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INTERNET OF THINGS & STARTUPS: STATE OF THE ART AND EMERGING TRENDS

MASTER GRADUATION THESIS

MSc in Management Engineering

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This project has signified the last piece of a puzzle full of hard work but also, and most importantly, unforgettable memories, concluding, without a doubt, one of the most important parts of my life.

Not only is my Master of Science being concluded with this project but also, what has been my academic education, as I initiate, moving forward, my professional career.

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Thank you.

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ABSTRACT *(English)*

Internet of Things offers nowadays a range of solutions that can have a very relevant impact in many applications and industries. Over the last years, a lot of new companies have emerged with the purpose of not only gaining relevance in their markets but also pushing the boundaries of what IoT applications are capable of.

For that reason, it made sense to conduct a research to understand what applications and industries have been the most interesting and had gathered more entrepreneurship in the last few years. This research aims at providing a deep understanding of the current context of the IoT startups, as well as analyzing what new emerging trends can be seen most recently that can help distinguish what the future of the IoT Market will look like.

Three main areas are divided in this project:

The first part is dedicated to understanding both the origins and the growth enablers that has caused IoT related applications to be so disruptive in the modern world. It is useful and necessary to set the base over which more precise and technical analysis can be build.

Secondly, a quantitative analysis is performed in order to understand global trends in terms of funding and investments, applications, targeted market or type of offer. This scrutinization is key to understand the current state of the art and helps discern what are the main characteristics and trends to be further analyzed.

Lastly, the same type of analysis is done following the emerging trends highlighted through the second phase of the project. In there, Smart Home, Smart Building and Smart Cities applications are examined to fully comprehend their relevance and paper inside the growth of the IoT Market.

ABSTRACT *(Italian)*

Internet of Things offre oggi una gamma di soluzioni che possono avere un impatto molto rilevante in molte applicazioni e industrie. Negli ultimi anni sono emerse numerose nuove aziende con lo scopo non solo di acquisire rilevanza nei loro mercati, ma anche di spingere oltre i confini di ciò che le applicazioni dell'IoT sono in grado di fare.

Per questo motivo, ha avuto senso condurre una ricerca per capire quali applicazioni e industrie sono state più interessanti e hanno raccolto più imprenditorialità negli ultimi anni. Questa analisi mira a fornire una profonda comprensione dell'Internet of Things, tra l'osservazione delle sue startup attuali e l'identificazione del futuro mercato che lo aspetta, grazie allo studio delle nuove tendenze emergenti.

In questo progetto si evidenziano tre macroaree:

La prima parte è dedicata alla comprensione sia delle origini che dei fattori di crescita che hanno portato le applicazioni legate all'IoT ad essere così dirompenti nel mondo moderno. Ha l'obiettivo di porre le basi su cui costruire un'analisi più precisa e tecnica.

In secondo luogo, viene effettuata un'analisi quantitativa per comprendere le tendenze globali in termini di finanziamenti e investimenti, applicazioni, mercato mirato o tipo di offerta. Questo studio è fondamentale per comprendere lo state-of-the-art attuale e aiuta a discernere quali sono le principali caratteristiche e le tendenze da analizzare ulteriormente.

Infine, lo stesso tipo di approfondimento viene effettuato seguendo le tendenze emergenti evidenziate nella seconda fase del progetto. In essa vengono esaminate le applicazioni Smart Home, Smart Building e Smart Cities per comprendere appieno la loro rilevanza e la carta all'interno della crescita del mercatodell'IoT.

EXECUTIVE SUMMARY

Internet of Things and startups framework

The first chapter of this thesis is to set a clear framework on the concept of Internet of Things, the Startup definition and characteristics and how these two ideas are mixed.

A research-based analysis was useful to clarify and list all the relevant characteristics of the IoT, from a theoretical framework on how it functions moving into a current market analysis, also based on academic researches and publications on the topic. A combination of reduced technology costs and the increase of smart devices as well as computing power has driven IoT to have unprecedented levels of growth. After that, and following these guidelines, the research proceeds on giving an overview on the current level of IoT and its projected future development. This research displays and expected continued, an accentuated YoY growth, at least, until 2025, finally reaching a total number of connected devices worldwide over 75 Billion. Being connected devices one of the main growth drivers, IoT market value is also expected to have a continued growth, with a CAGR of 27% from 2017 to 2022. Moreover, a current segmentation of the IoT market is also analyzed based on different types of application. It shows a superiority of fields involving Smart Cities and Industrial IoT applications, while Smart Home or Smart Car have less relevance. This states as very relevant and interesting as during the whole document we will see high levels of growth on those two categories.

After the Internet of Things framework, the startup ecosystem is also analyzed, providing definition and research-supported context on how their lifecycle is. This also gives a very interesting view on the different stages of a startups and how its success is directly linked to the ability to capture funds. This is rather significant, as a very important part of the thesis aims at analyzing funding trends based on fields of application, and it directly links with the previous point.

Objectives and Methodologies

This part of the work wants to give the reader a very concise understanding on what questions this thesis is trying to answer. The three main questions or topics are: (1) Define a current state of the art for IoT startups and its evolution over the years; (2) a financial perspective of such situation and evolution and (3) a deeper analysis on the emerging trends seen in points (1) and (2), more precisely in Smart Home, Smart Building and Smart Cities.

The methodologies used during the whole process are also explained and have been: (1) Literature review; (2) Companies research and (3) Self performed analysis based on an IoT startups database.

Database description and analysis

The whole concept and definition of such database is explained and detailed in Chapter 3.

After the whole introductory framework and settlement of base ground, the thesis continues with the actual quantitative analysis of such database during Chapter 4, as well as the more detailed view on emerging trends during Chapter 5.

The first, and overall analysis shows the distribution of the full list of startups according to different points of view. For example, geographic distribution shows a larger presence dominance of developed regions such as North America and Europe (47% and 38%). However, it also showed a higher growth rate over the last 10 years in emerging regions like Asia, where it registered a 21% CAGR, much higher than both North American and European.

When analyzing most frequent fields of applications, targeted market addressed and type of offer, there are also some meaningful insight being extracted. For example, Smart Home, Smart Cities, Multiapplication platforms and Smart Buildings are the most frequent ones, being almost 50% of all companies. In terms of targeted market, the majority is addressing the market with B2B business models, or a combination of B2B and B2C. However, there are some singularities, like Smart Home, that have over 70% of all offers being end user (B2C) oriented. For the type of offer there is a less

concentrated distribution as there are endless possibilities that are yet to be fully exploited.

Moving towards the financial analysis, it has the goal at extracting meaningful insights from an investment and funding perspective. The main trends to be highlighted, and it does occur across all possible perspective, is the growth for the last 7 years of the total captured funds (59%) as well as the average funding value (37%). When looking at the funding collection by field of application and funded startups growth rate, the same ones mentioned before (most frequent) still occupy the first positions, meaning that they are not only the most common, but they are the ones gathering more interest from the investors.

This is the clear rationale of why, when going into detail for the emerging trends, Smart Home, Building and City are the ones to be analyzed. For that fifth Chapter, not only their particular view is given, but also a comparison is made between them to underline main differences and singularities that could explain their successful behaviors.

As a point of reference, for Smart Home and Smart Building, while sharing same functionalities have very different target markets, the first one focusing on B2C business models (71%) and the second one tends to attract more B2B. However, for Smart City we see main differences in the type of offer being more diverse instead of predominantly defined by one of them.

For the financial analysis of emerging trends, it shows some variabilities between them. Smart City is the one having largest funding evolution growth of 88% CAGR, much higher than the general trend. Smart Home is also growing faster than all startups with a 59% CAGR, while Smart Building is the least of those three with a 51% CAGR.

Conclusions and next steps

The conclusions segment of the thesis recaps the meaningful conclusions that can be extracted from all the work of this project while also linking it with the next steps, where limitations as well as possible complementary research ideas of the thesis are detailed and argued..

1. INTERNET OF THINGS & STARTUPS FRAMEWORK

The objective of this first chapter is to introduce and give sufficiently detailed background information of the two pillars on top of which the thesis and the research will be based. These are: Startups & Internet of Things.

As mentioned, this project aims to provide a detailed analysis on the state-of-the-art of Internet of Things Startups. Hence, it is key for the right development and explanation of such analysis to give a comprehensive explanation on the features and characteristics of each pillar.

First, there will be the categorization and explanation of the Internet of Things, detailing definition, characteristics, the technologies that are enabling its development and its applications. All of it complemented with an overview of the current market situation, the challenges it's facing and the future trends that are yet to come.

Second, there is the Startup side explanation. Nowadays this term is more used than ever, and the number of startups is growing faster each year, mainly driven by the success stories that some of them have achieved in a relative short amount of time. Not only a definition of what a startup is will be given but also the different stages that a company goes through since the foundation of the startup as well as the categorization and considerations that have been used for the purpose of this thesis.

The following chapters will then talk about how the relationship between these two pillars establishing and working around the concept of the IoT startups.

1.1 INTERNET OF THINGS

1.1.1 Origins and definition of Internet of Things

The Internet of Things comes as the next big stage of evolution of the Internet. Although the Internet itself has had its own big development since its invention in the 1980s, transitioning from just a couple of PCs connected to billions of different computational devices, with IoT, technology, and therefore society, is moving towards a phase where not only computational devices are connected but all items around us will be connected to the Internet and with the ability to interact and communicate with each other without even human interaction required. While the term of Internet of Things is broadly used, there is no common definition of what the IoT really is and what it includes.

The first application of a "connected device" dates to the early 1980s, and it was a Coke machine at Carnegie Mellon University [1]. Programmers working several floors above the vending machine wrote a server program that chased how long it had been since a storage column in the machine had been unfilled. The programmers could connect to the machine over the Internet, check the status of the machine and determine whether there would be a cold drink waiting them,
should they decide to make the trip down to the machine

Though the buzzword "Internet of Things" evolution was set out a way back in 1980's with coffee vending machine, Kevin Auston, the Executive Director of Auto-ID Labs in MIT in 1999, coins the original term, and was attributed the work of the Auto-ID Center Labs at the Massachusetts Institute of Technology (MIT) on networked radio-frequency identification (RFID) infrastructures. Since then, the concept and visions of the IoT had been further developed and extended beyond the scope of RFID (wireless WLAN, wide area networks and other means).

[1] IBM | *The little-known story of the first* IoT *device* - https://www.ibm.com/blogs/industries/little-known-story-first-iot-device/ , accessed January 2020

There is not an official definition for the "*Internet of Things"* as both concept and definition had been changing as technology and the capabilities of connected devices has expanded.

It can be described in a simple but concise manner as: *"A network of items – each embedded with sensors which are connected to the Internet"* from the IEEE special report on Internet of Things [2], or with a much more elaborated and complete one like: *"An open and comprehensive network of intelligent objects that has the capacity to auto-organize, share information, data and resources, reacting and acting in face of situations and changes in the environment"* [3].

In any case, what the term highlights is the fact that technological devices bring a much complete functionality when they are to be connected with each other. Enabling communication and exchange of information with the capability of reorganizing, positioning, tracing, real time monitoring or process controlling [4] .IoT can be divided into three categories [5], depending on the type of connectivity there is:

1. People to people
2. People to machine (things)
3. Machine (things) to people

[2] IEEE Internet of Things | Towards a definition of the Internet of Things, May 2015
[3] IJERT | An Analysis of Internet of Things: Novel Architectures, Modern Application, Security Aspects and Future Scope with Latest Case Studies, June 2017. ISSN: 2278-0181
[4] Dr. Ovidiu Vermesan & Dr. Peter Friess | "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", 2013
[5] IJESC | Internet of Things: Definition, Characteristics, Architecture, Enabling Technologies, Application & Future Challenges, May 2016. DOI 10.4010/2016.1482

It is a concept and a paradigm that considers omnipresence in the environment of a variety of thing that through wireless and/or wired connections are able interact and cooperate with each other to create new applications and reach common goals. In this sense, the opportunities to create a smart world where not only computer and mobile devices are connected, but also buildings, cars and other vehicles, home appliances, medical instruments and industrial systems are enormous. But so, they are the research and development challenges needed to hurdle todays limitations to reach that point where the digital, real and virtual world converges into smart environments that make our living more intelligent.

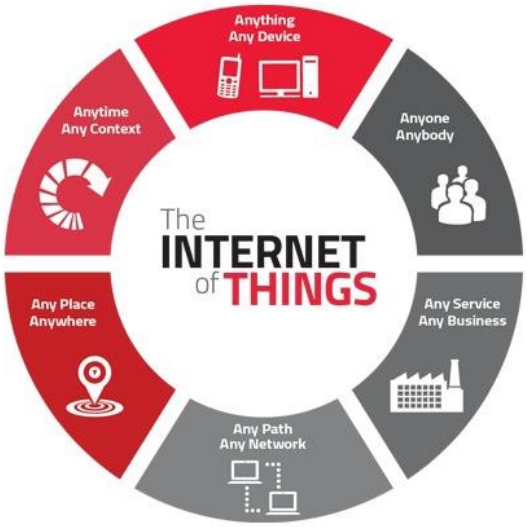

Figure 1. Internet of Things Ecosystem

1.1.2 Growth drivers of the Internet of Things

As mentioned, the concept of Internet of Things is not new. However, its growth has been accelerated in the last years in an almost exponential way. Truth is that, technologies advances and behavioral modifications in the society have led to an enhanced development of the Internet of Things and its applications. Here are the main factors that contributed to the growth and intensification of the IoT paradigm: [6]

New business models:

[6] Seagate BLOG | *Internet of Things: Growth Drivers, Challenges and Impacts on Storage Architecture* - https://blog.seagate.com/business/internet-of-things-growth-drivers-challenges-and-impacts-on-storage-architecture/ , accessed January 2020

Product as a service, pay per use and sharing economy are examples of business models that had emerged since the growth of the Internet of Things and the connectivity between different devices that it enables.

Lower costs of technology and connectivity network:

Chips, processors and sensors are the key element without which, IoT devices couldn't work. Their prices have been dropping significantly over the past few years. Moreover, broadband connectivity has not only improved in the last years as well, but is now more available than ever to everyone, everywhere. These two elements combined allow IoT to be a reality.

Smartphone penetration

The penetration of smart devices in general, but most importantly smartphones, has been increasing exponentially. So much so, that it has made mobility easier and has led to an app boom. Developers are creating apps that work efficiently as an IoT growth driver, working as an intermediate interface between the embedded device and other smart devices, while also allowing data exchange.

Big Data

Companies are starting to understand the real power of data analytics and the effectiveness it has driving decisions. It is a key element when transforming their businesses, and with so, big data is a big part of it, and companies are investing more and more in it.

Cloud computing power

The speed in which data is generated is lower every day and the amount of data generated itself is higher also every day. This calls to action that computing power increases, and so it has been. This has given the opportunity to companies to make instantaneous decisions by applying real-time analytics. Also, the fact that multiple options coexist in the market, drives competition to a level where development is

pushed to its maximum efficiency. Examples of it are: *Amazon web services, Google cloud computing, Microsoft Azure, etc.*

Regulation and legislation

In some cases, governments are pushing the embracement of IoT solutions, for example for energy saving use cases (LED lights), smart meters or automotive functions (reduction of pollution).

1.1.3 Architecture of IoT

There are different architectures for the IoT system that represent various perspectives about the IoT and its functions. However, the most common architecture for the IoT is the one made by IoT World Forum (IWF) [7] architecture committee in October 2014. This reference model provides a common framework to allow deploying the IoT easily and quickly in the industry

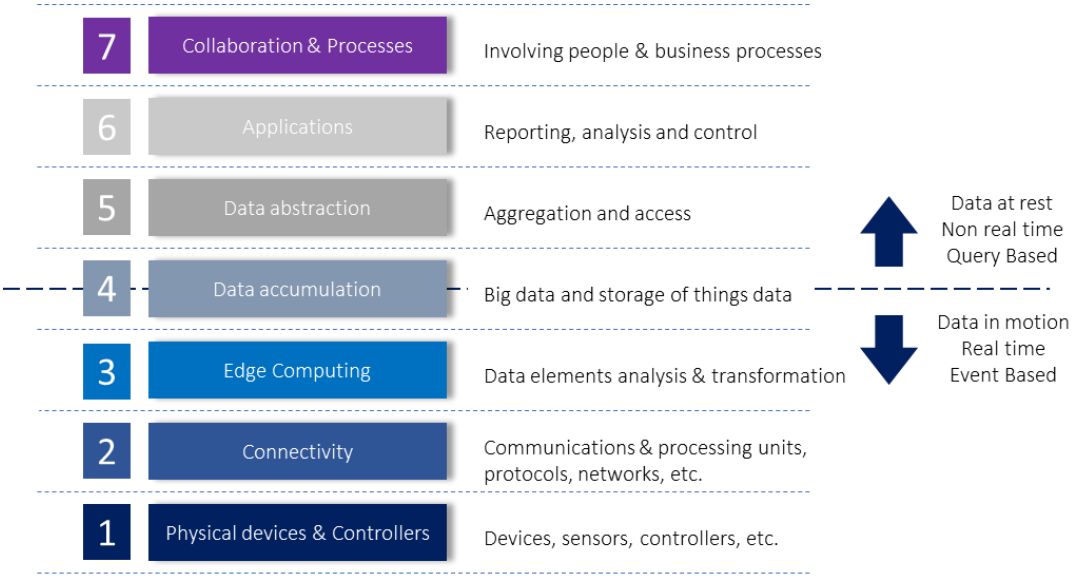

Figure 2. IoT reference model by the IWF

[7] The Internet Protocol Journal | William Stallings | *The* Internet *of Things: Network and Security Architecture.* December 2015. ISSN 1944-1134

The expected route of the whole interactive process of an IoT application is supposed to go upwards, starting on layer 1. Layer 1 compose the physical space. The hardware sits there and it's the responsible to collect data from the real world and transfer it to the upper layer. This data can be temperature, pressure, water quality, noise, motion detection, pollution, etc. Then it comes layer 2, where the interconnectivity between devices takes places. There is where the information is gathered and transferred for processing into the next layer, Edge computing. In this third layer, the data received is converted into proper storable information. At this point, processing component should be able to work with lots of data and perform some transformation to reduce the size of it.

After a first unit where data is transformed in an initial and basic way, the data coming from layer 3 is stored in layer 4, where it will be then accessible from the upper layers. It is the point where data categorization is changed from event based (based on what is happening in the real world, the data behaves in a way or another) to query based (based on the orders coming from upper layers, the data.

Going into layer 5, data abstraction. Here, data coming from different places, is combined and converted into the right format for the applications to manage it in an efficient manner.

Layer 6 is the application layer. This is where the layer is prepared to interpret the information depending on the IoT application given (i.e. Smart City, Smart Car, Healthcare, Smart Home, etc.). After it, the final layer is where the collaboration with people and businesses takes places. This layer may provide functionalities for the final user such as graphs, chart or business models based on the data received from the application that are useful for the individual to take insights from it and use it efficiently.

Internet of Things concept has now been described and its architecture defined. Following, there will be a detailed explanation on IoT characteristics as well as the challenges that is bringing with it.

1.1.4 Characteristics of IoT

As mentioned before, it is not that easy to define IoT because it has become an umbrella term for many realities which, in the end, have little in common, depending on how you look at it. Internet of Things can have a different perspective depending in the use case you focus on. Many other specific terms for the IoT have appeared and, even though they fall under the same umbrella they may work differently. Examples of it are: *Industrial IoT* (IIoT), *Consumer IoT* (CIoT) or *Internet of Everything* (IoE).

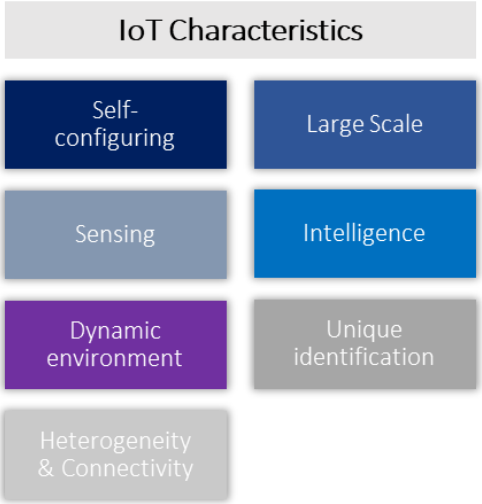

Figure 3. Map of IoT characteristics

However, they are not different worlds and they do have some characteristics in common. This is what we will explain in this section. Which are the common characteristics through which an IoT application can be identified [8]. Here is a detailed list of them:

Large Scale

The extensive, and yet still increasing, number of connected devices creates a large-scale network built to share information and data is a pillar of the functioning and development of IoT.

Intelligence

Sensors, processors and computers have been around for decades. What differentiates the IoT applications from the ones we were currently using these devices for, is that they will be capable to manage themselves and make decisions autonomously. IoT objects become able to respond intelligently to different scenarios.

[8] Hany F. Atlam, Gary B. Wills | *Technical Aspects of Blockchain and* IoT. December 2018. https://doi.org/10.1016/bs.adcom.2018.10.006

Sensing

Sensors are the main pillar on top of which IoT is based, as they are responsible for gathering and perceiving the surrounding information that is later going to be analyzed.

Unique identification

Each IoT device involves some type of tag (RFId) that provides a unique identification. Being the network of connected devices so extensive, the IoT needs a naming architecture that provides unique identities to each of the billion devices out there to enable proper communication and interaction between individuals.

Dynamic environment

The IoT is a dynamic system and it requires that it can be adapted to environmental changes and act intelligently and autonomously depending on the context.

Heterogeneity & Connectivity

The IoT large scale of connected devices not only faces a challenge because of its size, but also because of its heterogeneity. It must be able to enable communication, exchange of information and interoperability between devices with different hardware platforms, networks, communication protocols and operating systems. Though this is a challenge it faces, it also has the ability to link and interconnect those devices to offer new market opportunities for generating new applications and services.

Self-configuring

With the self-configuring features of the IoT, devices can work with each other to deliver specific operation and even configure themselves, avoiding larger complications for the service providers and manufactures of those devices.

1.1.5 Challenges of IoT

It is naive to assume that all the benefits and innovation that we have been seeing from the IoT comes without difficulties or problems in implementation. All the potential of

the IoT is well accompanied by many challenges. In fact, every characteristic from it has a difficulty or obstacle to overcome. [9]

The Large-Scale characteristic comes with an obvious issue, and it is the scalability challenge. It is hard to process that amount of data with classical database processing methods. It demands a much more sophisticated implementation, and here is where Big Data comes into place as it is the method necessary to deal with the size of information that is needed.

Related to the scalability challenge, and already previously mentioned, come both Interoperability and Heterogeneity. A lot of devices, all with different hardware, communication protocols, operative systems etc. Enabling efficient communication between all of them without misinformation being transferred or information not being actually exchanged when needed, is the main challenge for the ecosystem, as it highly depends on the proper information to be exchanged to get the best out of it and call to action the right responses.

