fi:* these protocols allow wireless access to local broadband networks. these are protocols that allow wireless access to local broadband networks. They are initially developed for multimedia applications, which require a huge amount of data transmission. For this reason, they have high energy consumption, that limits the applicability in the IoT sector;
- *Reti Mesh Low-Power (RMLP):* low-power networks formed by classic wireless sensors (WSN), with complex architecture, self-configuring, able to support dynamic data and for low power consumption (e.g. ZigBee, WHart). This is one of the most important technology field of the last year, continuously evolving. One of the objective is the standardization of the protocols;
- *PLC (Power Line Communication):* the PLC technology realizes the transmission of information through the modulation of the electrical signal used for the power supply. There are different protocols, one for the residential field and one for the medium and high voltage network. The main difference is the maximum communication distance and the supported data-rate;
- *Cellular networks:* Cellular networks are the usual cellular communication technologies, such as GPRS, GSM (2G), HSPA (3G), and LTE (4G). Due to the high energy consumption, the application of these technologies is limited to the cases where it is possible to feed the nodes, as well as in combination with RMLP and Wireless Bus for the communication between second-level devices (concentrators) and control centres.

In *Figure* 60*61* it is provided a framework to analyse which are the most used technological solutions used in the various fields of application of the IoT market.

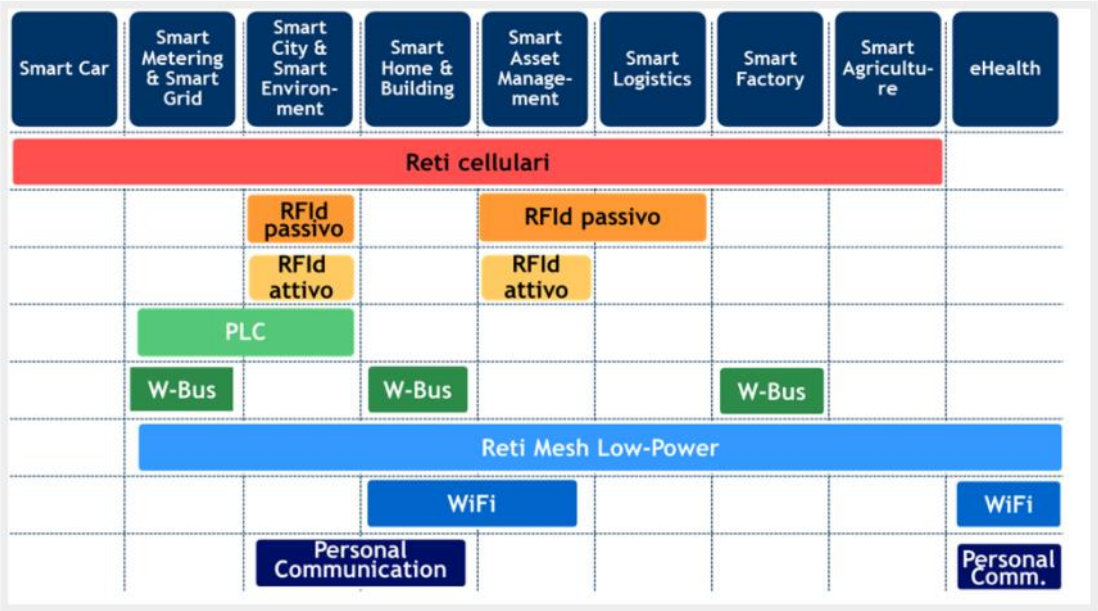

Figure 60: Framework of the technological solutions used in the fields of application; Source: IoT Observatory of Politecnico di Milano

In addition to the technologies aforementioned, *Palattella et al. (2016)* stated a new innovation that will take a central role in the future IoT scenario: the 5G technologies, belonging to the Cellular networks field. The previous cellular technologies were designed essentially for broadband. On the contrary, the 5G communications will satisfy specific requirements that allow to make the technology a good fit for IoT applications, in particular those for MTC (Machine Type Communications). Some of the improvements are lower costs, lower energy consumption and support for very large number of devices. Moreover, from the point of view of the business model, the 5G technologies synergy with IoT might have interesting implications. For example, the role of these new technologies in the change of the IoT from infrastructure-driven to business-driven. With the coming diffusion of the IoT services, 5G will be one of the fundamental technology for their implementation and spread.

IoT architecture

The IoT Observatory of Politecnico di Milano (2017) proposed an architecture structured on three hierarchical macro levels, through which information flows:

1) Interface with the physical world: this first level is characterized by the presence of smart objects that work as nodes and interact with the environment. Through their smart components, these objects get information from outside or activate an actuator; instead, through their connectivity components (wired or wireless), they send their identification code and all the acquired data to the second level. These nodes are powerless (passive tags) or battery powered (sensory units and actuators) and are generally characterized by a reduced processing and memory capacity.