Finally, it comes the security & privacy issue. Unfortunately, it is something that may go unnoticed at the beginning, but it is remarkably important to handle it appropriately. With the network of devices growing every day, it also grows the risk of security vulnerabilities in those devices. Also, they become part of our lives, sensing our daily behaviors through cameras or microphones, understanding our marketing preferences and exposing valuable and private data to other third parties.

1.1.6 Current IoT market situation

It has been clearly established already that the IoT concept is radically disruptive. In it, multiple different technologies coexist and cooperate to get the most out of it. It has the capability to modify business models and value chains in different organizations. It is not only a smart thermostat connected to the internet. It is true though, that it relies

[9] Hany F. Atlam, Gary B. Wills | *Technical Aspects of Blockchain and IoT.* December 2018. https://doi.org/10.1016/bs.adcom.2018.10.006

ultimately to devices being connected to the internet, and that is the key element of it. But the capabilities and the opportunities that come with it are just unthinkable.

The number of connected devices is growing at a higher rate every year. Regarding a study done by the IHS Markit in 2016 [10], it is going to reach 30.7 billion devices by the end of this year (2020) and 75.4 billion devices by 2025 (Figure 4.)

This populates the ecosystem with unlimited capabilities and new applications and services to be created every day.

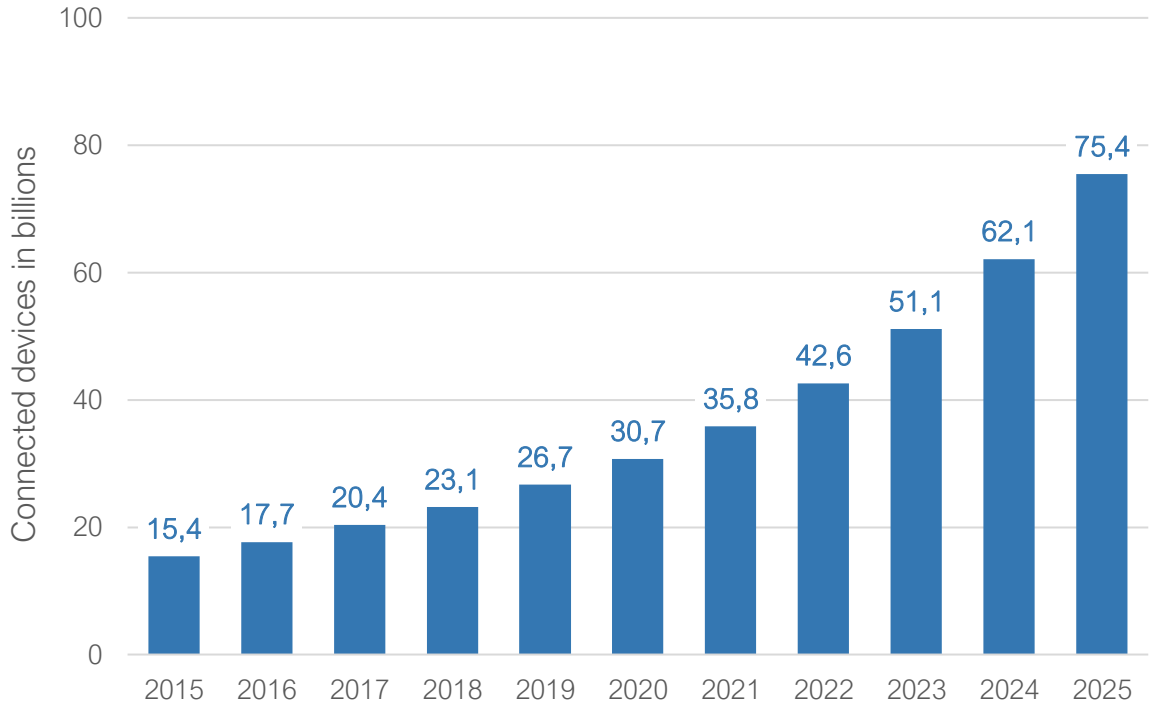

Figure 4. Connected devices evolution in the next years. Source: IHS Markit

Other studies highlight the growth of connected devices by type of device. Form the one done by Strategy Analytics done in 2017 [11] and represented in the following figure (Figure 5) two conclusions can be highlighted. First, that the two main type of devices are Smartphones and Smart Home devices. Second of all, PCs, which at the time

[10] IHS Technology | IOT Platforms: enabling the Internet of Things, March 2016.
[11] Strategy Analytics | *Global Connected and IoT Devices Forecast Update*, accessed January 2020. https://www.bitdefender.com/box/blog/iot-news/connected-home-overtake-enterprise-biggest-iot-revenue-driver/

where the initial connected device have not only not grown their share of devices, but it has even shrunk in the last ten years. It is a clear demonstration that the IoT is not a computer connected world, but a world where everything is connected to everything. Arguably, in the following years, this distribution may look different, and other type of devices had gained representation and weight in the IoT ecosystem.

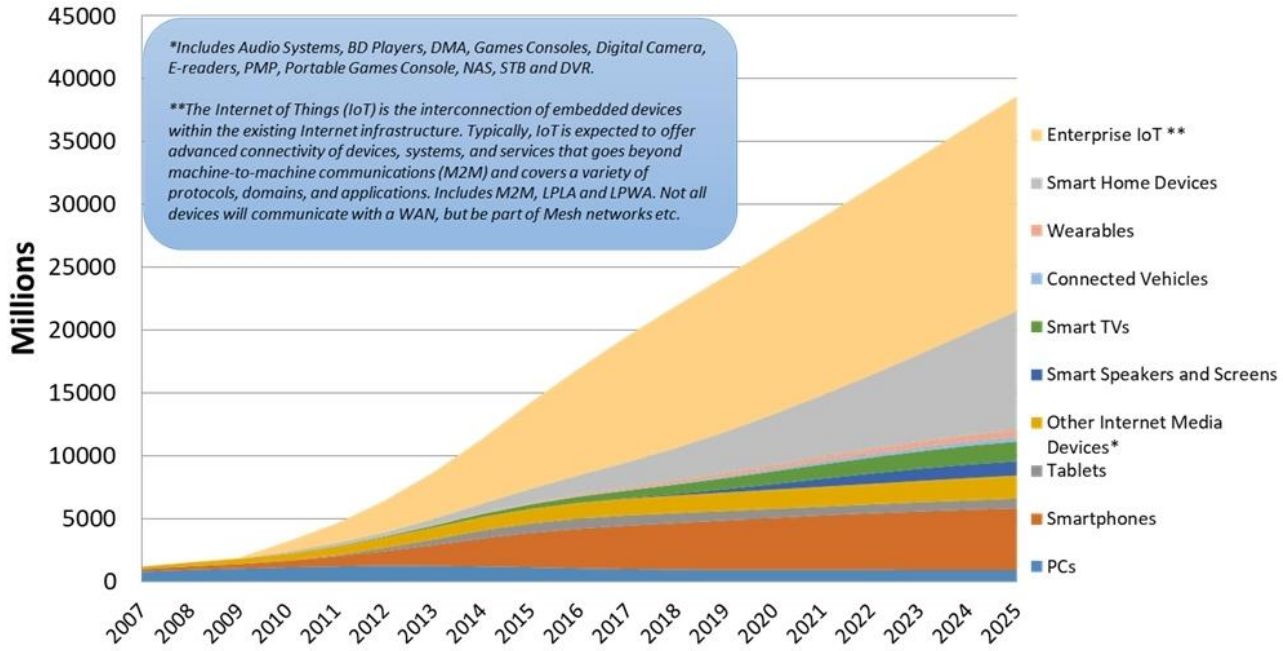

Figure 5. Connected devices by type of device. Source: MarketsandMarkets

We must take into consideration, that as they are separate studies, they may not reach the same final numbers in terms of connected devices. However, it is clear that they both relate to the same order of magnitude*. IHS Technology* is talking about 35bn devices in 2021, whereas *Strategy Analytics* situates that number at 30bn.

On another perspective, a *MarketsandMarkets* study [12] of 2017 forecasts the estimated market size in 2022 to reach USD 561.6 billion. Having grown from USD 170.6 billion in 2017, at a CAGR (Compound Annual Growth Rate) of 26.9%.

[12] MarketsandMartkets | *Internet of Things (IoT) Market research report,* June 2017. Report Code: TC 2895.

CAGR[13] is a term for the geometric progression that provides a constant rate of growth over the time period chosen. It dampens the effect of volatility of periodic returns that can render arithmetic means irrelevant. It is particularly useful to compare growth rates from various data sets of common domains such as revenue growth or units delivered of companies in the same industry or sector.

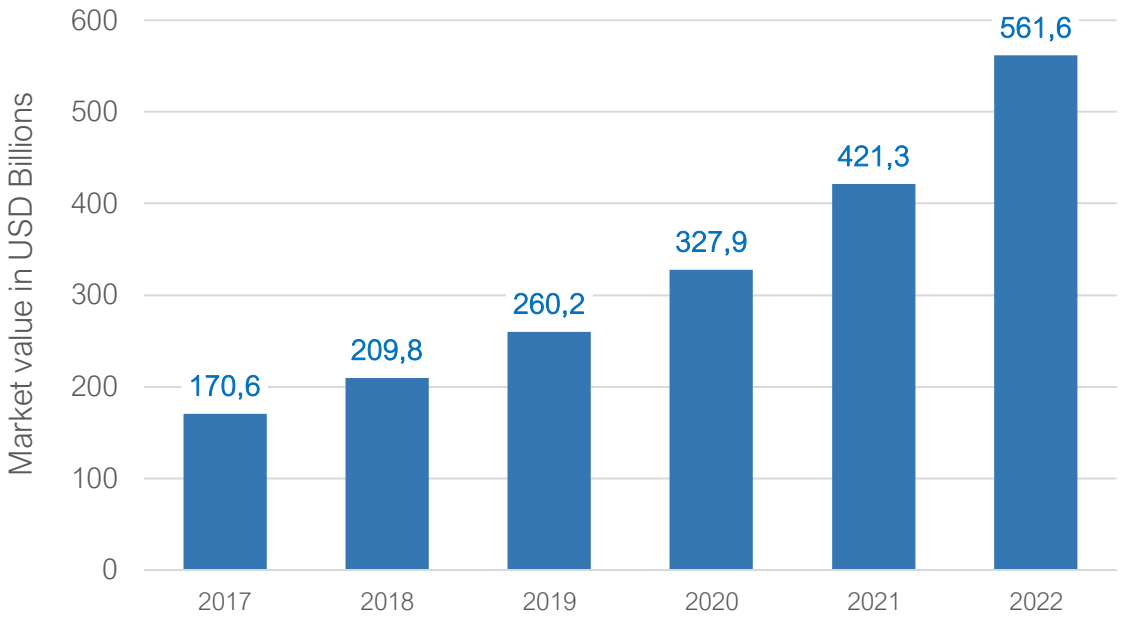

Figure 6. Market size (in $Bn) evolution. Source: MarketsandMarkets.

Market growth is attributed to the increase in adoption of cloud platforms and the reduction in cost of the sensors. Moreover, there are some uncharted opportunities yet to be discovered and exploited, such as geographic expansion to emerging markets and the large-scale implementation of IoT technology that for now is replicated at reduced scale. It also highlights the effect that emerging economies will have, as they are growing and offering new opportunities. For example, the Asia Pacific region.

It is also stated that the global IoT market share will be dominated by three sub-sectors; Smart Cities (26%), Industrial IoT (24%) and Connected Health (20%). Followed by

[13] Wikipedia / *Compound Annual Growth Rate*, accessed January 2020. https://en.wikipedia.org/wiki/Compound_annual_growth_rate

Smart Homes (14%), Connected Cars (7%), Smart Utilities (4%) and Wearables (3%) [14], as seen in Figure 7.

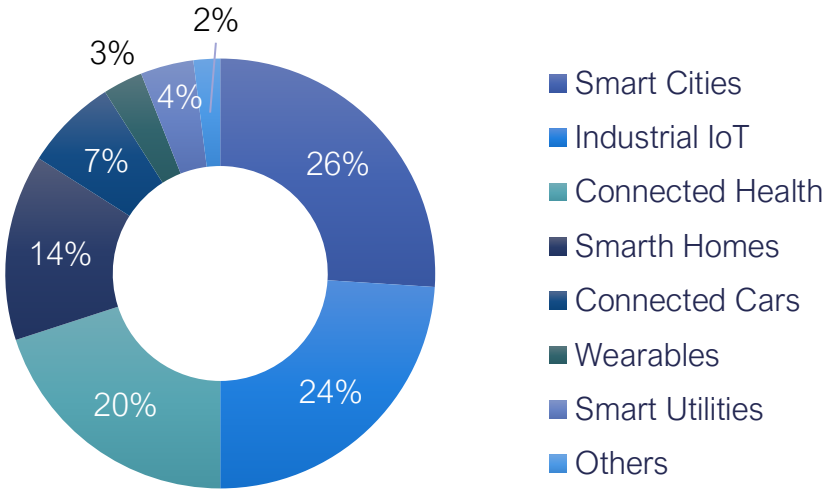

Figure 7. Global Market Share by sub-sector. Source: Growth Enabler.

Both connected devices and market value behave correspondingly with higher YoY (year on year) growth every year. Which makes sense, as the amount of business opportunities increase with the number of connected devices. Not only that, but if we were to look at investment in IoT globally, we would find similar behavior as well. The Growth Enabler IoT Report[15] also highlights the increasing amount of investment received by IoT industries. It has doubled in four years, from $2.2 bn to $4.5 bn, and it is expected to continue growing at a 5% rate YoY.

The numbers illustrated in this section show clearly how IoT is and will be one of the most important trends for the next years. Moreover, being a new concept, it is highly important the presence of startups, as they are the main source of innovation to this market. Hence, in the next chapters, the IoT startup situation will be discussed. Going in detail into the business models, types of startups, IoT technology they are benefiting from, their organizations, etc.

[14] Growth Enabler | Market Pulse Report, Internet of Things (IoT), April 2017
[15] Growth Enabler | Market Pulse Report, Internet of Things (IoT), April 2017

It will also be discussed in a market point of view. Once we know the current situation, it is interesting to see how it has behaved in the last years and highlight any possible significant change as well as understand where the most successful ones sit, and how are they contributing to push IoT capabilities to the limit while bringing wealth, development and employment to their respective countries and societies.

First, it is important that the concept of startup is also clear and determined, so that for further analysis we can have a correct and structured conceptualization of what a startup is and who can classify as one.

1.2 STARTUPS

1.2.1 Startup definition

Something like the IoT definition happens when we talk about startups. And is that there is no unique definition. Someone may define a startup in one way or another, depending on their own criteria of what is characteristic to a startup or not.

While new ideas and concepts have appeared in the last years, it's understandable that their definitions can vary from one place to another. However, there are always some good examples that have the ability to describe those ideas in the best manner, and are, then, broadly used for many others.

In the case of startups, the term was initially used during the 1980s, becoming more popular towards the late 90s. No coincidence that it happens at the same time as the internet and its technology arose. Since the beginning, startups were highly linked to the use of new technologies and the internet as main enabling factors. At the beginning, though, the term was used to describe a new company that had the potential to grow largely.

Nowadays, the term startup is being defined in many different ways, but on relevant definition is the one coined by Steve Blank, a Silicon Valley entrepreneur and developer of the customer development method that launched the lean startup movement. Steve Blank definition of startup [16] cites as following: "*A startup is a temporary organization in search for a scalable, repeatable and profitable business model"*.

Other definitions that we can come across are for example the following from Neil Blumenthal [17] : *"A startup is a company working to solve a problem where the solution is not obvious, and success is not guaranteed".*

However, we have to consider also the definition provided by the Observatory of Digital Innovation from the Politecnico di Milano. It gives a much more practical description, useful to categorize them when we go into the analytical aspect of this thesis. It refers to a startup as *"a company created after 2013 or, in case it was founded before, has received funding after 2016"*

Being as they are, different in definition, they all reflect something in common. Startup founders deal with a need of developing and validating a business model, and there is uncertainty both of finding the right solution and finding success. Because even if the solution is appropriate, it will also need to be scalable and repeatable, otherwise it fails.

1.2.2 Startup lifecycle

It is clear that a startup doesn't transform into a regular, defined and structured company in a matter of weeks. There is a process by which the startup goes through different phases, each with different goals and needs, in order to achieve the ultimate

[16] Forbes | *A Startup Conversation with Steve Blank,* accessed January 2020. https://www.forbes.com/sites/kevinready/2012/08/28/a-startup-conversation-with-steve-blank/#8077e97f0dba

[17] Forbes | What *is a Startup*, accessed January 2020. https://www.forbes.com/sites/natalierobehmed/2013/12/16/what-is-a-startup/#42b5554f4044

objective of becoming scalable enterprise. This is known as the startup lifecycle[18], shown in Figure 8.

This approach emphasizes a disciplined process of exploration, validation, and refinement of the business concept as an essential first step in the development of an entrepreneurial venture.

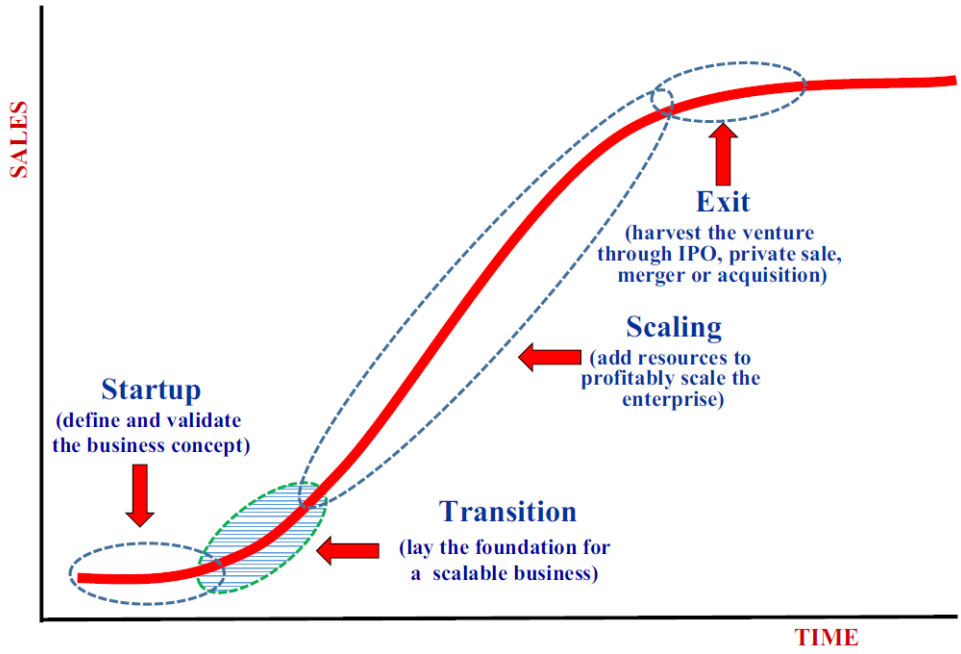

Figure 8. Startup Life Cycle. Source: Joseph C. Picken

The entrepreneurial innovation process proceeds through four stages: Startup, Transition, Scaling & Exit.

Startup

At this stage, the goal is to define and validate the business idea. It requires to seek for the market opportunity, establish the offering clearly, define the business model and

[18] Joseph C. Picken | *From Startup to scalable enterprise: Laying the foundation,* July 2017. DOI: 10.1016/j.bushor.2017.05.002.

the go – to – market strategy to deliver the offering reliably to the target customer and profitably.

The focus of the team is narrow and clear, as the resources and time is also limited. However, the economic risks are low and the typically informal and loose structure enables a more fluid and agile behavior.

Transition

Transition represents the essential bridge between the loosely structured of the startup and the structured and disciplined model required for the required rapid scaling. The entrepreneurial team's challenge is to complete the development of the offering and establish a solid foundation that enables the company to scale rapidly in the following phase.

It is, indeed, required because once the company has engaged with the initial customers it will need additional resources, new capabilities and the ability to face with the larger and more complex challenges.

Scaling

The company needs to add significant resources and take advantage on processes and partnerships to grow the business within the framework of a validated concept and offering and a sustainable business model. With a rapid growth, the startup can position with a sustainable market leadership and achieve competitive scale.

The fluid and agile organization becomes inconvenient. It requires a company with structure, process and discipline. Functional specialists assume roles previously covered by generalists and policies and procedures substitute ad-hoc decision making. This is all needed because a solid foundation is key for consistent and predictable profitability to be able to at the end provide a return for investors.

Exit

At some point, there is a need for a successful exit (an IPO, private scale, merger or acquisition) to collect all the value accumulated by the company for the benefit of the entrepreneur and investors.

As illustrated in Figure 8, the boundaries between the neighboring stages are fuzzy and frequently overlapping. While it is essential to get the business concept right in the startup stage, laying the foundation for a scalable enterprise during the period of transition is equally if not more critical to achieving venture success than the startup stage. [19]

As the nascent startup matures into a disciplined business many challenges are to be overcome. This period is relatively short, between 18 to 36 months. The team must build a foundation on top of which the, yet to be, scalable enterprise will rest. The experience and competence necessary for this phase extends dramatically. Founders must deal, practically at the same time with strategic direction and market positioning, building a management team, implementing discipline, structure process, acquire resources, achieve a supportive company culture and manage risks and, on top of it, adjust their own leadership and management style.

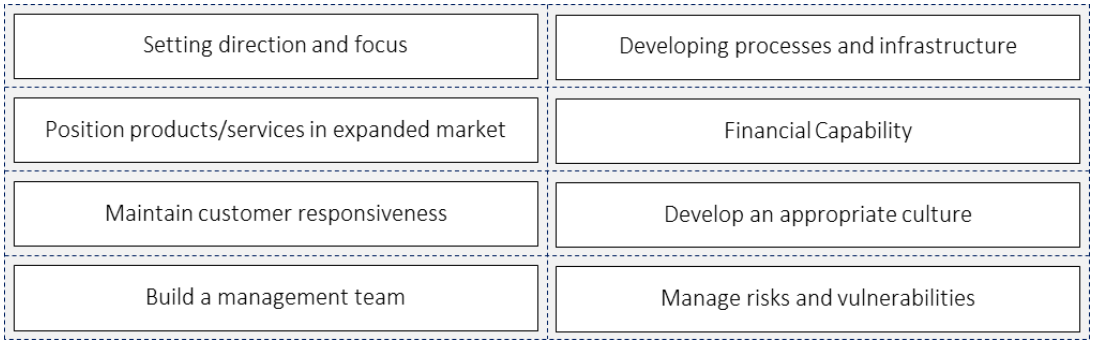

Figure 9. Challenges of the transition stage. Source: Joseph C. Picken

All of them requirements (resumed in the table in Figure 9), determine eventually which companies are set for success and which don't. No matter how brilliant or compelling the idea or the product was, only the ones that are able to negotiate these challenges and successfully resolve them survive. Even with the company going into the scalation phase and receiving substantial funding, it doesn't mean they have set proper

[19] Joseph C. Picken | *From Startup to scalable enterprise: Laying the foundation,* July 2017. DOI: 10.1016/j.bushor.2017.05.002.n

foundation in the transition phase. To reassure that, mora than 75% of venture – backed firms fail or sustain to marginal existence. [20]

[20] Journal of Business Venturing | John C. Ruhnka, Howard D. Feldman, Thomas J. Dean | *The Living Dead Phenomenon in Venture Capital Investments,* March 1992. https://doi.org/10.1016/0883-9026(92)90009-G

2. OBJECTIVES AND RESEARCH METHODOLOGIES

The goal of this chapter is to lay out what will be the main objectives of the work of this thesis. Also, what are the methodologies that were used for this purpose.