2) Mediation: he units of the second level have the task of collecting information from the nodes in the first level and conveying them to control centres (third layer). Generally, the set of units include RFID tag readers and gateways. They are characterized by a greater processing capacity and memory, by multiple communication interfaces, and are generally fed by the electric distribution network. They allow the ubiquitous integration of heterogeneous communication networks, including the existing Internet, communications networks, extensive networks and a variety of access and private networks, realizing the information transmission and processing;
3) Control centre: this top level is constituted by servers, acquisition systems and operating rooms. They have the task of receiving the information from units of the second layer for the subsequent stages of analysis, processing, storage of the data and provision to the various application users. The units in this layer manage and supervise the entire architecture.

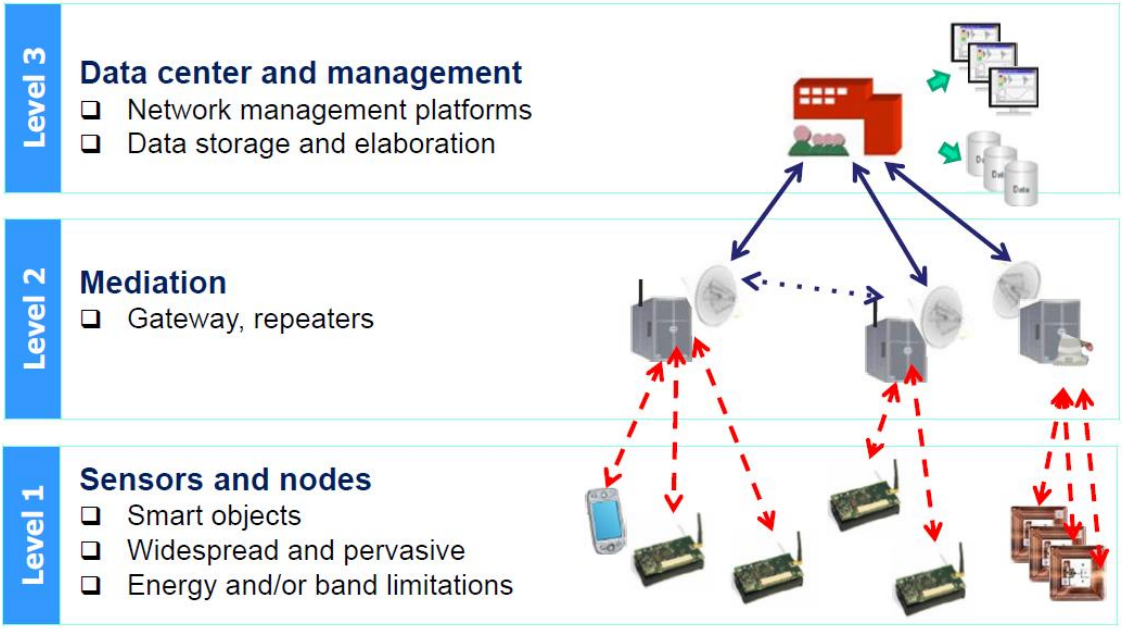

Figure 62: IoT architecture; Source: IoT Observatory of Politecnico di Milano

An alternative and slightly different architecture was proposed by Michael Porter and James E. Heppelmann (2015). This technology infrastructure, called "Technology Stack ", is composed of three different elements (Figure 63):

1) Product level: it includes both hardware (sensors, actuators, processors, connection ports and antennas) and software (embedded operating systems, on board software applications, user interfaces for control);
2) Cloud level (or “Product Cloud”): it includes a database, a platform for the development of software applications, a computational engine for the processing and analysis of Big Data and software applications for the product that manage the four features of smart objects;
3) Connectivity level: it includes all the protocols that allow the communication between product and cloud levels.

These three elements share an identity and security structure, able to control the user authentication and access to the system, information from external sources and tools that integrate data with business systems such as ERP, CRM and PLM.