To begin with, an important aspect of this work to highlight is the fact that the thesis has been done in collaboration with the *Osservatori Digital Innovation,* a Digital Innovation Observatory from the School of Management of Politecnico di Milano university. They have provided since the beginning the guidelines and feedback needed to align this work with the ultimate objectives of the research. Dynamic conversations have taken place throughout the period of the thesis elaboration and has made possible significant insights and results to come out.

2.1 OBJECTIVES

To offer a better description of what the paper is including and the overall overview, the work is divided into three main areas. Each of them aims at providing answers to the general topic covered while going also through the details to identify interesting and meaningful insights from each area.

These questions have not been set at the beginning of the project but are consequences of the ongoing research and analysis that have brought conclusions and other intrigues.

The three main topics to discuss, then, are:

1. Which is the state of the art of Internet of Things at international level?
2. Which are the main trends of the market?
3. Which are the main evidences for Smart Home and City areas?

The first one goes into the details of geographical distribution, field of application, market offer, type of customer and any other variable related to understanding the relevance and increased popularity, if it were, of every application.

The second one goes into the economics of the industry understanding the behavioral tendencies of the funding and investments captured by the startups and scrutinizing every possible perspective useful to understand in the best way. It also helps visualize which are the applications most interesting in terms of investment capturing.

The third one is an extension of the first two but with the focus placed in the Smart Home, City and Building. However, by the relevance of it and the amount of research placed into those three categories can be considered a third leg of the overall research.

2.2 RESEARCH METHODOLOGIES

Different research practices and methodologies have been used for the completion of this thesis. They are going to be explained in detail each of them but, to summarize, these are the main ones.

1. Literature review
2. Analysis of secondary sources

2.1.1 Literature Review

This part of the research has been the most relevant in order to fully understand the Internet of Things market and the framework we were going to be working on, based on previous researches on this topic, current and expected trends analyzed, technological innovations to be considered, etc.

It was the starting point for this thesis (referring to the first chapter) to set the framework correctly but has been used during all stages of the project, as it not only was used to understand the framework but provide extra validation points during the analytical part as well.

We have to remember that this project also refers to the startup ecosystem and how it merges with the stated boundaries of the Internet of Things. Hence, research is also conducted to understand the startup market specificities.

The main sources of information for this part have been academic papers. All those used have been cited during all the document and are also listed in the bibliography part at the end of the document.

2.1.2 Analysis of secondary sources

The second main source of information is related to news, press releases and other publication that, not belonging to the any academic institution, can also provide relevant information about the topics.

This not only includes third party web portals or article, but even information directly coming from the different startups further analyzed.

Ultimately, and even though it does not classify as a research approach. There is the last part of investigation that has been done during the project, self-performed analysis, and that it is explained in detail in the following chapters.

3. STATE OF THE ART OF THE IOT STARTUP ECOSYSTEM

3.1 DATABASE FIELDS AND DEFINITION

In this section we will be defining the database that was used to complete all the analysis. It is, indeed, relevant because both the scope and the limitations of the analysis are linked to the source of information that has been used.

As mentioned before, this work was initially generated by the *Osservatorio Digital Innovation* of the Politecnico di Milano. Not only they provided the request and the guidelines but also the database from which the analytical part of the research was performed.

The database has many data fields for each entry, up to 36 different ones. However, they can all be grouped into three different categories.

1. Company information: Description of the company, foundation, country of origin, etc.
2. Financial information: Funding received, acquisitions, investors, etc.
3. Offering information: Product/Service, technology they use, IoT application etc.

The detailed description of each category as well as the fields description are given in the next sections.

3.1.1 Company information

Within the first category fall all the details regarding company and founder description. They are going to be listed by order of appearance in the database.

Company Name

Complete name of the company as showed in *Crunchbase*

Source of information

Place where the information has been found. Mostly *Crunchbase* but also other portals or articles.

Website

The URL that addresses to the company's Web Site.

Description

Brief description of the company and their offering.

Startup Foundation Year

The foundation year of the startup.

Contact information

Email addresses and phone number (if there is one)

Continent Headquarter

Continent where the startup has the headquarters. Europe, North America, South America, Asia, Africa & Oceania.

Country Headquarter

Second level of detail of the location of the company, following previous continent information.

Italian Founders?

The cell is filled if the founder is Italian

Founders

The name of the founders. As in *Crunchbase* but sometimes information coming from the website. In some cases, there may be missing information.

Competences Profile

It's a field useful to understand the background of the founders: Managerial, Technical or Managerial and Technical

Age

The founder's age within intervals: Under 30, between 30 & 40 or over 40

3.1.2 Financial information

Within the second category fall all the details regarding funding information. The goal of the work, between other, is to have a clear overview of the investment's trends and distribution across IoT startups until 2019. For this reason, the database had been updated periodically, checking any variations until the beginning of 2020, to make sure all data was updated correctly and to have trustworthy information. The following are the fields used to capture all information relevant for posterior analysis.

Total amount of funding received (USD)

This field indicates the total amount of funding received by each company since its foundation until early 2020. It is shown in US dollars, for the purpose of standardizing all info into one single currency. However, this also allows for some variability in the real numbers as currency conversion factors change over time.

Funding received in last four years (USD)

This field indicates the total amount of funds collected in the period from 2016 to 2019 (both included)

Last Founding round type

This field indicates the total amount of funds collected in the period from 2016 to 2019 (both included)

Last Funding Round

Not only the total funded is relevant, but also the funding round in which the startups sits, as it a way to understand the level of development and the amount funding they can account. This categorization in the database is done following *Crunchbase's*, as most information comes from there, it is convenient to have standardized categories.

For this reason, and also to have a clearer perspective and definition of what each stage really means, the explanation of the details of each funding round is taken from the glossary of funding types from Crunchbase: [21]

- **Angel**: An angel round is typically a small round designed to get a new company off the ground. Investors in an angel round include individual angel investors, angel investor groups, friends, and family.
- **Pre-Seed**: A Pre-Seed round is a pre-institutional seed round that either has no institutional investors or is a very low amount, often below $150k.
- **Seed**: Seed rounds are among the first rounds of funding a company will receive, generally while the company is young and working to gain traction. Round sizes range between $10k–$2M, though larger seed rounds have become more common in recent years. A seed round typically comes after an angel round (if applicable) and before a company's Series A round.
- **Venture - Series Unknown**: Venture funding refers to an investment that comes from a venture capital firm and describes Series A, Series B, and later rounds. This funding type is used for any funding round that is clearly a venture round but where the series has not been specified.
- **Series A and Series B** rounds are funding rounds for earlier stage companies and range on average between $1M–$30M.
- **Series C** rounds and onwards are for later stage and more established companies. These rounds are usually $10M+ and are often much larger.
- **Equity Crowdfunding**: Equity crowdfunding platforms allow individual users to invest in companies in exchange for equity. Typically, on these platforms the investors invest small amounts of money, though syndicates are formed to allow

[21] Crunchbase | *Glossary of funding types*, accessed February 2020. https://support.crunchbase.com/hc/en-us/articles/115010458467-Glossary-of-Funding-Types

an individual to take a lead on evaluating an investment and pooling funding from a group of individual investors.

- **Product Crowdfunding**: In a product crowdfunding round, a company will provide its product, which is often still in development, in exchange for capital. This kind of round is also typically completed on a funding platform.
- **Private Equity**: A private equity round is led by a private equity firm or a hedge fund and is a late stage round. It is a less risky investment because the company is more firmly established, and the rounds are typically upwards of $50M.
- **Convertible Note**: A convertible note is an 'in-between' round funding to help companies hold over until they want to raise their next round of funding. When they raise the next round, this note 'converts' with a discount at the price of the new round. You will typically see convertible notes after a company raises, for example, a Series A round but does not yet want to raise a Series B round.
- **Debt Financing**: In a debt round, an investor lends money to a company, and the company promises to repay the debt with added interest.
- **Secondary Market**: A secondary market transaction is a fundraising event in which one investor purchases shares of stock in a company from other, existing shareholders rather than from the company directly. These transactions often occur when a private company becomes highly valuable and early stage investors or employees want to earn a profit on their investment, and these transactions are rarely announced or publicized.
- **Grant**: A grant is when a company, investor, or government agency provides capital to a company without taking an equity stake in the company
- **Corporate Round**: A corporate round occurs when a company, rather than a venture capital firm, makes an investment in another company. These are often, though not necessarily, done for the purpose of forming a strategic partnership.
- **Initial coin offering (ICO)**: An initial coin offering (ICO) is a means of raising money via crowdfunding using cryptocurrency as capital. A company raising money through an ICO holds a fundraising campaign, and during this campaign, backers will purchase a percentage of a new cryptocurrency (called a "token"

or “coin”), often using another cryptocurrency like bitcoin to make the purchase, in the hopes that the new cryptocurrency grows in value.

- **Post-IPO Equity**: A post-IPO equity round takes place when firms invest in a company after the company has already gone public.
- **Post-IPO Debt**: A post-IPO debt round takes place when firms loan a company money after the company has already gone public. Similar to debt financing, a company will promise to repay the principal as well as added interest on the debt.
- **Post-IPO Secondary**: A post-IPO secondary round takes place when an investor purchases shares of stock in a company from other, existing shareholders rather than from the company directly, and it occurs after the company has already gone public.
- **Non-Equity Assistance**: A non-equity assistance round occurs when a company or investor provides office space or mentorship and does not get equity in return.
- **Funding Round**: “Funding round” is the general term used for a round when information regarding a more specific designation of the funding type is unavailable.

Main Investors

The name of the main investors of the startups is shown. In some cases, there might be many main investors and in others there can be missing information.

Revenues

This is supposed to have the revenues of the startups. However, it is very complicated data to get, as most of them are undisclosed or they are very recent companies without relevant revenue. For this reason, most of the cells are empty.

Went Bankrupt?

If the company went bankrupt, it is indicated here. If the company is still active, this filed is left blank.

Acquired?

Some startups have been acquired by other bigger companies and if this occurs it is indicated here.

Year of Acquisition

The year in which the startup was acquired based mainly *Crunchbase* but also through other sources.

Acquiring Company

The name of the company which acquired the startup.

Value of Acquisition

The figures of the acquisition. This is a difficult information to find, indeed many of these
fields are empty due to values of acquisition being undisclosed.

3.1.3 Offering information

The third category is related to the actual offering of the company. It involves many different variables and/or type of information., which are described below:

Description

Detailed description of the startup idea. In a few sentences, it is illustrated what the concept is and how it works.

Cluster technology

Here, the technology used for their offering is chosen. The choice is made among 8 different technologies, listed and descripted below:

- **RFId (Radio-Frequency Identification):** it is the most common, as it is super easy to use. It refers to all use of electromagnetic fields to automatically identify

and track tags attached to objects. They can be either *passive*, powered from the RFId reader's interrogating radio waves, or *active*, where it would need an external battery or power source.

- **Wi-Fi:** is a wireless networking technology which allows devices to communicate through a wireless signal
- **BLE (Bluetooth Low-Energy):** is a wireless personal area network technology with low power consumption and similar communication range to the one of traditional Bluetooth (<100M)
- **Low-Power Mesh Network:** is a communication network with a "node architecture" organized in a mesh topology. Its main characteristics are the autoconfiguration and the low power consumption.
- **Cellular Network:** is the traditional mobile network and it's represented by technologies such as GPRS, GSM, HSPA (3G) and LTE (4G) which are characterized by a high-power consumption. For this reason, using this technology requires an incessant power source for nodes. In the upcoming years, 5G networks are expected to drive IoT growth by boosting cellular operations and IoT capabilities with it
- **Personal Communication:** it is composed by PANs (Personal Area Networks) technologies. A PAN is the interconnection of information technology devices within the range of an individual person (<10m)
- **PLC (Power Line Communication):** it transfers data through the same conductor used for the electric power transmission.
- **LPWA (Low-Power Wide-Area):** this technology enables the connection between devices in order to communicate over large areas at low bit rate. The LPWA (also known as LPWAN – Low Power Wide Area Network) is a technology used to connect sensors which don't need human intervention.

Field(s) of Applications

This is the categorization of each startup based on the application. There is the possibility that one startup serves multiple applications at once, for that reason the

database contemplates up to three different applications to be filled. The possible applications defined are the following:

- **Smart Home:** automatic and remote management of home appliances and other objects (lighting, heating system, etc.)
- **Smart Building:** automatic management of buildings' facilities.
- **Smart City**: any type of application that has to goal to improve city livability and automate current processes in a more efficient way (traffic management, water distribution, waste management, parking management, etc.)
- **Smart Grid:** systems able to energy management, consumption and costs.
- **Smart Metering:** devices which measure electrical and energy consumption automatic and seamlessly.
- **eHealth***:* products that enable preventive care and improve well-being of the person autonomously.
- **Smart Car**: interconnectivity between vehicles and the external environment.
- **Smart Logistics**: real-time tracking of shipment, monitored and optimized fleet management and improved warehouse management.
- **Wearable**: products - such as smart watch – that are wearable by people and that have intelligent functionalities
- **Smart Asset Management:** remote management and monitoring of machines to enable predictive maintenance and minimize breakdowns
- **Smart Agriculture:** monitoring of environmental parameters, livestock health, water and energy consumption and management of irrigation processes
- **Smart Factory:** Supply chain and processes optimization and management based on interconnected machines and operators.
- **Smart Retail:** applications destined to understand customers behaviors better to reach a more targeted audience thanks to relevant advertisements.
- **Infrastructures and Networks:** is composed by development of new technologies which enable products to communicate with each other and exchange data through those new channels

- **Multi-applications Platform:** they are platforms which allow to control more devices. Usually developed for the integration of different products in order to control them from only one access point
- **Smart Object:** Device with smart functionalities and that are able to collect and exchange data.

Functionality (for Smart Home, Smart Building & Smart City)

Another objective of this work is to deep dive into three of the main categories there are: Smart Home/Building & City. For that reason, a second level of detail is determined for the application of this cases. These applications are divided into two main groups (Smart Home & Building in the first one and Smart City in the second one)

- **Smart Home/Smart Building:**

  - Air conditioning & Heating: solutions based on enabling the preferred settings for climate commodity inside houses and buildings to be set remotely and via smart devices.
  - Appliances management: It refers to the combination of both Smart appliances (oven, fridge, etc.) and the application from where to control the appliances.
  - Security: systems to prevent and detect intruders, both physical and virtual (online).
  - Scenario management: systems which make possible to set routines to be executed when specific conditions are met
  - Irrigation: includes smart solutions to water plants efficiently by monitoring soil conditions
  - Energy consumption monitoring: these are solutions that can monitor electrical and energy usage.
  - Water consumption monitoring: it includes products that are able to monitor water use and detect possible leaks

- Pets monitoring: products designed for monitoring animals' well-being and nutrition
- Environmental monitoring: systems made by sensors that can monitor the environmental conditions inside the building such as humidity, temperature, gas presence, etc.
- Entertainment: products designed to provide joy, amusement and diversion.
- Children monitoring: it includes solutions to monitor children's well-being, their activities, sleeping and health.
- Fire, smoke and flood detection: it includes sensors which can monitor specific parameters, detecting potential issues.
- Service to people: consists of solutions that can ease life of people with disability, elder people or people with specific needs

- **Smart City:**

  - Traffic management: systems that collect, monitor and manages traffic information in real time
  - Parking management: solutions that monitor parking lots to enable real time availability reporting for parking spots
  - City problems report: systems that make easier for citizens to report issues
  - Smart lighting: street lighting systems that can be controlled centrally and remotely thanks to smart lampposts
  - Security: systems to detect dangerous situations in real time, both physical and virtual (online), and also help prevent them in the long term
  - Public transportation: solutions aimed at helping people in their usage of public transportation. Either by providing real time information or enabling a certain degree of applications related to public transport online and remotely.
  - Touristic services: group of solutions aimed at enabling tourists have a better and easier experience with touristic activities

- Private transportation: solutions for making private transportation affordable, accessible and adaptable to everyone.
- Garbage collection: monitoring of garbage levels in public bins as they can remotely send live status updates for better planification of their collection
- Landscape management: monitoring and reporting solutions to keep territory under control and preventing issues
- Environmental monitoring: systems of sensors that can monitor the different environmental parameters

Reference Market

The classification of the different possible markets is divided into 6 different categories:

- **B2B (Business to Business):** it is a form of transaction between two businesses.
- **B2C (Business to Consumer):** it is the typical form of transaction. Where the offer goes from company to a final consumer directly.
- **B2D (Business to Developer):** in this kind of transaction, the company sells its products directly to developers for them to make final readjustments or extra development and configuration on the product.

These three are the main pillars. However, some companies may have combined offerings from the three pillars. So, the last three would be:

- **B2B&B2C**
- **B2B&B2D**
- **B2C&B2D**

Offer

In the IoT market, the offer is not only smart hardware. There are multiple business opportunities that come along with the development of IoT in general. There are three main type of offerings in this industry:

- **Hardware**: company only offers hardware products and may have to partner with other companies to provide the complementary software and/or service

- **Software**: company only offers the software. Without any hardware it need to be applicable to different type of hardware providers.
- **Service**: when a company offers a service to complement some other offering from another company or simply provide a new and unique service.

Then again, some companies offer a combination of them, expanding the full list of possibilities that is reflected in the database

- **Hardware & Software**
- **Hardware & Service**
- **Software & Service**
- **Hardware, Software & Service**

Finally, there is a final type of offering that is not related to the offer itself, but to the technology enabling all of this offers to take place, and that is I*nfrastructure & Networks.*

- **Infrastructure & Networks:** related to all the infrastructure that is required to provide the technological requirements for other companies to develop their products. As the IoT market has been growing, so has the demand for updated and expanded networks. Thus, more companies have been founded with this offering purpose.

3.2 ANALYSIS STANDARDS AND CRITERIA

The aim of this chapter is to illustrate the different criteria followed for the classification of startups, used to perform all the analyses. The main objective will be describing the reasons behind trends and understanding the market's peculiarities.

The database that was initially given had originally 1117 entries. That is 1117 companies, as each entry correspond to one company.

The first part of the job was to update the current database information (new funding, investment stage, acquisitions, etc.), continuing with the already established fields and also adding new entries of companies that may have been created after the last update of the file.

To do so, the information was looked up in the portal web called *Crunchbase* [22]. There, a lot of information can be found regarding companies at a worldwide level and check their updated status.

After completing the update of the database, and the addition of other companies, the total number of entries ascended to 1405, meaning there were 288 new additions.

The full database is composed of 1405 startups. However, and as there will be many different areas of analysis, it will have to be cleaned and reorganized in order to have always only the relevant information for each case. For each case, the source of information and the filtering criteria applied to the database is indicated so that that there is always a clear perspective on where the numbers are coming from.

The database does not only include startups. It also includes companies that were considered startups in the beginning but at some point, ended up not being aligned with the definition of the *IoT Observatory.*

The criteria are:

1) The company must be founded after 2013

[22] Crunchbase | https://www.crunchbase.com/

2) If it had been founded before 2013, they must have received funding after 2016 (included) for it to still be considered startup
3) Has not failed as a company.

For the most part, the analysis is conducted excluding those companies from the database. This is a total of 197 companies out of the standards, which translates into a final database involving 1208 startups. Out of the 1208, 223 have never received funding. So, a total of 985 startups will be used to conduct investment related analysis.

Criteria	DTB size
Original database	1117
Updated full database	1405
Comply with startup definition	1208
Have received funding	985

Figure 10. Database size based on different criteria.

3.3 GEOGRAPHICAL OVERVIEW OF STARTUPS

This first part of the research has the goal of providing a general overview on the current worldwide situation, just considering number of startups and where they come from. It is important to understand the landscape in which we are going to deepen into afterwards. So, first thing should be to see how many companies there are, when and where.

For this part, all startups considered where those that comply with the standards to be categorized as startups and have not failed. This means that the total of startups is 1208.

3.3.1 Startups foundation

A good starting point is evaluating the rate at which startups have been created over the last years. Figure 11 shows such evolution. From there we can appreciate how the increase has had almost an exponential behavior until 2014. From there, it seems to have decelerated.

However, there might be a reasoning to it, as the graphs only shows data from our database and it obviously has its limitations. Data from the database gathers information found in web portals such as *Crunchbase*. This means that there are some companies that may have been created but are not already displayed or registered into those webpages.

Moreover, the way these companies are discovered and included in the database is because of a significant investment received. This is a second reason why they may take some time (years) to appear and why not all companies created in 2015 and onwards are represented. Startups from 2012-2015 have had some years to refine their offering and business model, and so it has enabled them to raise potentially more funding money. Therefore, they are represented in the database easier than rather new ones with still iterations in their own offering.

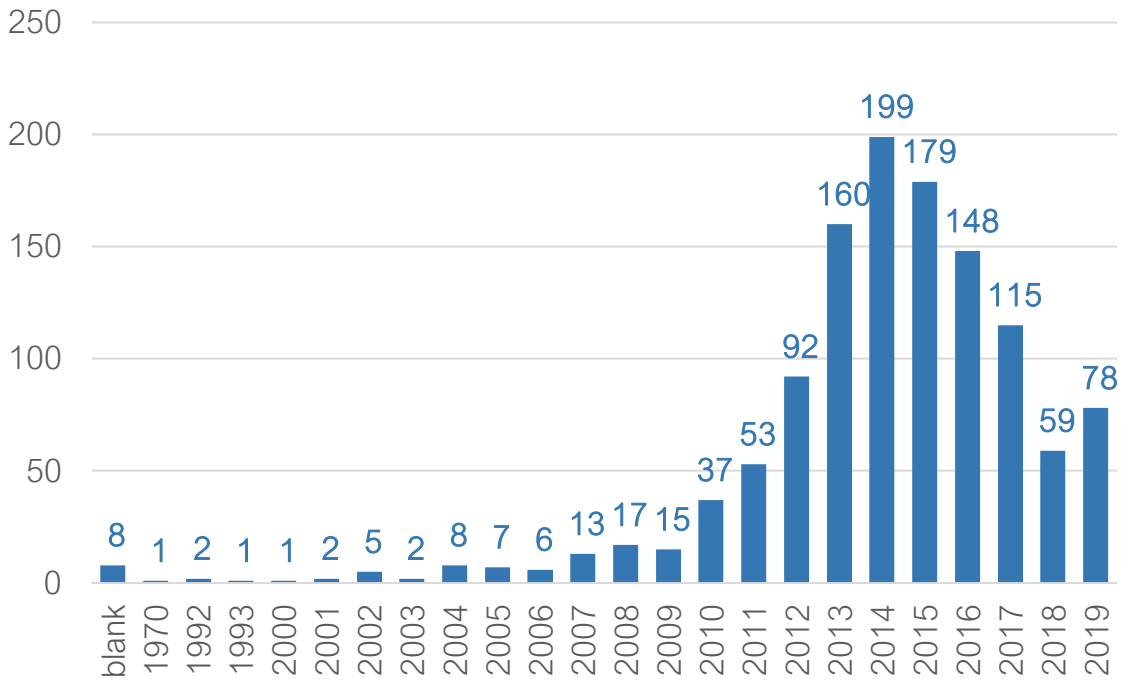

Figure 11. Distribution of startups by year of foundation. N: 1208 startups.

Another aspect worth mentioning is the fact that there is always some type of representation of companies founded years ago but are still under investment stages and haven't found and exit yet. This is obviously not the ideal case nor the typical one, as exit time for startups goes varies from 4 to 11 years depending on the industry. [23]

3.3.2 Geographical distribution

The next view analyzed is the geographical distribution of startups. Internet of Things is without a doubt a global trend. But there are always bigger and smaller contributors to the overall development and implementation, especially regarding disruptive

[23] Crunchbase | *How long does it take a startup to exit?,* accessed February 2020. https://about.crunchbase.com/blog/startup-exit/

technologies and applications that haven't been imagined before. This part is aiming at resolving this matter.

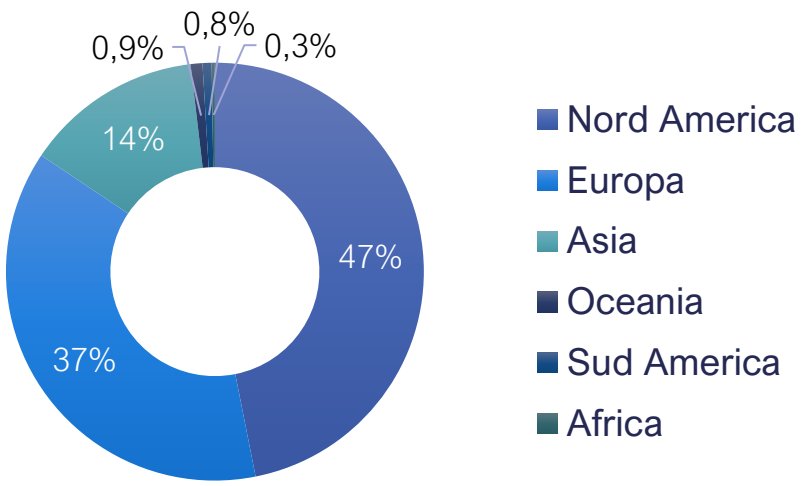

Figure 12. Geographic distribution of startups. N: 1208 startups.

If we have a look at global distribution separating by continents for now, it can be, without a doubt, appreciated that the most of all market magnitude is driven by North America with 566 companies (47%) followed by Europe at 453 startups (37%). This two continents account for the 84% of all companies, which is the vast majority, leaving other areas with minor participation. However, overall weight of Asia (166 startups; 14%) must not be ignored.

If we consider the evolution of funded companies by continent over the last decade, shown in Figure 13, it can be acknowledged the increasing trend coming from Asian countries. It is coherent, as the so-called emerging markets from Asia have been having economic development specially in technological industries [24] such as IoT. Moreover, it is shown how Europe has been slowly, but steadily, growing relevance until they reached market leadership [25] in 2018. Taking into account the last 10 years (2010-2019) it shows a CAGR (Compound Annual Growth Rate) of 21%. To put it into

[24] MSCI | MSCI Emerging Markets Asia Index (USD), February 2020.
[25] Market leadership is a term used to describe the IoT startup market in a holistic manner, based on this owned research, where each continent act as independent players.

perspective, Europe is at a CAGR of 10% and North America at 4%. This indicates that Asian market is growing twice as fast as the European and 5 times faster than the North American. [26]

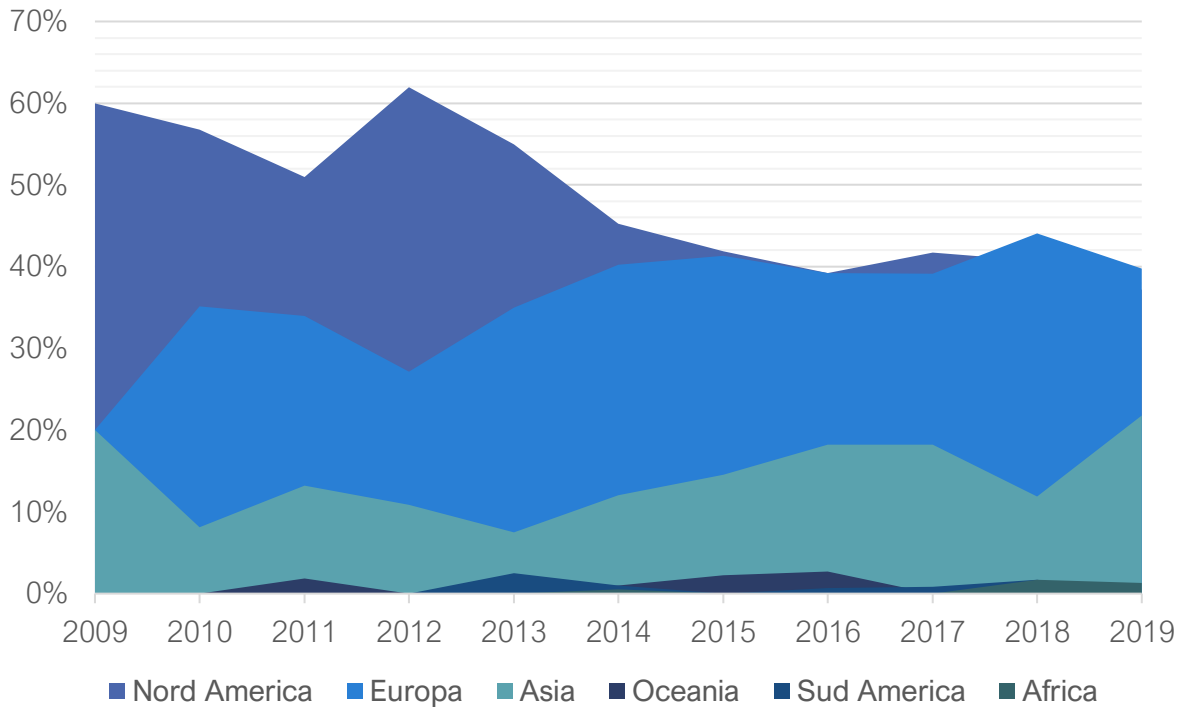

Figure 13. Evolution of foundation share by continent and year. N: 1208 startups

The lack of representation of continents like Africa, South America and Oceania can be attributed to the fact that, first of all, it is not as common as in other more developed countries to initiate entrepreneurial adventures, and second, this research is based mainly on available data and information which is easier to find and collect when it comes from more developed regions of the world.

As the goal is to understand which are the drivers of this industry, a more deepened analysis on the top regions (North America, Europe and Asia) is conducted, leaving the last three aside.

To begin with the major overall contributor to the market, let's consider firstly North America. The country division is very simple as there are not many countries in that

[26] Self-calculated values based on database numbers.

region (Figure 14). Not only that but it is exceedingly dominated by the United States with 532 startups (93%) followed by Canada with just 37 (6.5%). Mexico is meaningless compared to the whole volume, as it counts just 2 companies (0.5%).

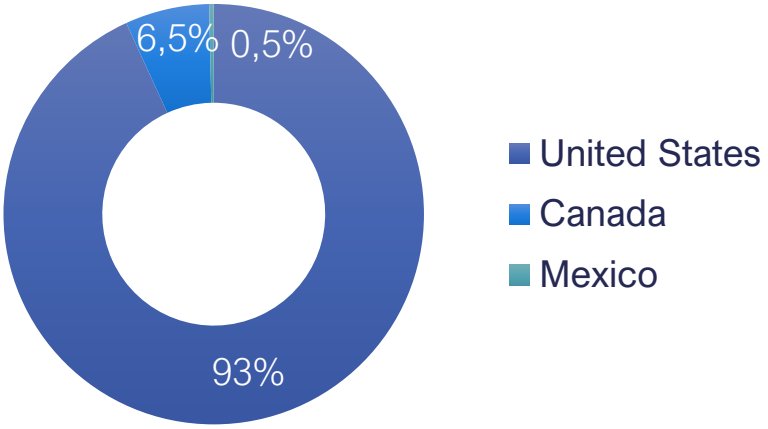

Figure 14. North America startup distribution. N: 566 startups

In Europe the history is tremendously different, as it gathers a much broader list of countries. In total, there are 30 different countries. However, and for the purpose of simplifying the chart (Figure 15), the last 24 countries, with minor individual representation, are bundled together into the *Other* label.

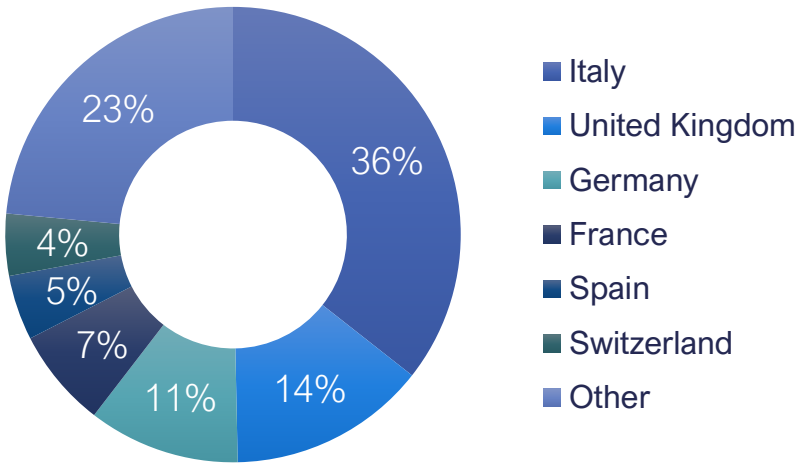

Figure 15. Europe startups distribution. N: 453 startups

Two principal observation can be extracted. Firstly, the high presence of Italian companies. This is mainly due to the focus that has been put in the Italian market during the process of building the database. This is represented in those figures because the more you look for them the more companies you are able to find. This highlights also one of the limitations of the work, the fact that the database is not globally standardized and without lacking information. It is mainly due to the self-modulation and construction of the database. This numbers, then may not describe the real distribution of companies across the continent. However, the number of startups collected, and the funding related to those is significantly relevant and coherent with different studies and reports to assume that anomalies are being dispersed.

Secondly, the main countries in which startups are rapidly emerging coincide with European countries with a higher nominal GDP (in USD) [27]. Germany (3.862 Bn. USD) is top of the list followed by UK (2.743 Bn. USD), France (2.707 Bn. USD), Italy (1.988 Bn. USD) and Spain 1.397 Bn. USD). This cannot be the sole only reason why a certain country has startups, though. The commodities that an entrepreneur may have when

[27] International Monetary Fund | *World Economic* Outlook *Database,* October 2019.

trying to start a new company in a certain country as well as the growth opportunities and support received both in resources and investment are also fundamental. Hence, it is understandable that the UK ends up as one the top country after Italy (acknowledging the anomaly Italy may suppose). UK is seen as the most attractive country for startup founders as 30% of Europe Venture Capitalists are based in UK [28] and their corporate tax, while not being the lowest in Europe, is not extremely abusive.

Last but not least, it comes the Asian market. We have already seen that it may not be the biggest one, but it for sure is the one growing the most. When doing the same country segmentation for Asia, again, multiple countries are involved. The same reasoning is applied, and the countries accounting for the last 13% (less than 2% each) are grouped a displayed in the *Other* group (Figure 16).

Here, there are three countries that represent almost the 80% of all continent. Those are: Israel, India and China, followed with minor percentages by Singapore and Japan. The top three countries are not only the top startup ecosystems in Asia, but their main cities also fall inside the Top 20 worldwide ranking of startups ecosystem.[29] In fact, Shanghai and Beijing (China) and Tel Aviv (Israel) fall into the Top 10, while Singapore (Singapore) is ranked 14th and Bangalore (India) is positioned 18th.

[28] EU-Startups | *Best 5 countries in Europe for* founders *and startups*, accessed February 2020. https://www.eu-startups.com/2019/11/the-5-best-countries-in-the-europe-for-founders-and-startups/

[29] Startup Genome | Global Startup Ecosystem Report 2019.

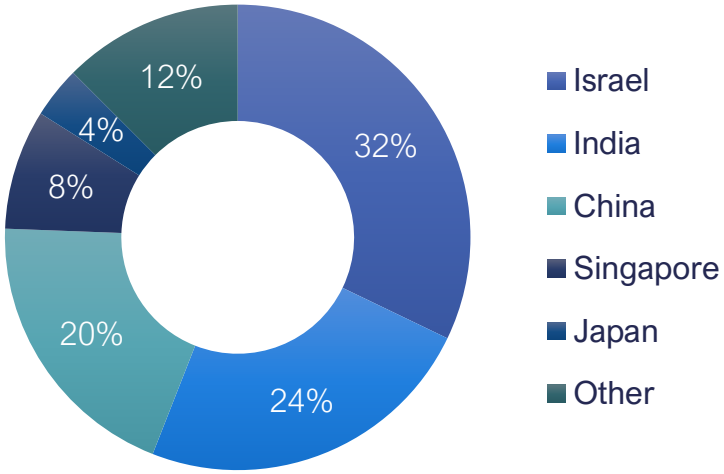

Figure 16. Asia startups distribution. N: 166 startups

Having evaluated that, makes it even more reasonable for Asia to have had such significant growth over the last years.

The following parts of the analysis will delve into what are the main applications being developed, how have they evolved over the last years and how is the investment scenario, analyzed with many different perspectives.

3.4 STARTUP SEGMENTATION BY DIFFERENT FIELDS

This section intents to provide a quantitative segmentation of all the startups covered by the database according to different fields and variables. The fields used to accomplish this approach are going to be field of application, targeted market and type of offer. With these, the ground to successfully perform further analysis should be set and it will also provide a general but meaningful understanding of the IoT industry.

To do so, and for this part, the analysis is based on the whole database, excluding those that have failed or not comply with the definition provided by the *IoT Observatory*. The total amount of startups considered, then, for this section is 1208.

3.4.1 Field of application

First, and after having gone through the different types of field of application described in the previous chapter, it seems reasonable to see what the distribution is of startups based on their field. The result chart is shown in Figure 17.

The analysis shows that the most trending applications are Smart Home (17%), Smart City (11%) and Multiapplication platforms (11%). Out of these three, Smart Home has had the highest growing rate over the last years, which is seen by the demarcated difference between all fields and Smart Home. It has a CAGR of 63%, while Smart City and Multiapplication platforms stand with 15% and 25% respectively [30].

[30] Own calculations based on the database figures. Considering created startups per year and during the growth period (2010-2015)

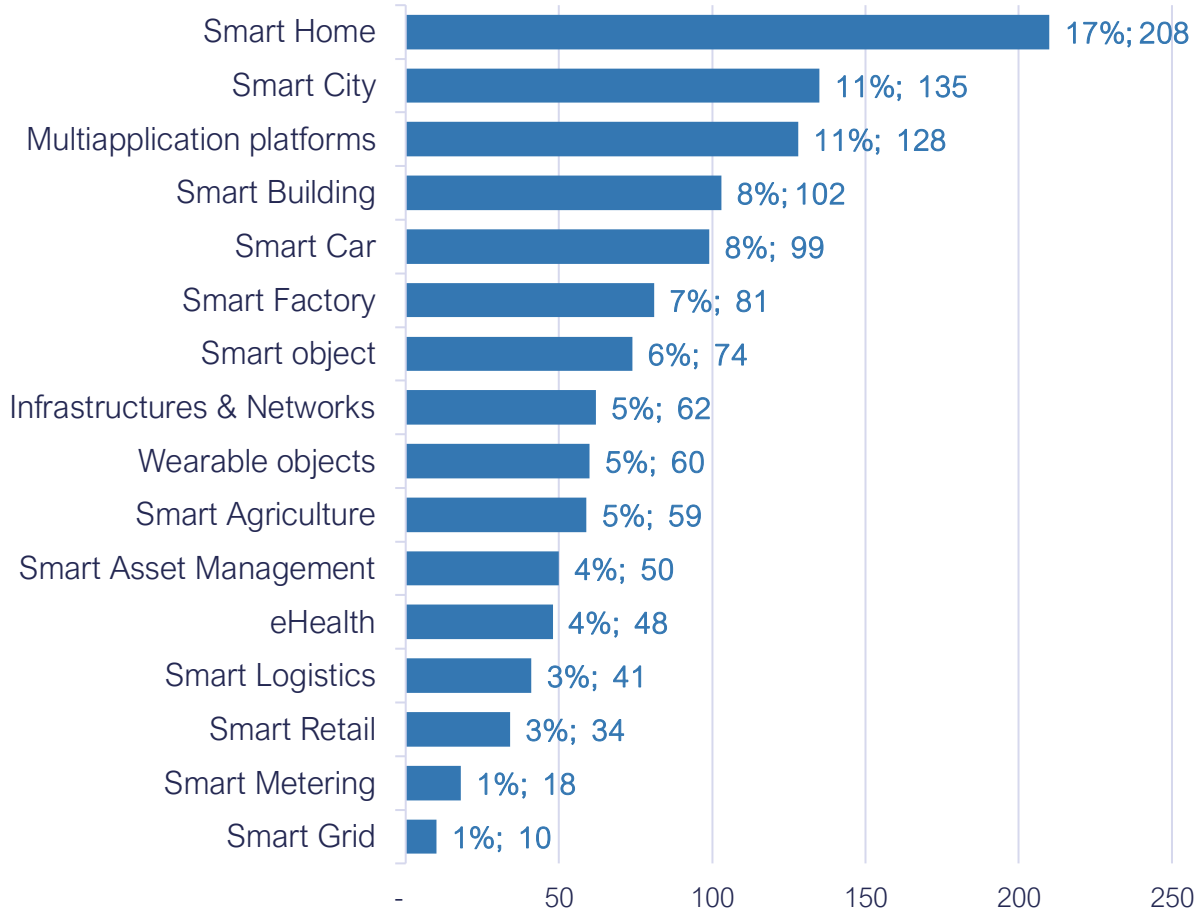

Figure 17. Distribution by field of application. N: 1208 startups.

Another interesting field is Smart Car, which, in the same period, has registered a growth of 78% CAGR. It is the highest growing rate out of all fields.

A deep dive into the different functionalities of Smart Home, Smart City and Smart Building is done further on, to understand not only the specific trends inside each field but also to see some examples of why these trends are so representative in the modern world.

Nonetheless, when segmenting the companies in order to understand what the tendencies in this industry are, we must consider all relevant variables related to it. Not only is the field of application important but also what type of customer is targeted and through which kind of offer. The first one has been addressed with the previous chart and analysis.

3.4.2 Type of offer

To analyze the type of offer as well as the targeted customer, the following charts were made. The first one (Figure 18) displays the distribution based on the type of offer. This is related to the description given in the previous chapter which includes Hardware (HW), Software (SW), Service and Network offering, as well as a combination of those.

It is visualized that more than half of the startups (56%) offer hardware and software bundled together and out of those, 22% includes some sort of service apart from the others. Hardware and software offering can easily be combined because of the relative simplicity to develop a mobile application to complement the physical product. Simplicity not only in the development phase of the app but also the reachability of such apps as the Smartphone industry has very high levels of penetration into developed and emerging societies. In fact, this penetration has done nothing but increase in the last ten years, especially in the first half, where units' shipments were increasing at a +30% YoY average in the period of 2010-2015.[31] Nowadays it has slowdown a bit and it is back to single digits growth, but the addressability of the market has still maximum levels ever.

[31] Fehim Duzgun, Gonca Telli Yamamoto | *The Effect of Promoter Incentive to the Smartphone Sales in Retail Chains: a Turkish Case, January 2016*. DOI: 10.4172/2162-6359.1000382

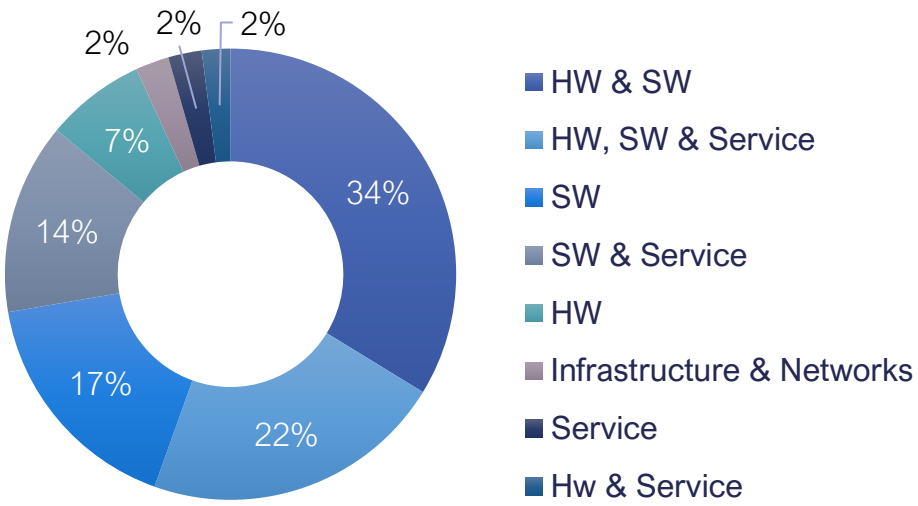

Figure 18. Distribution of startups based on type of offer. N: 1208 startups

We can also discern that hardware does not have to be included in every offer, as companies offering just software or software plus an added service represent a significant 31% of all startups. This can be understood as companies that leverage on current smart products that people already have to complement and provide an additional service with them, making the purchase process easier for the customers and without having to do any physical installation or additional process. *Veego* is the prime example of it. A company that has raised over $5M and works by scanning all the IoT connected devices to the same network and detecting possible bugs, malfunctions, threats or anomalies. It doesn't require any extra installation and provides an answer to a need that IoT has created. So, not only is the IoT offering solutions to previous

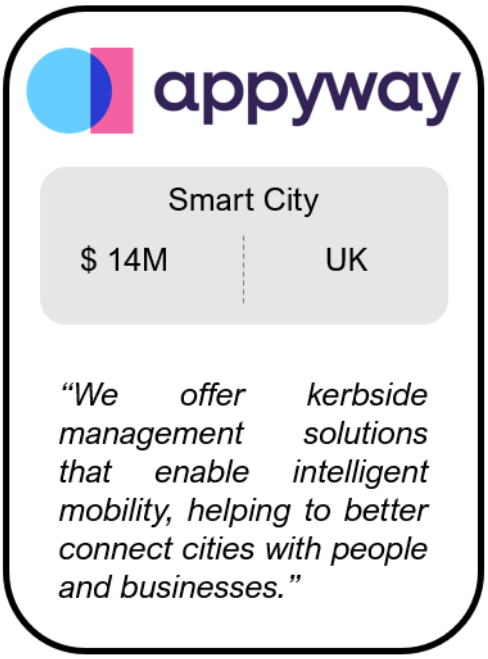

Figure 19. AppyWay startup information card

problems but it also creates extra ones that must be answered as well.