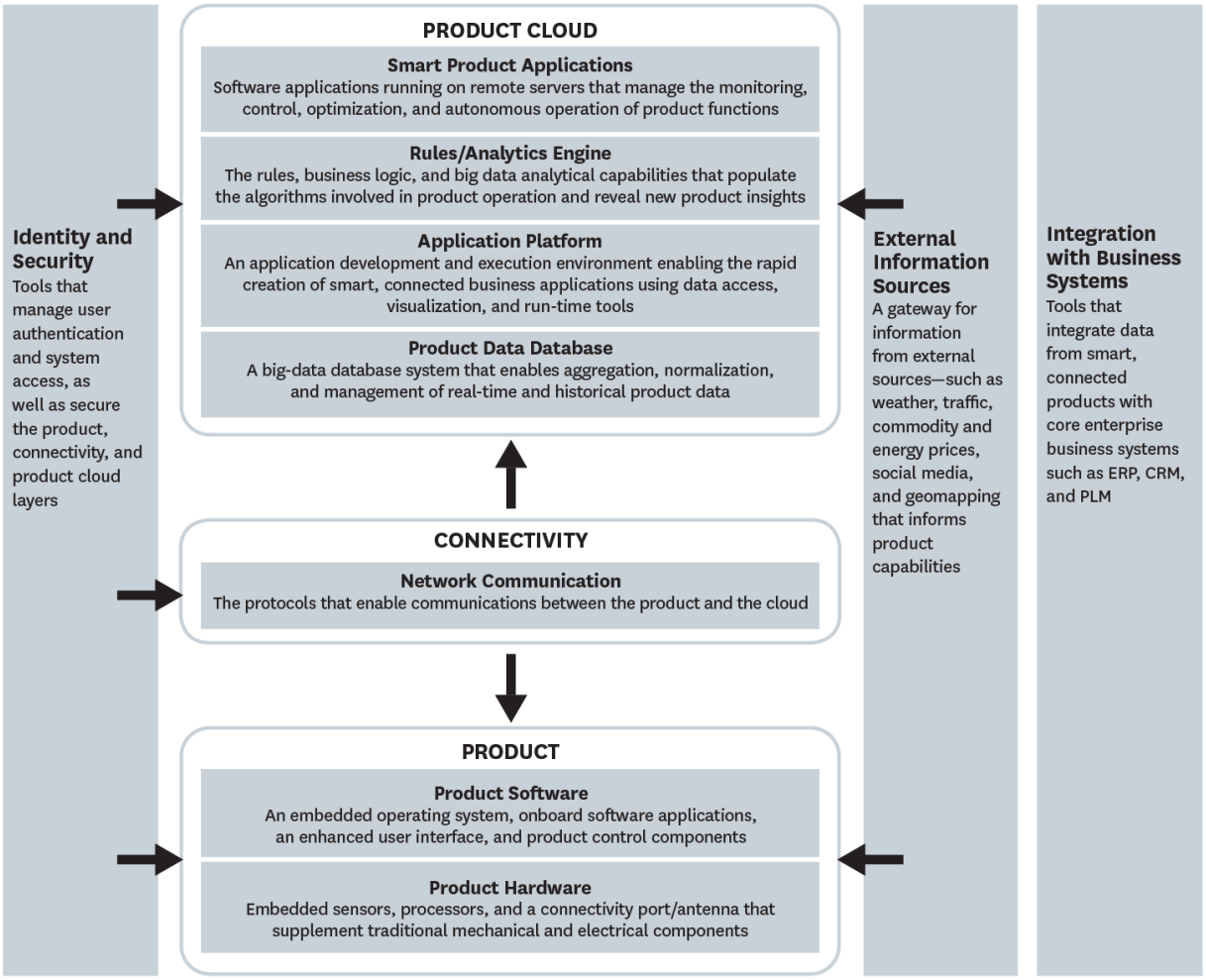

Figure 63: IoT architecture; Porter M. and Heppelmann J.E. (2015)

IoT Application Fields

The Internet of Things can enable several different application areas. The IoT Observatory of Politecnico di Milano, defined the following:

- *Smart City & Smart Environment:* this sector is dedicated to all the applications used to monitor and manage the elements of a city (for example the public transport, traffic, parking areas, bins) and the surrounding environment (such as rivers, woods, mountains). The objective of the IoT devices is to improve the liveability, sustainability and competitiveness of the city
- *Smart Metering & Smart Grid:* Smart Metering comprehends the meters to measure the energy consumptions (electricity, gas, water, heat), to verify their correct billing and remotely monitor them. The Smart Grid refers to the smart power network to optimize the distribution, to manage the distributed production and the electric mobility;

- *Smart Home & Building:* automatic management of the equipment and building systems in order to save energy, to improve the comfort, to monitor the security of the building and people inside it. Some example are the administrations of systems related to lighting, air conditioning and home appliances;
- *eHealth:* solutions that allow, thanks to remote and real time information, to: monitor vital parameters (for diagnostic and treatment purposes, reducing the hospital admissions); to get the localization of patients (increasing their freedom and maintaining the control and security);
- *Smart Car:* in this field IoT allow vehicles to connect among themselves (V2V) or with the surrounding infrastructures (V2I), e.g. with guardrail, for the prevention and detection of accidents, the offer of new insurance models and of detailed information on road conditions.
- *Smart Logistics:* these solutions are used for the traceability along the supply chain, the brand protection, the monitoring of the cold chain, the safety in complex logistics poles
- *Smart Asset Management:* remote management of valuable assets for several purposes such as to detect faults, tampering, localization, traceability and inventory management;
- *Smart Factory:* adoption of cyber Physical Systems, connection of machinery, operators and products to enable new approaches for production management, supply chain planning and products life cycle management;
- *Smart Agriculture:* monitoring of micro-climatic parameters to improve the quality of products, reduce the amount of resources used and the environmental impact.