Moreover, there may be service offers that don't even require a physical object to function and leverage on existing technology or available information to fulfill the purpose. A representative company for this second group could be *AppyParking,* now renamed as *AppyWay,* a company that has raised over $14M and work on pushing their technology and offer for smart cities development. It combines different solutions regarding parking management like, between others, finding available spots and enabling direct payment, per minute, through the phone saving time and money for the users.

3.4.3 Target market and customer

The last variable to consider, after the field of application and the type of offer, is the targeted customer. Again, this is following the segmentation that the database has and that is explained in the previous chapter. As seen in Figure 20, the vast majority of companies aim at B2B & B2C (95% of all startups). That is because very few ones dedicate their efforts to prepare some type of product/service to a point where it has to be finished or redeveloped by other users. They mainly produce something already usable and fully functional, and even though some type or readjustment might be needed it usually is included with the offering itself. Since B2B englobes not only companies, but any large organization or group of stakeholders benefiting from a solution, it is reasonable to see half of all startups being aimed at that segment. B2C only, being the 30%, are startups offering solutions to only end users. However, most of them can also be escalated to enterprises and companies, which would make them fall in the B2B & B2C category (15%).

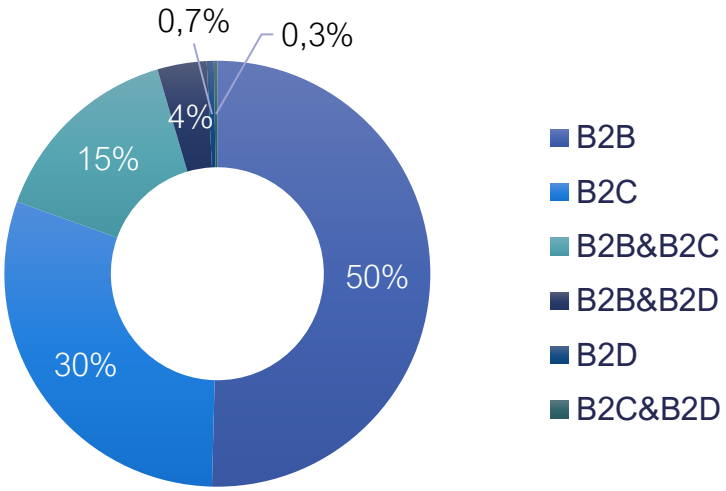

Figure 20. Distribution of startups based on target customer. N: 1208 startups

Having done the first level of analysis based on the type of market and offer, the next step is to look at investment and funding behaviors. This is performed in the next section of this chapter.

3.5 FINANCIAL ANALYSIS

This section is aimed at evaluating the situation and its evolution from a financial perspective. Startup differ in many ways from traditional and well-established companies. As we have seen, they tend to incorporate a more dynamic and juvenile culture, which is, in many cases, the key to their success, as they are capable of pivoting and reconducting quickly and successfully. However, they also differ in the financial and funding characteristics. While large companies can leverage on their own profits to reinvest in the companies, startups rely highly in the funding they receive and the investments they can attract. For many years they will be just an expense structure, until they can successfully monetarize their offer and eventually start making profit to pay back all the investments.

Nowadays, it is a very competitive marketplace, where a lot of new companies compete for the same investor's resources and they must convince them to allocate those into their companies. This is one of the peculiarities that end up linking funding received with success and profitability.

Those companies with better offer, business model and messaging are the one getting the money. And if they work in a very crowded market, where a lot of opportunities are emerging thanks to the IoT, it will mean that a lot of startups will also emerge on that sector.

We can conclude that the more money one sector or industry receives, the more chances there is of profitable success and therefore, profitable future for the company and their investors.

To perform this analysis, data had to be limited to those companies that received funding. Thus, from the total amount of startups used in the previous chapter, 223 companies where removed, and the total left is 985 startups, as it has already been explained in the database introduction.

It can seem that there are too many startups that had been left out for this part, while they were included in the previous. The reason being, is that there are a lot of new additions to the database from this past 2019. Many of those haven't received funding yet. In fact, of all companies without funding, almost 30% of them were founded in 2019, which means that they may need some time to finally receive funding. However, the fact that they have been created, their geographical origin and even their offer is still significant because helps to underline the relevance, and trend, of certain parameters.

3.5.1 Geographical overview

To begin with, it is interesting to see if more startups equal more funding. May seem as obvious but with this type of researches is necessary to substantiate every assumption so every affirmation has its data-based proof.

To corroborate the stated premise, geographical funding distribution should have a similar comportment than the company distribution. Figure 21 shows the funding distribution by continent. Comparing it against Figure 12 in the previous section. There is no doubt in confirming that more startups equal more funding. North America has 50% of the funding and 47% of all companies. Europe has the biggest difference with 33% of all funds and 38% of companies and, last but not least, Asia is practically identical with 15% of total funds and 14% of companies.

We can clearly state that number of companies have a direct relation with funds received.

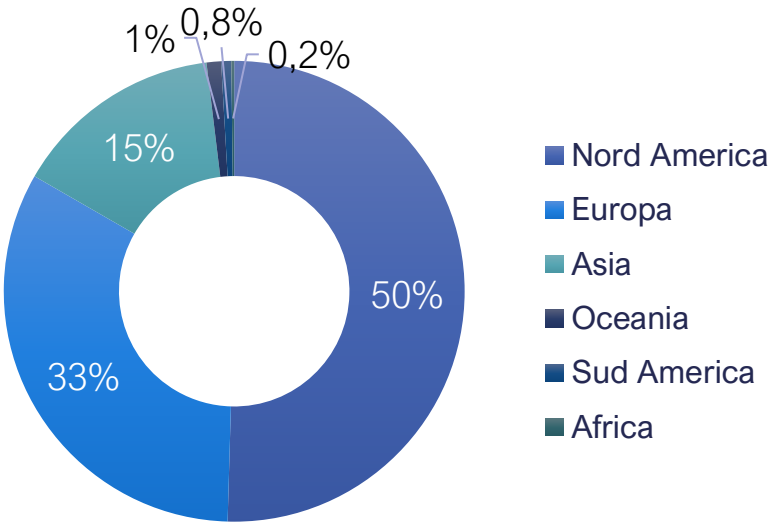

Figure 21. Funding distribution by continent. N: 985 startups

Once we have made clear that the more startups there are, the more funds are destined towards the industry, the following question would be: *how are funds distributed?*

3.5.2 Funding evolution

Let's start by understanding the evolution of funding received through the last years. The database has different fields in which it specifies the amount each company has received each year, from 2013 to 2019, both included. With those, the requested information can be easily displayed (Figure 22). It shows not only the total amount, which is the main interesting metric, but also average and maximum amount. Both numbers can be used to complement the information, making sure there are no anomalies or distorting factors considered. Or, in the case they are being considered, to have awareness of them.

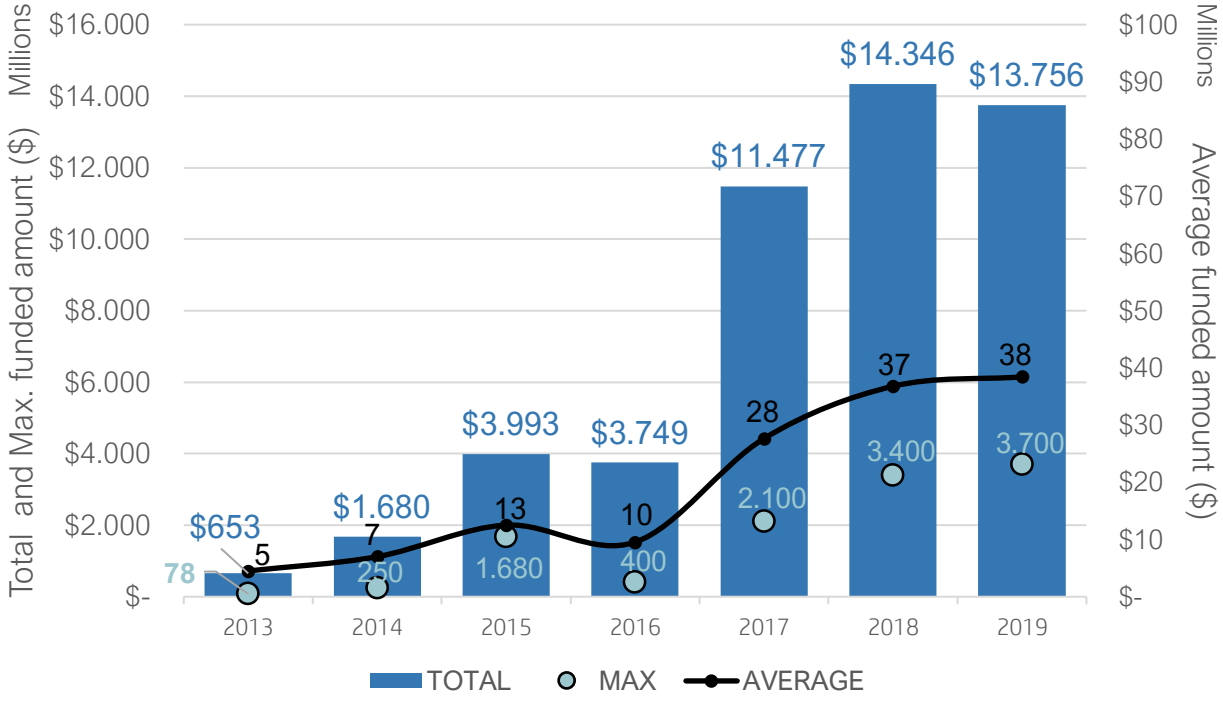

Figure 22. Funding evolution over time period (2013-2019). N: 985 startups

Three main highlights are to be extracted from this chart. First one, is the increasing tendency. It has a CAGR of 66% during the registered period of time. This amount of growth in less than 10 years really shows the outburst this market has had. To have a fair comparison, when talking about established companies, they are usually aiming at

a CAGR of between 5-10% for it to be considered a successful and rapidly growing industry. IoT has been growing six times faster than that. Granted it is a relatively new industry and that is what is expect from such a disruptive and innovative technology.

Secondly, it can be seen that the average amount received by company has also been increasing. This indicates the interest IoT startups have attracted. Growing amount of funds is not related only to the growth of companies and offerings but also to the average amount is received by each startup.

Finally, the third main highlight is the total investment drop year over year registered in the years 2016 and 2019. Here is where understanding the anomalies inside the database is relevant. 2015 has a maximum investment value of $1.680M out of a total amount received of $3.993M by all companies together. This means one single company received 42% of the total amount. Same thing, even though it has less of an impact, is seen in 2017, 2018 and 2019, where companies have received individually a large percentage of the total.

For this reason, it was decided to look into the companies that caused this distortion and exclude them from the analysis, so that a fairer and clearer view was given.

It was decided to put the threshold for a company to be considered an *outlier* [32] at $1.000M. Meaning that every company that have received more than this amount with just one investment round was excluded from the analysis. Here is the list of companies found and their investments over the threshold, Figure 23.

[32] Outlier is the term used to reference these companies that were extracted for further analysis

Company Name	Year	Investment
Lyft	2015	$1.680M
Lyft	2017	$2.100M
Farraday Future	2017	$2.013M
Ofo	2017	$1.150M
Fair	2017	$1.016M
Cruise Automation	2018	$3.400M
View	2018	$1.100M
Tenglong Holding Group	2019	$3.700M
Rivian	2019	$1.550M

Figure 23. List of companies classified as outliers

The logical next step is to see how Figure 22 would be seen without the eight *outliers* from Figure 23. This is displayed in Figure 24.

It shows now a more normalized behavior. The average and total values are now increasing every year at a steady rate and it doesn't seem to be any big distortions.

CAGR now is at 59% (vs. the 66% seen previously), while the average is also growing at a CAGR of 37%. Maximum values now represent less significant percentages out of the year total.

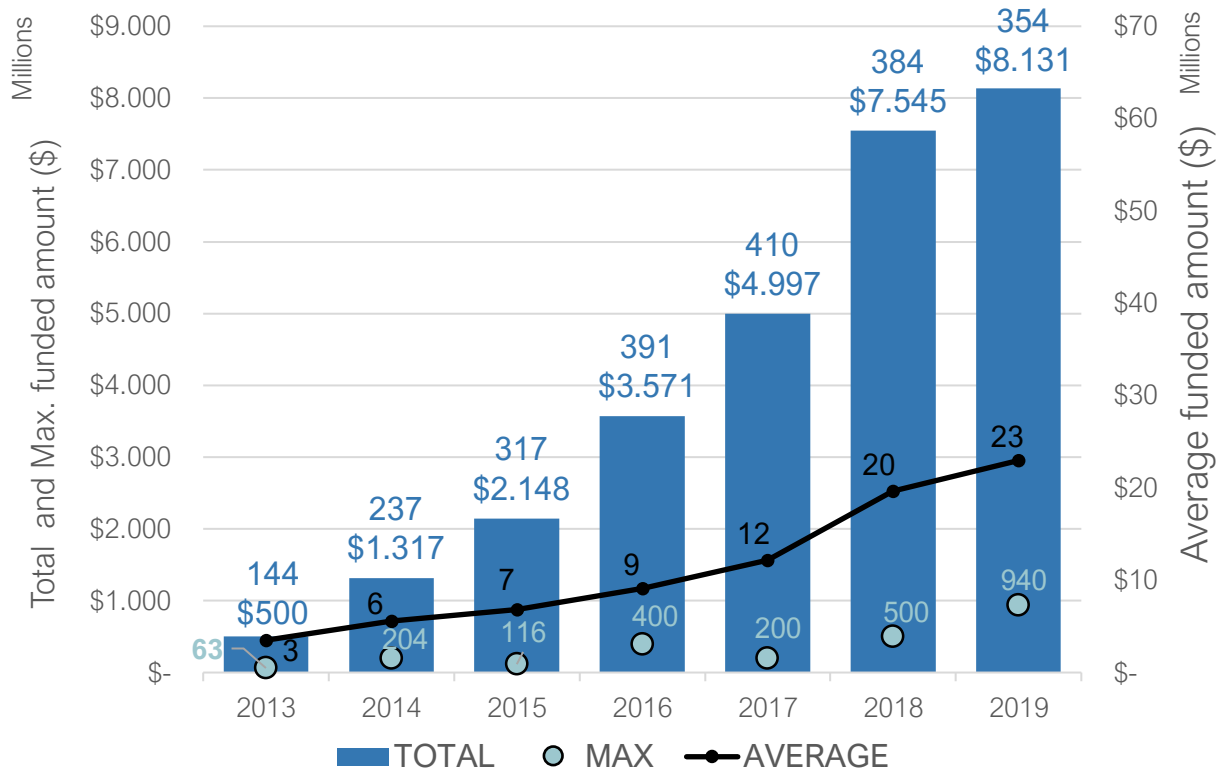

Figure 24. Funding evolution without the outliers). N: 977 startups

Another variable considered and added to this chart is the number of startups that receive funding each year. The value is written on top of each column. It had been growing in the first years, during the appearance and initial growth of such industry, from 2013 to 2016. However, it has stabilized in the following years between 350-400 companies per year. It appears that this market doesn't absorb more companies being funded. Despite that, total investment amount is still increasing as average per company also increases.

3.5.3 Funding distribution by field of application

When talking about the investments and how are they distributed, understanding the evolution they have had during the last years helps understand how fast the industry

is moving. Nonetheless, there are other ways to look and funding that could bring meaningful insights to the overall research.

As we have seen before the distribution of companies depending on their field of application, it makes sense now to set that point of view also with the total amount of investments per company.

For the purpose of getting the most reliable information from a standardized behavior without considering outliers, next studies will be done following the criteria of the 977 startups, that is meaning the non-inclusion of the 8 startups mentioned before.

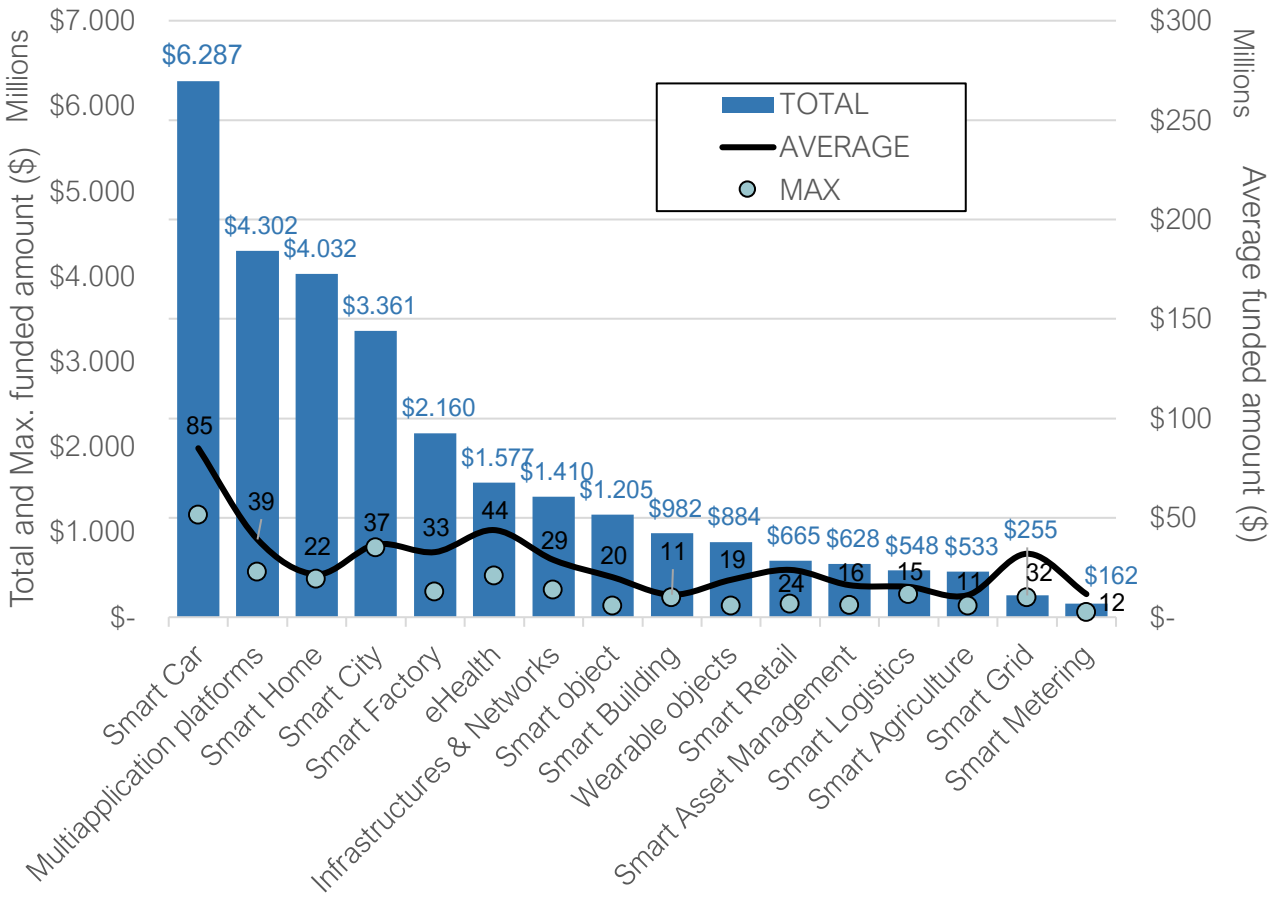

Figure 25. Funded amount by field of application. N: 977 startups

Smart Car is the most popular category, as it has a difference of about $2Bn. with the second place (Multiapplication platforms). There seem to be no relevant outliers when

checking the maximum values. However, when looking more in detail we discover the fact that in 2019 there have been three big deals for Smart Car companies. Those are: *Nuro* receiving $940M, *Byton* with $500M and *Aurora* with $600M. Without having one single company that could be classified as an *outlier,* based on the threshold set in the previous section, there are a few that have received large quantities in just one year. This can be considered as an increase in the popularity of the field and it's eventually translated into money invested into it.

This industry has a role model to look up to and it's Tesla. Tesla has become the most valuable US car automaker company surpassing Ford Motor Company or Company [33]. Truth is Tesla does not only sell cars, as it has also value coming from their batteries and solar powered systems, but it cannot overshadow the fascinating achievement that is to have surpassed a 100-year-old company with less than 20 years of existence. Tesla is the pioneer of the Smart Car model. Not only is it enabling cars to have "Smart capabilities" like internet connection, self-parking systems, etc., but also autonomous driving and continuous software updates like any regular smartphone. All of it without overlooking the ultimate purpose of a car and the security requisites it has to have. It is the role model definition and integration of Smart Car and IoT capabilities. This is evidence that this industry is set on the right track and growing relevance year by year.

There are a two more main insights than can also be extracted from the data representation in Figure 25. Firstly, is the presence of Smart Home and Smart City in the top five, which confirms once again that high numbers of companies from one same application bring high investment values to that field. Secondly, is the second position of Multiplication Platforms. This category is presented as the offering of a certain platforms that enable control or operation of multiple connected devices with the same interface. It also englobes applications or products that serve for more than one purpose or objective. This goes along with the fact that IoT is a big and interconnected network that offers multiple possibilities, for now only limited by the imagination of users and developers to build such capability. So, all things considered,

[33] Markets insiders | *Tesla is now the highest-valued* automaker *in US history*, accessed February 2020. https://markets.businessinsider.com/news/stocks/tesla-stock-price-rally-most-valuable-us-car-maker-history-2020-1-1028804022

it's reasonable to have this category in the second place, as the scope in which it operates has not reached its full potential yet.

If we were to look at the pareto chart of the funding by field of appliaction (Figure 26), we would see that 80% of all funding is captured by the following: Smart Car, Multiapplication Platforms, Smart Home, Smart City, Smart Factory, eHealth & Infrastructures & Networks. These are all the categories that collect, each, at least 5% of all investments. As a matter of fact, 50% of all the money ever collected is captured by just the top three: Smart Car, Multiapplication Platforms and Smart Home.

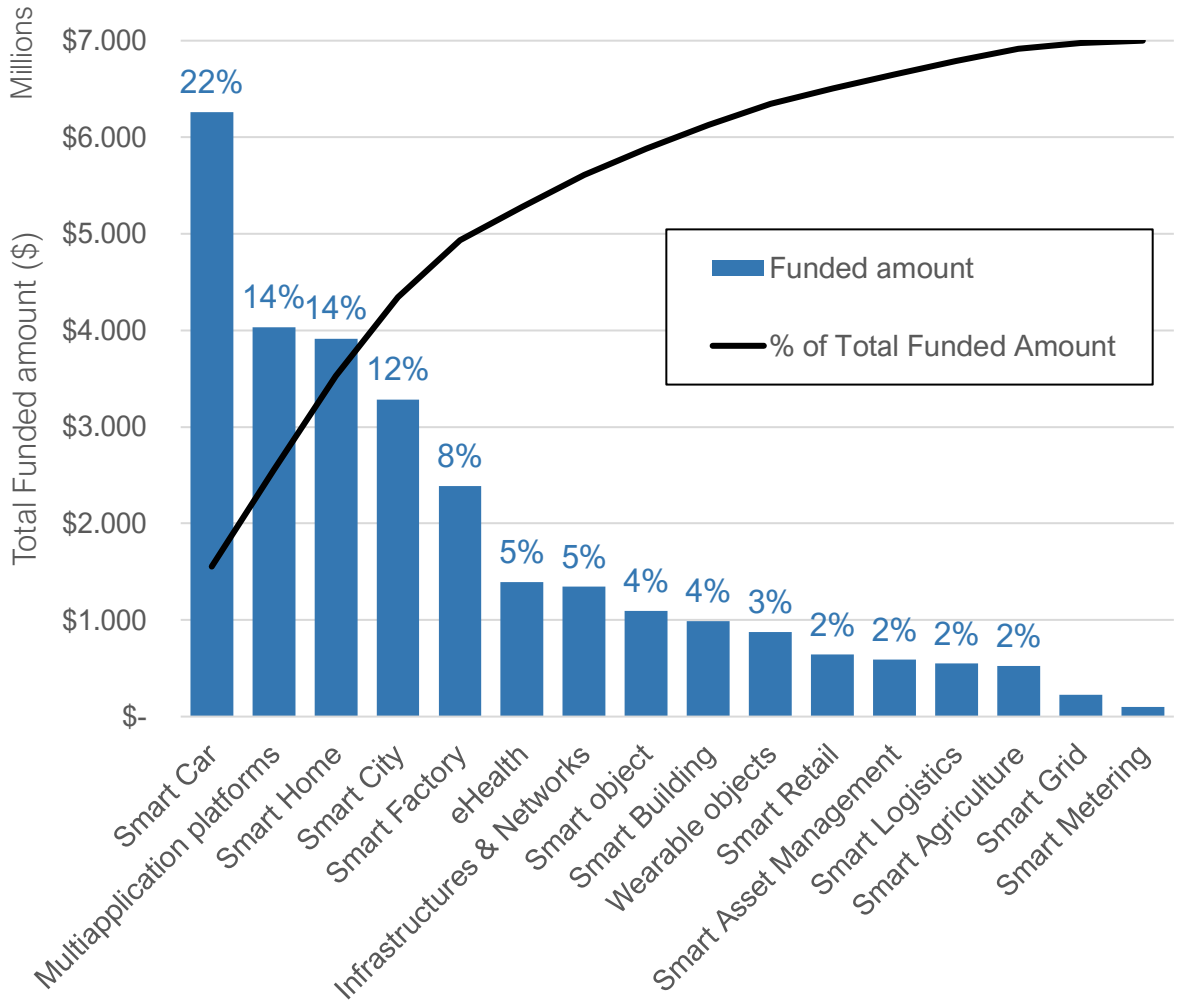

Figure 26. Pareto Chart of funded amount by field of application. N: 977 startups

From one side we have seen the evolution of total money received by the whole industry and from the other the distribution of such funds between all fields. It may be interesting to stay halfway across both views and study the evolution of funding of each category. Looking at a year by year evolution, may be hard to have a clear visual data representation. For this reason, it was decided to group years into three periods to evaluate changes between those time periods[34] (Figure 27).

It is clear also that the ones growing the most are Smart Car, Smart Home and Smart City, especially Smart Car in the third period. Again, goes along with the analysis performed in previous chapter on how it has gained popularity in the recent years.

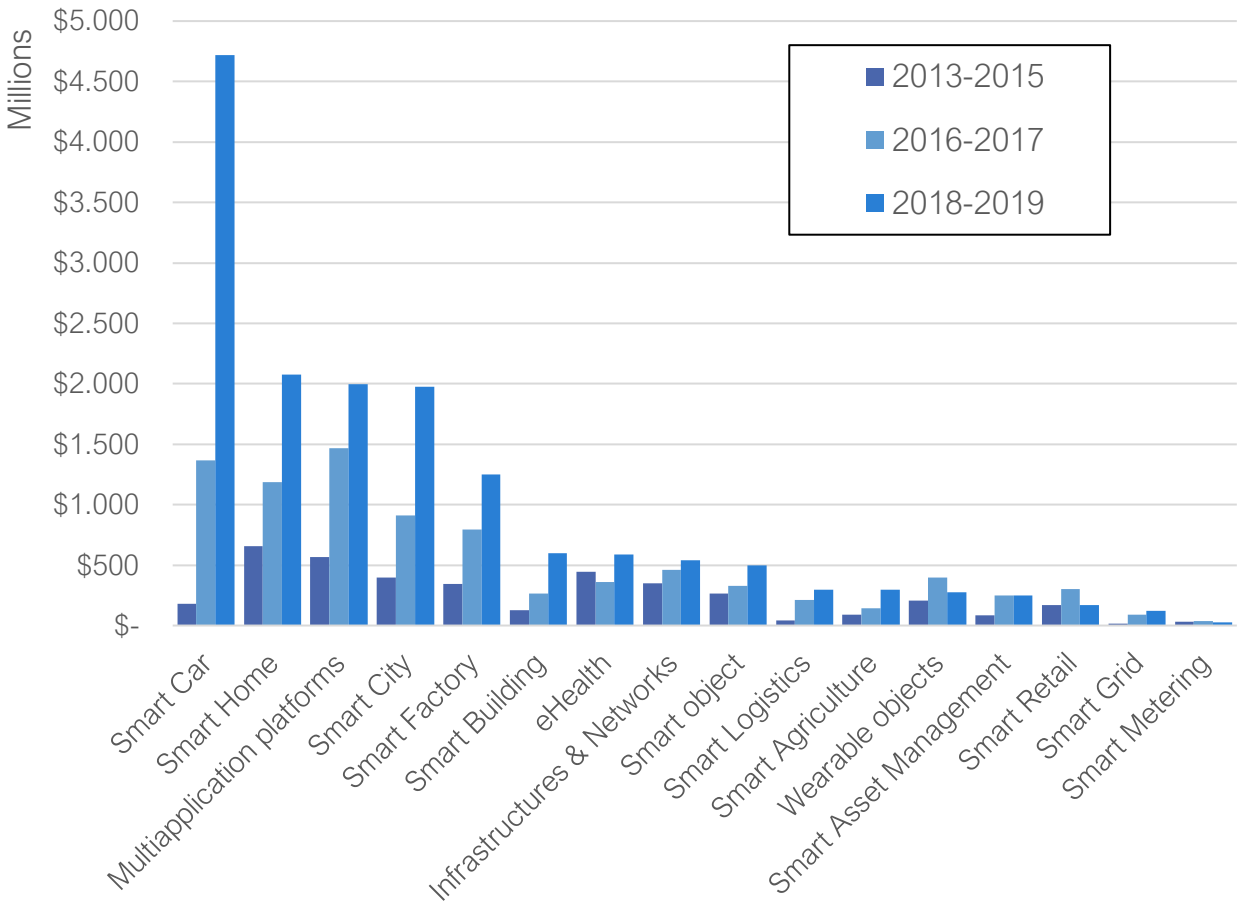

Figure 27. Evolution of funds by period and field of application. N: 977 startups

[34] Period 1: 2013-2015. Period 2: 2016-2017. Period 3: 2018-2019. Considered three years for the first period, as there is no even number of years with data, and the initial ones have brought significantly less investment than posterior years.

It is interesting to see how some of them have maintained the level of growth period over period (p/p[35]), and some of them have slowdown significantly. i.e. Wearable grew 91% p/p and then it dropped to -30% p/p in the following. Smart Retail has done something similar, with a growth of 79% p/p followed by a drop of -44 pp.

In other cases, instead of dropping massively, funding just stayed flat, maintaining same levels. For example, Smart Asset Management, where initially grew 190% to later maintain same levels of funding and gaining 0% p/p. Also, Infrastructure & Networks, has grown period over period for two periods consecutively at the same rate. However, it has not grown in the same order of magnitudes as other fields (32% & 17%). This underlines the fact that IoT disruptive innovation doesn't come with huge change in the internet and network infrastructure, granted it demands an improvement and continuous development, but it comes from adjusting other types of applications to what already existed. It is not about adjusting the "*internet"* to the "*things"*, but the "*things*" to the "*internet*".

3.5.4 Investment type by field of application

We have seen until now how the funds are distributed along each field of application. It is clear not only which fields receive the more funding, but also what is the average per field as well as the maximum amount. However, it could be useful to have a look at what is the most common type of funding that each field receives. This can be done by segmenting the amount of money a startup is given into different groups and analyzing them. The goal is to understand where the funding is concentrated, meaning how big are the investments each startup receives based on their field of application.

To have a clear perspective on the relative differences between each field, the way to proceed is to segment the funding into percentiles, considering all funding without differentiating field of application. Then, use that percentile segmentation to see where

[35] p/p stands for period over period. Not to confuse with pp, being percentual points.

each field of application fits in. This way helps to visualize and easily understand, with a general view, how representative and large their investments are.

If we were to represent how all the funds are distributed, we would see that they behave following the long tail theory, where most of companies receive small amount of money, while there are a few that receive large ones (as shown in figure 28).

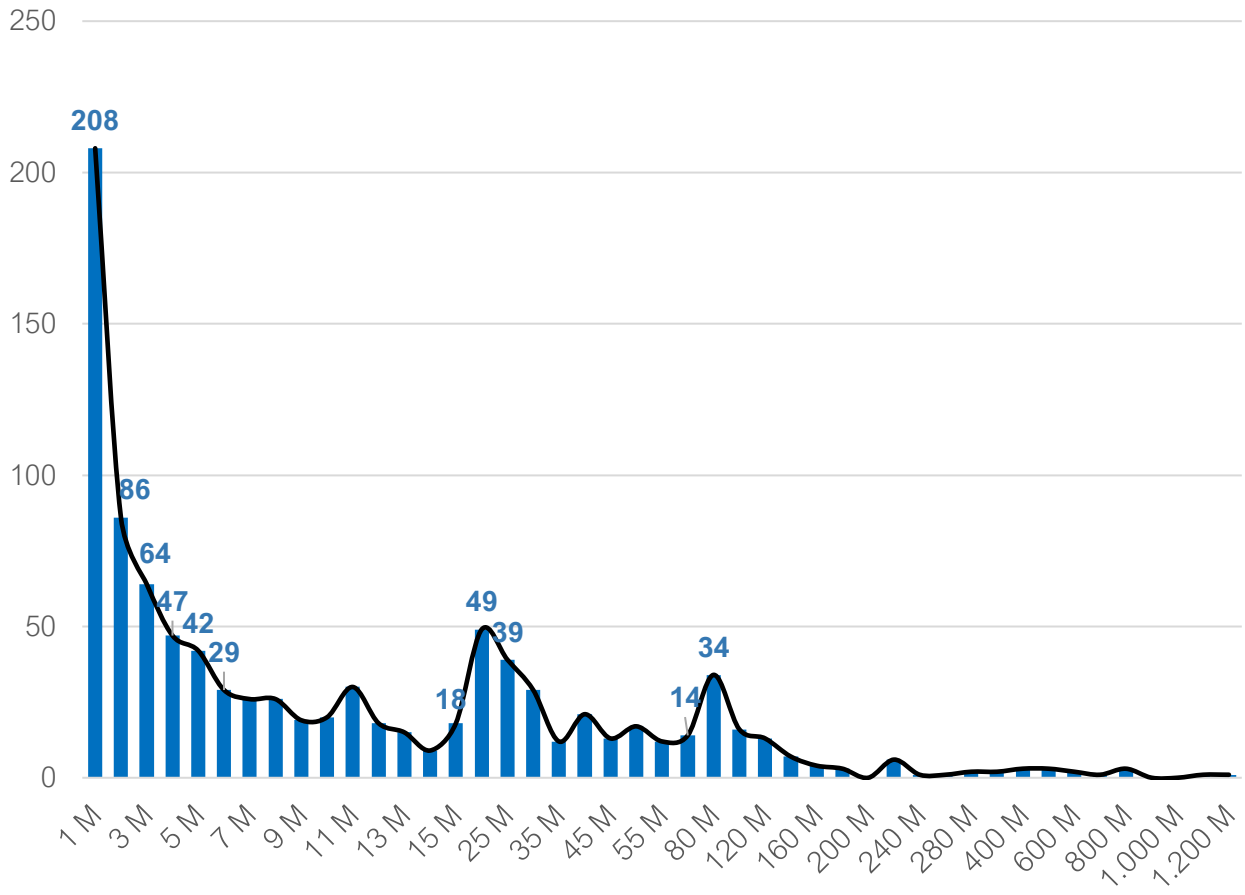

Figure 28. Distribution of companies based on $ received. N: 977 startups

To proceed as explained before, all funding in the last 7 years (2013-2019) has been taken into consideration. The percentile division is set to 20%, this gives us five equally distributed segments. Considering the previous figure, it is clear that the segments are going to be concentrated in the left part of the graph, as the final area of the tail (large investments) has low amount of companies. The final segmentation and the boundaries values are shown in the next table (Figure 29).

Segmented group	Percentile	Limit Values
1st	20th	$0 - $ 960k
2nd	40th	$960k - $ 3.6M
3rd	60th	$3.6M - $ 10.6M
4th	80th	$10.6M - $ 30M
5th	100th	$30M - $ 1200M

Figure 29. Percentile distribution of the funding. Total: 977

Field of Application	1st	2nd	3rd	4th	5th	Total %	Total #	Total $
eHealth	14%	25%	14%	8%	39%	100%	38	$ 1.394M
Smart Factory	18%	14%	18%	17%	33%	100%	66	$ 2.389M
Smart Car	13%	23%	20%	13%	32%	100%	71	$ 6.121M
Infrastructure & Networks	8%	12%	24%	29%	27%	100%	49	$ 1.34 M
Multiapplication platforms	12%	16%	20%	24%	28%	100%	109	$ 4.032M
Smart Retail	7%	22%	19%	30%	22%	100%	28	$ 641M
Smart Asset Management	13%	33%	23%	15%	15%	100%	40	$ 588M
Smart Logistics	15%	27%	30%	21%	6%	100%	35	$ 548M
Smart Grid	25%	25%	38%	0%	13%	100%	8	$ 229M
Smart Home	20%	23%	20%	21%	16%	100%	182	$ 3.915M
Smart Agriculture	25%	29%	15%	25%	6%	100%	49	$ 527M
Smart City	26%	16%	20%	20%	18%	100%	91	$ 3.284M
Smart object	28%	8%	25%	23%	15%	100%	61	$ 1.091M
Wearable	26%	26%	11%	19%	19%	100%	49	$ 878M
Smart Building	33%	19%	22%	16%	10%	100%	86	$ 986M
Smart Metering	43%	21%	14%	14%	7%	100%	15	$ 97M
Grand Total	**20%**	**20%**	**20%**	**20%**	**20%**	**100%**	**977**	**$ 28 Bn**

Figure 30. Percentile distribution of funding by field of application. N: 977 startups

Figure 30 shows the distribution of the funds based on the segmentation explained before. It helps visualize which field have higher amounts of investments. eHealth, Smart Factory and Smart Car lead the list with over 30% of all investments in the highest percentile. On the other hand, Smart Metering, Smart Building and Wearable objects fall into the smaller categories.

Different interesting aspect come from analyzing this table. First of all, we can see how the most growing field (seen in Figure 27) are also on top of this list, for example Smart Car and Smart Factory. We can also include in the top invested list the Infrastructure & Networks application. All the above mentioned are examples of applications that require large amounts of investment to successfully develop and deploy their offerings. So, it's understandable that the investment gathered by each company falls into the large groups. In comparison, other applications growing significantly like Smart Home, Smart City and Multiapplication platforms may not require such big investments to implement their solutions, thus, investments fall into smaller amounts

3.5.5 Acquisitions

The next and final topic of analysis for the financial parts of the research must be acquisitions. Acquisitions represent the exit phase of a startup. Most of them may be acquired by larger companies to leverage from their technology and innovations, while for others may be just the end of the road.

Out of total startups in the database 1405, there are a total of 112 acquisitions registered. They are all represented in Figure 30 with the total value of the acquisitions of each field. Bear in mind that there is some information related to the acquisition that is undisclosed so, the amount of money only represents the acquisitions that have revealed their real transaction value. For this reason, that there may be some anomalies like the super low value from the Smart City field or the ups and downs of the black curve that should be ideally declining.

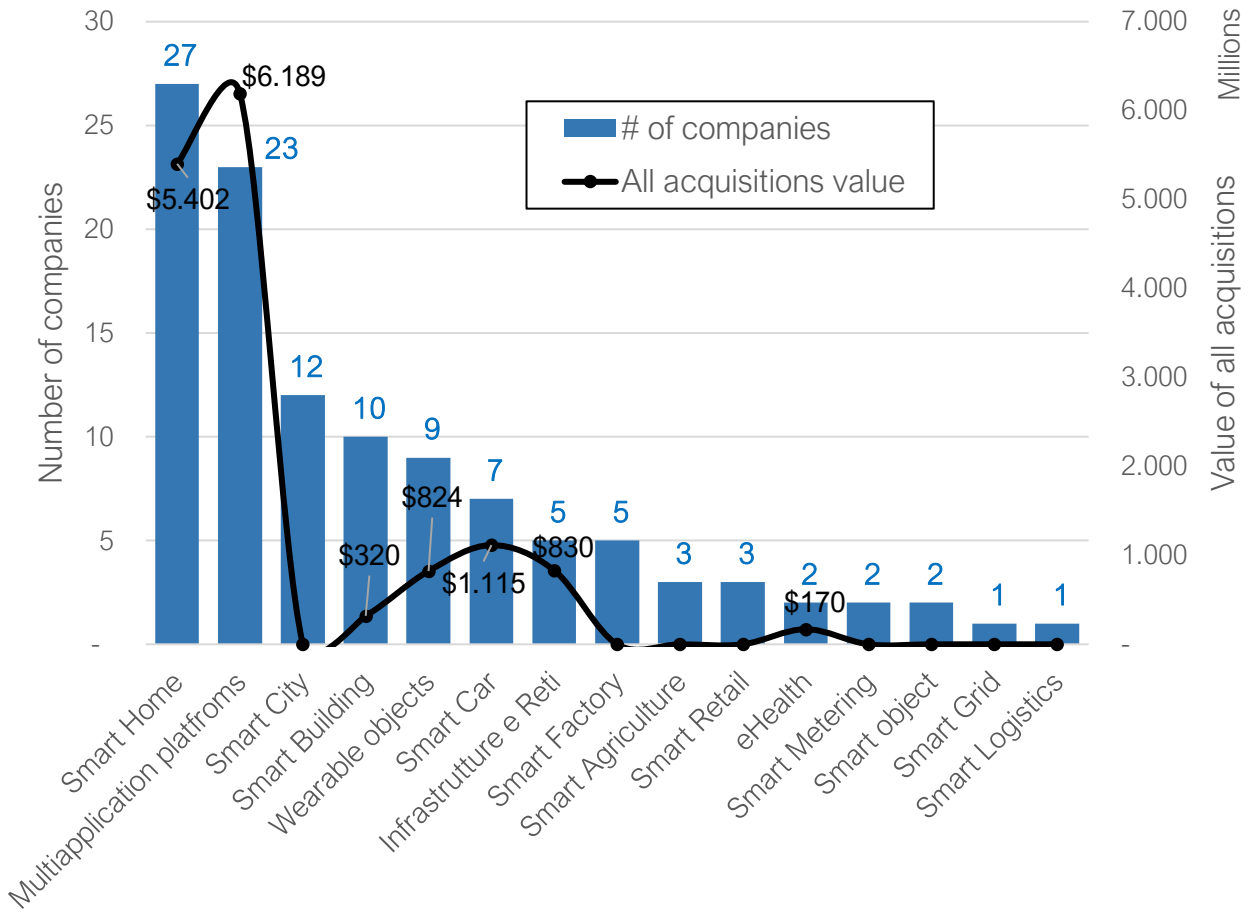

Figure 31. Number and value of acquisitions by field. N: 112 startups

Nonetheless, the number of acquisitions is still correct. With them, we can again see the predominance of fields such as Smart Home, Multiapplication platforms and Smart City. Mainly because they are the ones with the most presence in the industry, but also because the type of applications they are developing might be the ones easier to absorb and implement in the structure and organization of larger and, sometimes, less flexible enterprises.

Figure 32. Ring startup information card.

A good example of that is the company called *Ring,* founded in 2013, and provides security systems for the Smart Home like doorbells, locks, cameras, etc. It was acquired by Amazon in 2018 for $1 Bn. Again, this type of company offers a product that complements perfectly current Amazon products it didn't require significant efforts for Amazon to build synergies.[36] In other cases, the acquisition sets the purpose of enabling the acquirer to leverage from self-build experience when trying to initiate in new activities or markets. *Relayr* is the example of it. The company, bought in September 2018 by Munich Re, was aimed at boosting the IoT strategy of the company.[37]

As mentioned before, startups are usually acquired by very large companies to leverage on their innovations at a lower cost that would signify dedicating the needed resources on their own. Looking at the acquirers of the 112 acquisitions (Figure 33), we will certainly recognize some names, as some of them are the largest IT companies at a worldwide level.

[36] Business Insider | *Why Amazon acquired Ring?* accessed March 2020. https://www.businessinsider.com/why-amazon-acquired-ring-2018-3?IR=T
[37] Relayr | *Relayr acquired by Munich Re to boost its IoT strategy*, accessed March 2020. https://relayr.io/relayr-acquired-by-munich-re-to-advance-its-iot-strategy/

Company	USD Expense	Company	USD Expense
Cisco	$5.101.200.000	Harman Int. Ind.	$154.000.000
Google	$3.200.000.000	General Electric	$153.000.000
Amazon	$1.090.000.000	Mars Petcare	$119.000.000
General Motor	$1.000.000.000	Sirius XM Radio	$115.000.000
Itron	$830.000.000	Alibaba	$95.000.000
Nest	$555.000.000	British Gas	$90.900.000
Intel	$400.000.000	Palo Alto Networks	$75.000.000
Munich Reins.	$300.000.000	Direct Energy	$60.000.000
PTC	$282.000.000	Fitbit	$40.000.000
Fossil	$260.000.000	Huawei	$25.000.000
Acuity Brands	$252.000.000	SOMFY	$12.000.000
Electrolux	$250.000.000	Good Technology	$8.300.000
Samsung	$200.000.000	Telit Comm.	$8.000.000
Nokia	$170.000.000	Reply	$5.000.000

Figure 33. List of acquirers and money spent on all acquisitions

4. DETAILED APPROACH ON SMART HOME, BUILDING AND CITY

We have seen in the previous chapters the increasing relevance and predominance of the Smart Environments (Home, Building and City) primarily powered by the, almost exponential, growth of the connected devices, expected to reach 75 billion [38] by 2025. This will create endless possibilities for the current population to evolve into a Smart Society itself.

Smart Home is just the leading edge of a global technological transformation that is currently happening. But there is much more to it. The next steps, considering functional proximity, of Smart Homes are Smart Buildings and, ultimately, Smart Cities. Each of those can hold the same functionalities offered by the previous, while enabling other ones to appear or with another perspective.

Ultimately, the ease of use, affordability and convenience (relative to other type of applications) of some of those solutions boost their usage, making these applications the emerging trends that can have the biggest impact in how our current societies operate and evolve.

For this reason, this chapter aims at deep diving into those applications, trying to find the insights and observations that can exemplify the reasons of such predominance.

We will go through similar examinations and analysis that we have seen in the general overview of the previous chapter. It's necessary to highlight the second level of detail that it comes when analyzing such applications. As explained in the database description part of the thesis, there is a subgroup of field of application for Smart Home and Building and another subgroup for Smart City, based on the possibilities that each application can englobe with its solution.

[38] As shown in the first chapter; Figure 4.

4.1 SMART HOME

4.1.1 Smart Home functionalities

For the first segment, we will analyze the most common and significant out of the three: Smart Home. In this category there are registered 208 companies. However, and since we are also going to conduct financial analysis for them, we are going to consider the ones coming from the list of companies that have also received funding. This reduces the list to 185 companies under the Smart Home category.

The first chart to be represented is the number of startups in each subgroup inside the Smart Home field, as explained before, and its represented in Figure 34.

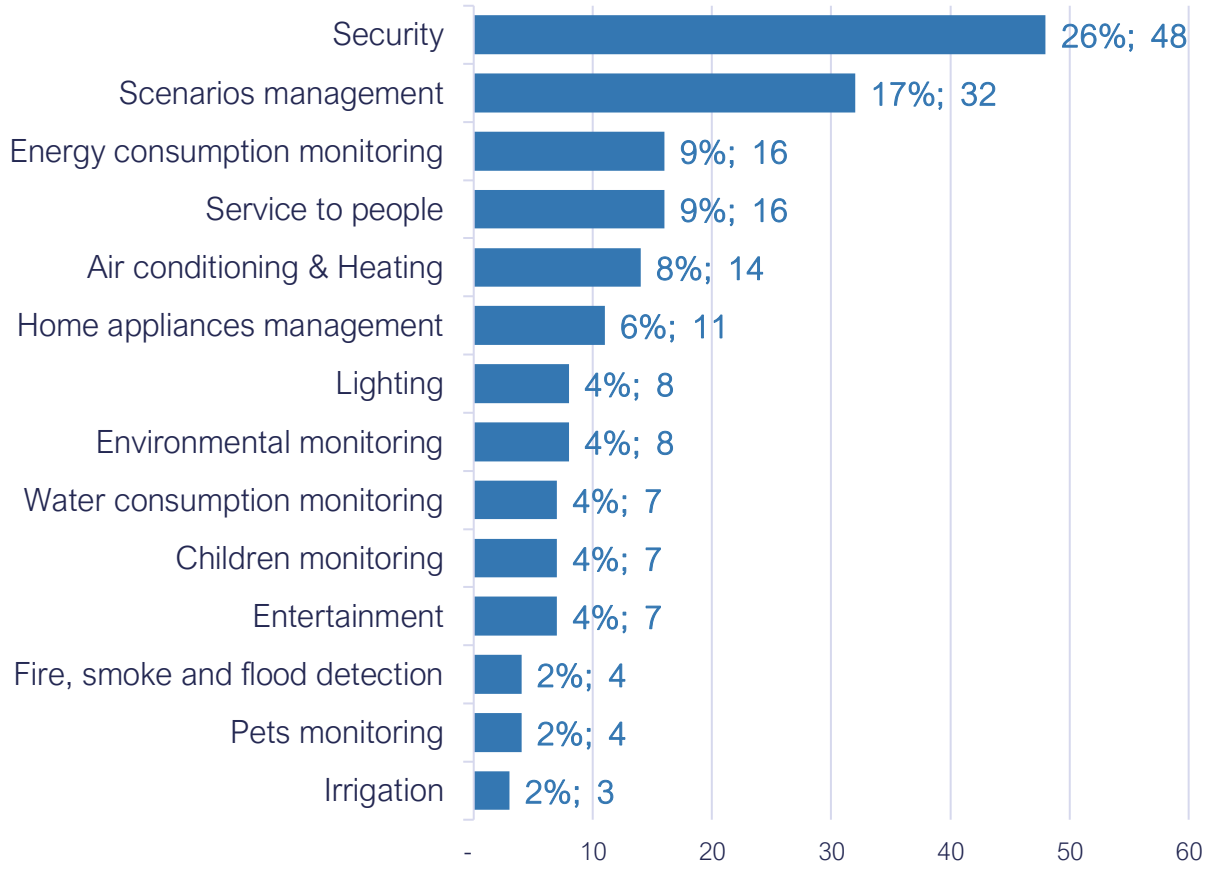

Figure 34. Smart Home functionality distribution. N: 185 startups

The most popular scope is *Security* with a 26% of all startups in it. This type of offer includes different solutions to ensure and increase security of the household. The most typical one is internet connected devices such as smart locks, doorbells and other type of accessories that provide security against intruders. *August* is a good example of this subset of applications; it offers smart locks and doorbells that can be connected and controlled with the smartphone. This type of solutions is very accessible by almost every user as it only requires internet connection, a smartphone and basic installations.

Figure 36. August startup information card.

On another hand, there are other type of security issues that can also be addressed, and it is surveillance and monitoring of movement inside or outside the house. Sometimes the most important thing when house break-in occurs is to identify the culprits. Cameras and sensors can help with this, complementing other security services like the first ones mentioned. *Orvibo* is the vivid example of this. It was founded in 2011, but it's still growing and collecting funds; last year has raised more than $19M. It's bunch of hardware and software solutions offer both smart locks and doorbells and surveillance systems. Moreover, and despite their main offering is, and has been, security systems, it has included in their product portfolio solutions related to scenarios management, the second most common type of offering.

Figure 36. Orvibo startup information card.

There is still another type of security issue, that has raised acknowledgement in the recent years, as the numbers of devices has also increased. The security of the IoT products themselves. Proved by a research paper this last year, some devices can be hacked and tricked into doing certain actions, like opening doors, without needing to be even inside the house.[39] This highlights the weak points of some connected devices as well as some of their ecosystems.

Some companies are starting to work on ensuring reliable connections. *SecuriThings* is a company that offers management of IoT devices, protecting them while also offering maximized operational efficiency. Even thought is a company that mostly aims at enterprises and operating a large scale of IoT devices, it is a clear example of the increasing concern that IoT devices' security represents.

In Figure 34 we can also see scenarios management as the second most common functionality (17%). *Scenarios Management* provide tools to create automated processes and activities when a set of conditions, provided by the user, are reached. In combination with smart devices (speakers, screens, lighting, etc.) can be useful to provide personalized services, like playing music, showing news notifications, changing the lights or adjusting the heating.

It is to be considered that even though there are specific fields for companies that focus on *Heating Systems*, *Lighting* or *Air Conditioning*, the scenarios management category englobes also those startups that can administer multiple of these solutions at the same time.

4.1.2 Smart Home geographic distribution

We have already discussed the overall geographical distribution observed when analyzing all startups. This section aims at comparing that view with the Smart Home view.

[39] Sugawara, Takeshi and Cyr, Benjamin and Rampazzi, Sara and Genkin, Daniel and Fu, Kevin | *Light Commands: Laser-Based Audio Injection on Voice-Controllable Systems*, 2019

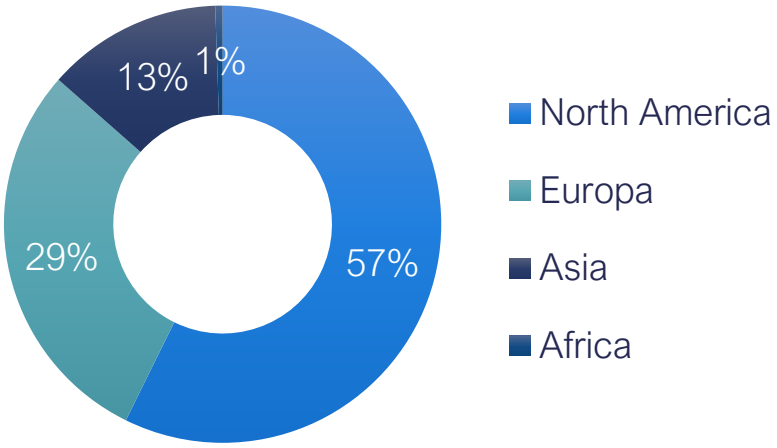

Figure 37. Smart Home geographical distribution. N: 185 startups

North America has the most predominance out of all continents as also seen when analyzing all companies. However, in the Smart Home market, the majority is accentuated, reaching a 57% (vs. a 47%). It seems to be all taken out from Europe, with a decrease from 38% to 29%, while Asia keeps approximately the same percentage (13% vs. 14%).

Considering that the overall population of Europe is around 160 Million larger than North America's, we can conclude that for, this applications, North American countries have a much more developed market as well as a much more solid demand for in-house Smart Home products than Europe.

4.1.3 Smart Home target market and type of offer.

The following evaluations to be done are understanding both the customer cluster and the type of offer dominant on this market. Again, these examinations are to be compared with the overall situation of all IoT startups. In that way, we can highlight where the differences are versus the general trend, and what is the rationale behind it.

First of all, the targeted customers. We have seen before that the majority of companies are targeted at business, with a 50% having a B2B business models, and another 15% combining B2B & B2C. For all startups, B2C only represented 30%.

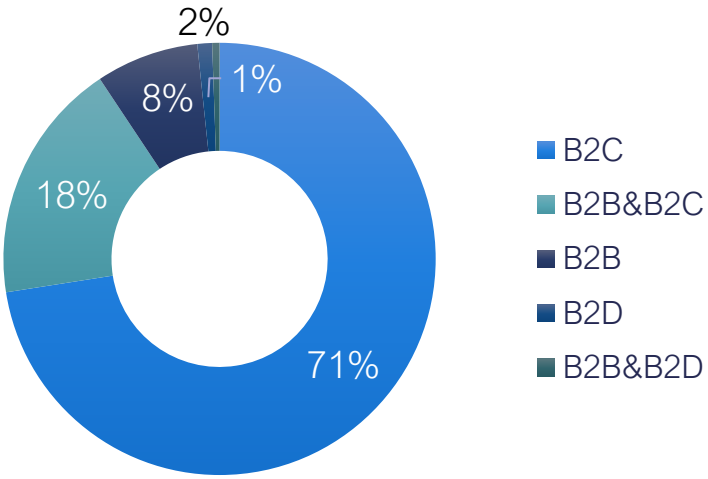

Figure 38. Smart Home targeted market distribution. N: 185 startups

For Smart Home, as represented in Figure 38, B2C now represents 71%, which is more than twice the previous representation. This highlights the main attribute of Smart Home products; they are conceived to be end user targeted. Distributed by large retail companies as well as online, the final customer can buy it, install it and start using it without any intermediary. The second biggest group of clients is a combination of both B2B & B2C, with 18% of all startups. This means that in reality there is only a reduced 11% of solutions that do not target B2C customers. This, once again, supports the stated conclusion.

The second analysis is to be made with the type of offer, shown in Figure 39. There we can see the notorious presence of HW solutions in this market, as 84% of all offers include some sort of physical device. Apart from that, other type of offerings can be served to complement it, like a software, a service or both of them together. The most used type of combination is accompanying the physical device with a software (45%), usually a smartphone application, as it usually has no big implementation costs for the

company and can enhance largely, the experience and capabilities of the combined offer.

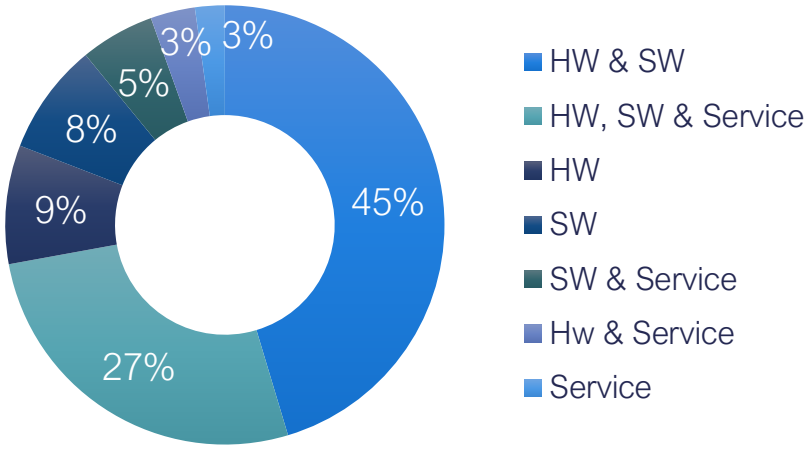

Figure 39. Smart Home type of offer distribution. N: 185 startups

Compared against the general overview from previous chapter, the main highlight is the accentuation of HW presence in the offers. Considering all type of combinations including HW, it has increased from 65% in all startups to 84% in Smart Home.

4.1.4 Smart Home funding and financial analysis

Once the first part of the analysis is conducted, regarding the segmentation of startups on different criteria. The next step is to conduct a similar financial analysis to the Smart Home sector,

For this analysis, and as mentioned before as well, the total of startups considered are those that have actually received funding and fall in the Smart Home category, being a total of 185.

To commence then, it is displayed in Figure 40 the evolution of the total investment gathered by these companies over the period of time from 2013-2019. A significant point to underline here is the non-presence of outliers in this field. Meaning there is no company that has received over $ 1Bn. in just one investment.

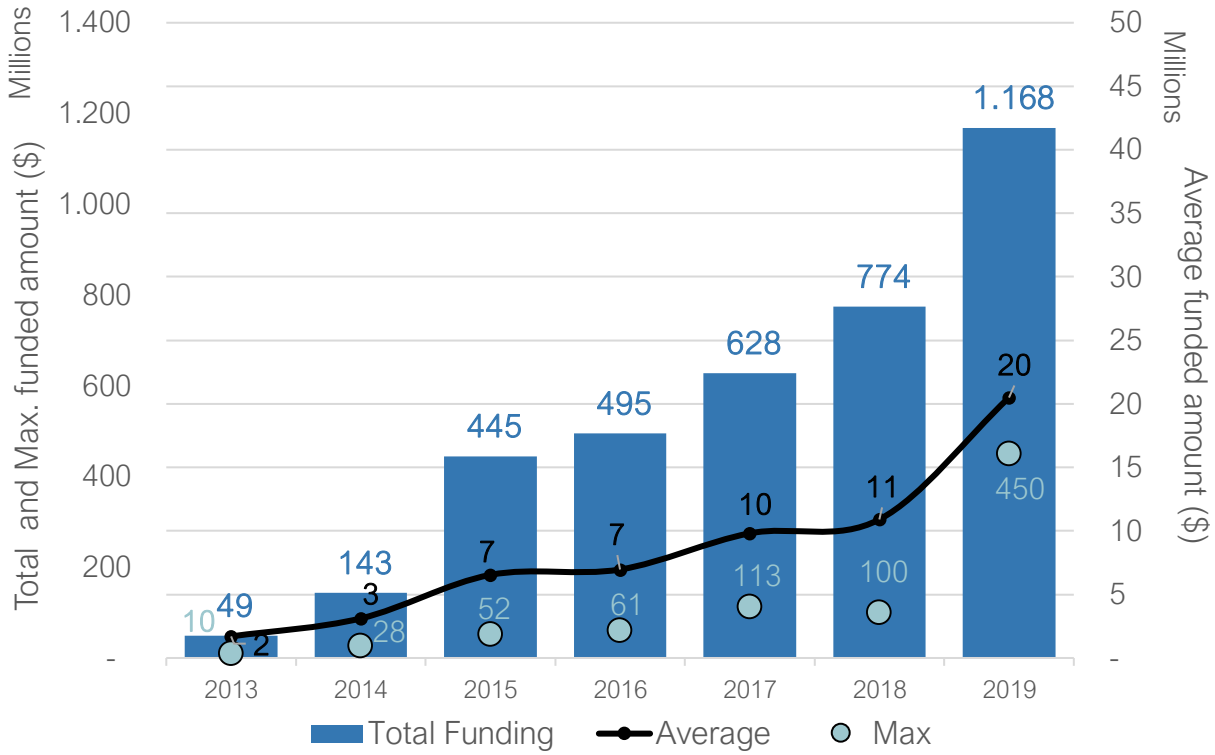

Figure 40. Smart Home funding evolution. N: 185 startups

It can be seen the same standardized behavior we also have seen for the overall analysis, with an increasing trend in both average of funding and total amount funded. The CAGR seen for Smart Home is a 69% for this period of time, which, compared against the 59% of all startups, shows a slightly higher growth rate for this sector. This also goes along with the previous conclusions extracted from previous chapters analysis, where we saw a larger growth in segments like Smart Home than in other fields applications.

If we were to look at the funding received by the subgroup of functionalities inside Smart Home (shown in Figure 41), we can see the so dominant position of security applications. We have seen both *Security* and *Scenarios Management* were the leading ones in terms of number of companies. The funding shows the same picture but with a larger dominance of security related funding.

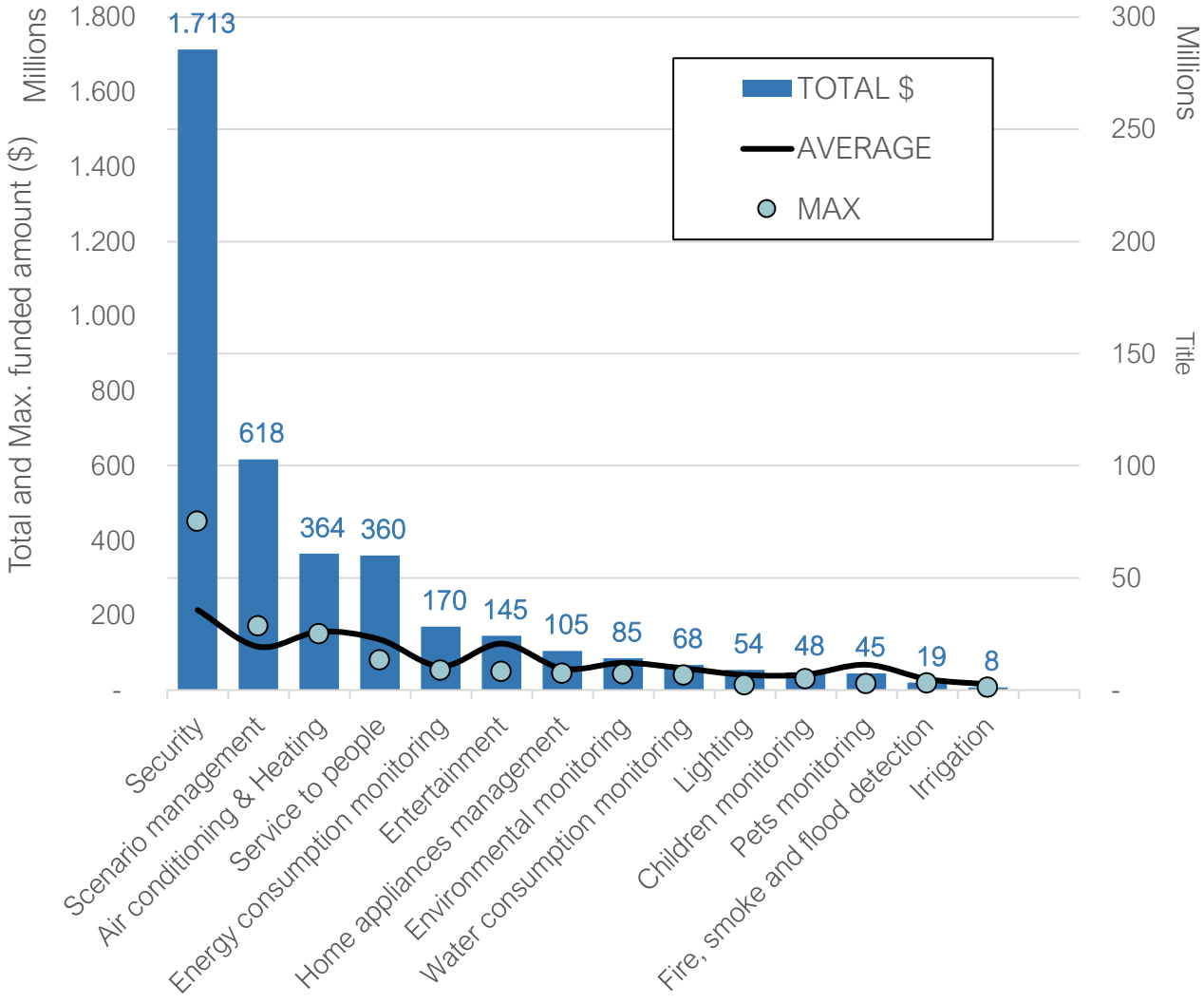

Figure 41. Smart Home funding distribution by functionality. N: 185 startups

Security captures about 40% of all funding destined to Smart Home applications. Which again demonstrates how this has been so relevant and so many companies have tried entering the market.

Lastly for the Smart Home sub-segment, it is also analyzed the distribution based on the type of investments received by each functionality type. Following the same criteria as in the same one for the previous chapter, the full list of companies and without separating by their application, five percentiles are set at a 20% division space. The distribution of each field of application is shown in Figure 42.

Field of Application	1st	2nd	3rd	4th	5th	Total %	Total #	Total $
Entertainment	29%	0%	0%	29%	43%	100%	7	$ 145M
Service to people	19%	6%	25%	19%	31%	100%	16	$ 360M
Air conditioning & Heating	14%	14%	36%	7%	29%	100%	14	$ 364M
Security	13%	17%	19%	25%	27%	100%	48	$1713M
Pets monitoring	0%	25%	0%	75%	0%	100%	4	$ 45M
Lighting	13%	25%	25%	38%	0%	100%	8	$ 54M
Children monitoring	29%	14%	43%	0%	14%	100%	7	$ 48M
Energy consumption monitoring	19%	19%	38%	6%	19%	100%	16	$ 170M
Scenarios management	19%	34%	16%	19%	13%	100%	32	$ 618M
Home appliances management	36%	18%	9%	18%	18%	100%	11	$ 105M
Water consumption monitoring	43%	14%	14%	0%	29%	100%	7	$ 68M
Fire, smoke and flood detection	25%	50%	0%	25%	0%	100%	4	$ 19M
Environmental monitoring	29%	14%	14%	29%	14%	100%	8	$ 85M
Irrigation	33%	33%	33%	0%	0%	100%	3	$ 8M
Grand Total	**20%**	**20%**	**20%**	**20%**	**20%**	**100%**	**185**	**$3,8Bn**

Figure 42. Smart Home percentile distribution of funding. N: 185 startups

It is worth mentioning the high positioning of the *Entertainment* sector gathering the majority of the investments (43%) in the highest percentile despite not being the largest in terms of investments.

Apart from that, the most invested categories are also shown in the top of the list here: *Service to People*, *Air Conditioning & Heating* and *Security*. However, *Scenarios Management,* despite being the second one with most funding, it gathers most of them under the $ 3M range, corresponding to the second percentile.

All things considered; it's understood the reach and relevance of the IoT Smart Home applications. It is the most common type of application inside the IoT startups market

and growing faster than most of them. Besides, having an offer really targeted at individuals and end users and without the need of expensive nor complicated installations makes it reach unprecedented numbers and distance itself from following categories.

After having analyzed in depth the singularities of Smart Home, the first of the three main areas we were focusing, it is time to go into detail with Smart Building.

4.1 SMART BUILDING

The Smart Building category could be interpreted as an extension of the Smart Home and solutions that can also be applied to larger set of households or entire buildings, rather than just a single house. For this reason, the subgroup of functionalities inside Smart Building are the same as Smart Home.

The interesting point here is understanding how the same range of solutions apply depending on what is the system targeted and how they differ from each other. Consequently, we are going to compare these results not only with the ones seen in the analysis of all startups, but also from the Smart Home one from the previous section.

The total amount of startups registered within this category, that have received funding, and is going to be used for the purpose of the whole section's analysis is 85.

4.1.1 Smart Building functionalities

Starting with the companies' distribution based on their functionality, Figure 43, we can already identify the main difference between Smart Home and Smart Building. While the first one had *Security* as its main functionality, Smart Building has *Energy*

consumption monitoring with a 38% of all companies, surpassing by more than 20% *Security,* which here holds the second place.

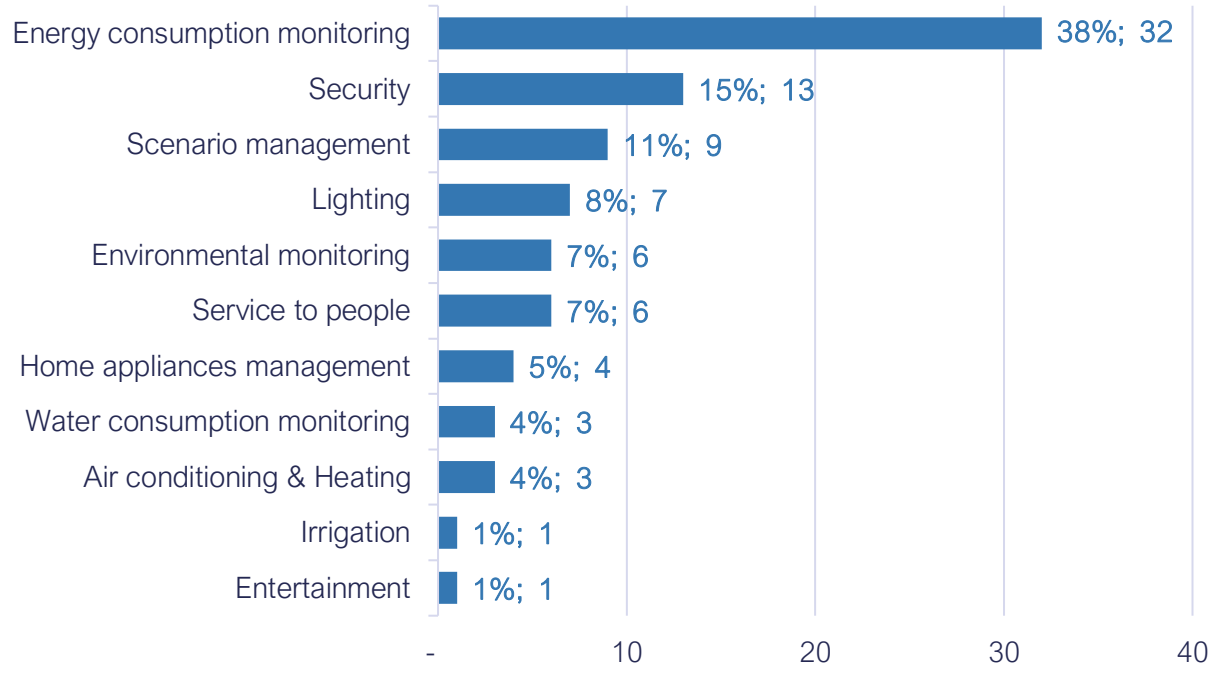

Figure 43. Smart Building functionality distribution. N: 85 startups

Like we have mentioned, Smart Building refers more to larger buildings and neighborhood communities rather than just individual houses, therefore the interests for their applications can differ. From what we can see when addressing a larger amount of people, the interest shift towards energy consumption, which is a big issue for large building as it can escalate to significant amounts of money.

A good example of this is the company *Logical Buildings*, founded in 2012 and has gathered over $3.5M. His solution is based on a group of sensors installed throughout the building to provide real time data and, thanks to an AI algorithm, they can help manage the entire building with a simple software to achieve reduction of operating expenses, optimize energy procurement and even generate energy revenue.

It is worth mentioning also the inclusion it exists of heating, water, gas and other resources monitoring inside this particular category. Meaning that applications offering a group of different solutions in this area are categorized as an overall energy

consumption and monitoring rather than specific applications like *air conditioning* & *heating.* For this reason, the presence of such specific functionalities is rather reduced.

4.1.2 Smart Building geographic distribution

When analyzing the geographic distribution, shown in figure 44, the picture we see is much similar to the Smart Home one. North America still gathers more than half of all companies with a 56% followed by Europe, which for this category it does have a similar presence to when considering all companies and fields (34% vs 38%) and a bit larger than in Smart Home (34% vs 29%). Asia in this case has a reduced participation of just 9%, below their average participation of around 14%. This chart continues to exemplify the dominance of North America when it comes to smartening buildings and homes.

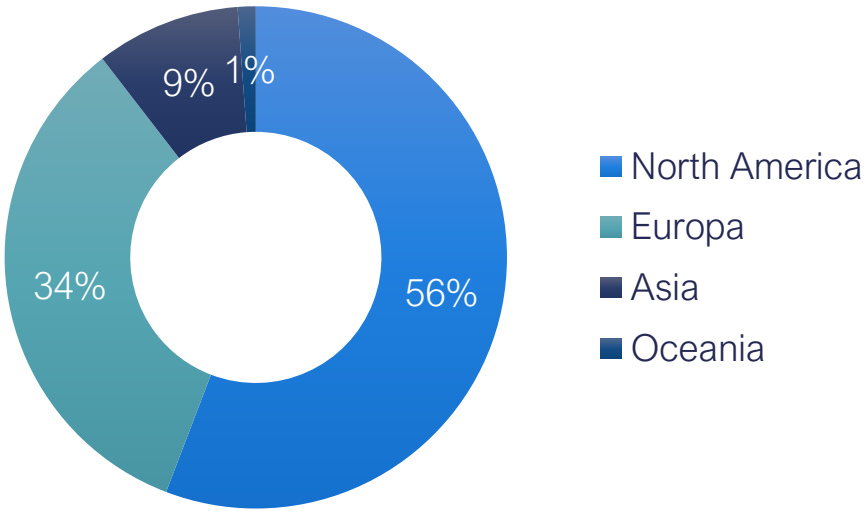

Figure 44. Smart Building geographic distribution. N: 85 startups

4.1.3 Smart Building target market and type of offer

Looking at the segmentation of the addressed market, another major difference is concluded. The main targeted market is direct business to business (B2B), with a 58%. All combinations including B2B collect 93% of all market, while in Smart Home just considering B2C it was already 71%. We can conclude, accordingly, that Smart Building is largely focused into companies, enterprises and large groupings. Besides, it's worth noticing the fact that the B2B group englobes all target customer that is not considered end user. For this reason, if a large neighborhood community decides to purchase some service from one of this companies it also falls as a B2B, as their intent is to benefit from the solution as a whole and at a large scale.

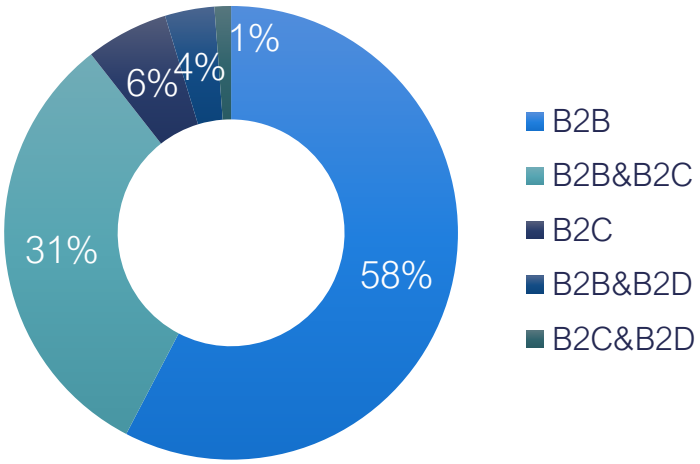

Figure 45. Smart Building targeted market distribution. N: 85 startups

The other part of this section also needs to be considered, in order to understand what it means being B2B oriented when it comes to the solution offered: Does it change significantly?. The answer to that question can be resolved by looking at Figure 46.

When comparing against the same analysis done to Smart Home, the main two offers remain practically unchanged in terms of percentage representativeness: *HW & SW* and *HW, SW & Service*. At the end, these type of solutions mainly relies on physical

devices such as sensors to function. Thus, it is logical that the main offers combine always a HW device and another type to complement them. However, more interesting insight can be extracted if we review the next groups. We can see how SW oriented offers (also accompanied by a service) has grown from a 13% to a 23%, while the only HW solution has decrease from 9% to 6%. It seems that Smart Building offerings are able to leverage from already existing physical that a building may have or even that they are able to provide a meaningful solution without the need of one, much better than Smart Home.

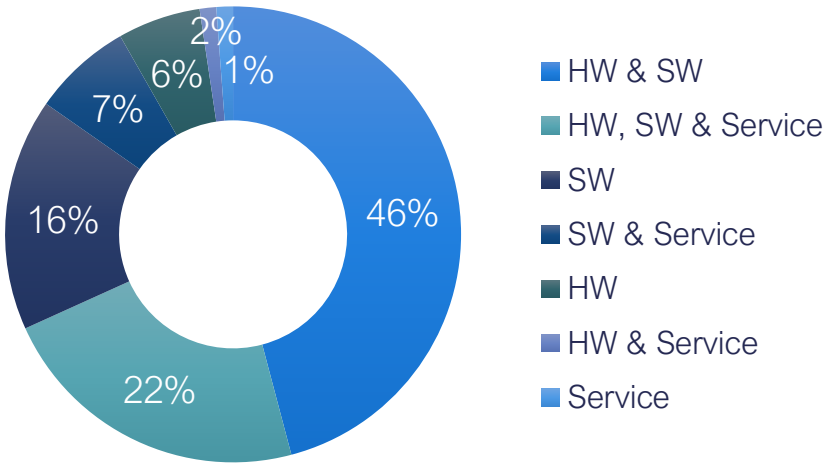

Figure 46. Smart Building type of offer distribution. N: 85 startups

4.1.4 Smart Building funding and financial analysis

Following with the funding analysis, we will start with the evolution of funding throughout the years, with the same time period between 2013 and 2019. It is shown in Figure 47.

This chart represents all companies that are under the Smart Building category and it doesn't include all the outliers mentioned previously. Moreover, it was decided to take

out another company: *Kinestral Technologies*. The reason being is that it was considered an outlier for this specific section, as is a company that belongs to the *Scenarios Management* field and had received 77% of all funds of that field. Also, it represented almost 40% of the overall funds of 2019 because it gathered a large investment that year. Without it, the total number of companies drops to 84 for the following charts.

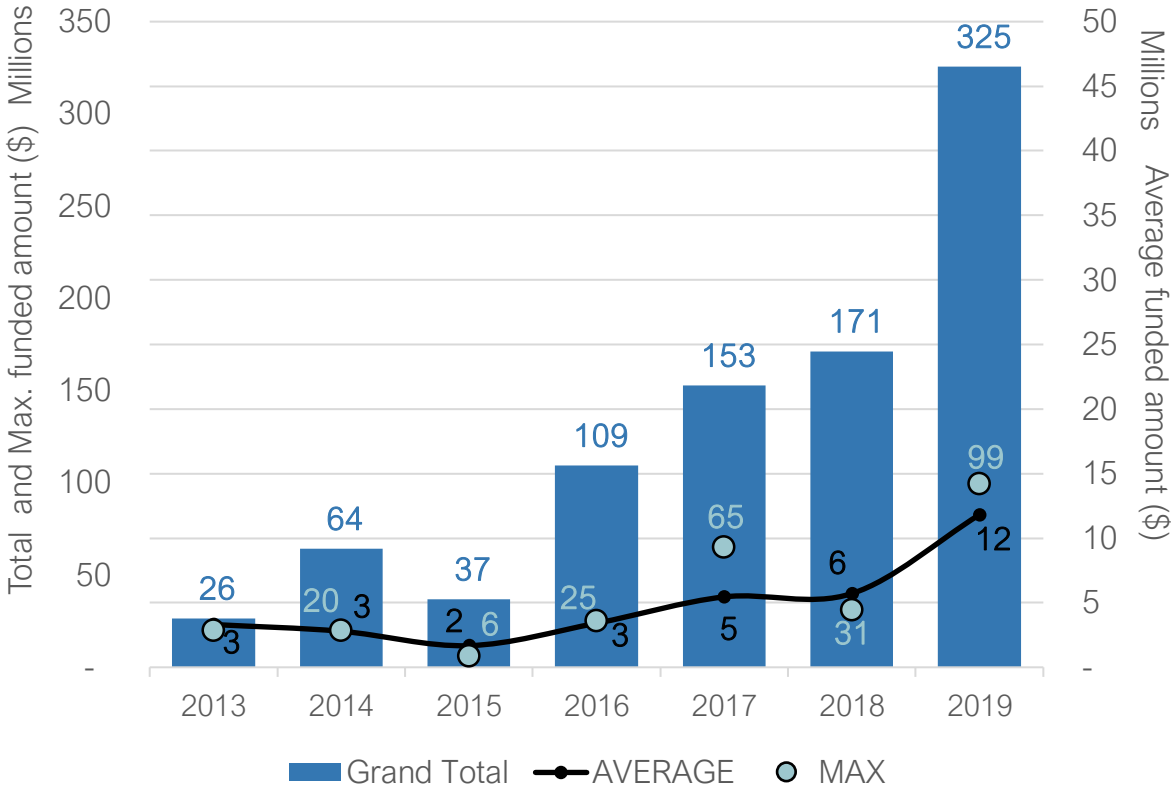

Figure 47. Smart Building funding evolution. N: 84 startups

Examining the chart, there is not much relevant information to extract, apart from what we have seen in previous similar charts. Growth is evidently displayed, accelerating in the last year. CAGR of the field is 51% from 2013 to 2019, within the same lines but a bit slower than the overall IoT market (59%) and much slower than Smart Building (69%). It can be possibly explained because of the need there to coordinate different

stakeholders of such building into embracing Smart Building solutions and not so much individuals like in Smart Home.

Let's examine now how the funding is distributed in based on the functionality, in Figure 48.

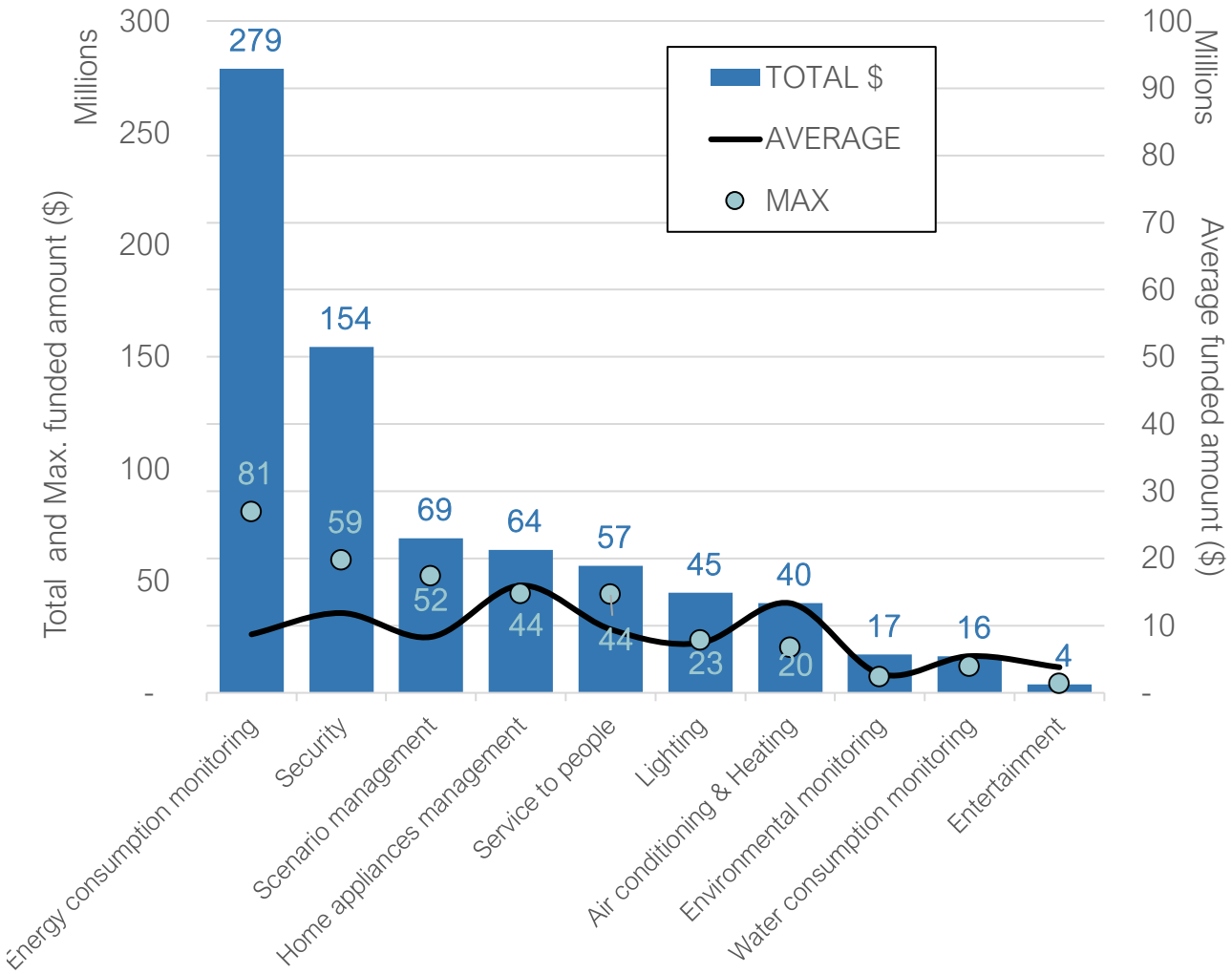

Figure 48. Smart Building funding by functionality. N: 84 startups

The chart shows what seemed logical, following the exploration we have done of the number of startups by each field. *Energy consumption monitoring* gathers 37% of all investments, while in terms of number of companies it was a very similar 38%. Following, security reaches a 20% of all funds against a 15% of companies. This

highlights the fact that in terms of investors interests, those two distance themselves majorly from the rest of competitors.

Another aspect that can be highlighted is how the average amount received by company flattens on the largest fields. It seems that even though there is more money raised by certain fields, it is due to the fact that more companies enter the market, not by the increase in how much each of them collects.

Lastly, we will examine the percentile distribution of the overall funding received by the startups depending on their functionality. It is including the "outlier" we have mentioned previously: *Kinestral Technologies* and displayed in Figure 49.

Field of Application	1st	2nd	3rd	4th	5th	Total %	Total #	Total $
Appliances management	25%	0%	25%	0%	50%	100%	4	$ 64M
Scenario Management	0%	22%	11%	33%	33%	100%	9	$ 298M
Lighting	33%	17%	0%	17%	33%	100%	7	$ 45M
Air conditioning & Heating	33%	0%	0%	0%	67%	100%	3	$ 40M
Energy consumption monitoring	19%	22%	19%	28%	13%	100%	32	$ 279M
Water consumption monitoring	33%	0%	33%	33%	0%	100%	3	$ 16M
Service to people	0%	17%	67%	0%	17%	100%	6	$ 57M
Entertainment	0%	0%	100%	0%	0%	100%	1	$ 4M
Security	8%	46%	15%	8%	23%	100%	13	$ 154M
Environmental monitoring	50%	0%	17%	33%	0%	100%	6	$ 17M
Irrigation	100%	0%	0%	0%	0%	100%	1	$ 150K
Grand Total	**20%**	**20%**	**20%**	**20%**	**20%**	**100%**	**85**	**$ 978M**

Figure 49. Smart Building percentile distribution of funding. N: 85 startups

Even though it may seem that some of the functionalities have a significant amount of companies inside the higher percentiles, it can be due to the low population of companies in each field. Thus, the most representatives can be *Scenarios Management* and *Security* (the largest ones). They fall in the middle range, which makes sense as they are the main contributors of companies in this field, and the percentiles are distributed based on them.

As a conclusion, we have seen how Smart building, even though having the same functionalities as Smart Home, targets a very different type of market and with other kind of offers. It may be conceived as an extension of Smart Home, but it has certainly proved to be another different application with almost opposite markets, which speaks in favor of having it separate from Smart Home. If it had similar characteristics they would have been merged into the same category.

4.2 SMART CITY

To finish the analysis on emerging trends, the final step is Smart City. It certainly differs from Smart Home and Smart Building by two main aspects, which can be understood as the two main challenges of Smart Cities. First, it needs to have not only the citizens but also the local governments involved. Most of the solutions are to work either with public services or in need of the approval of public. Second, as benefits are perceived by all population, it cannot serve specific needs, but general ones, which can translate into difficulties when engaging stakeholders and investors.

Having established that, the following analysis, in the same lines as the previous ones, aims at providing a bit more context and information to collect meaningful insights.

4.2.1 Smart City functionalities

The functionalities regarding Smart Cities area also explained in the database description chapter. In this case, it consists of a total of 95 startups. These includes the outliers, as for this first part of the analysis it is relevant to understand trends and overall behavior for which they need to also be considered.

Private transportation is by far the largest field with 24%, while second place is shared between *Traffic and Parking Management* with a 15% each, as shown in Figure 50.

Having seen that, the first and biggest conclusion is the dominance of transportation related application. Either to provide a new transportation, give information on parking system or consulting real time traffic information, it all circles around the same area.

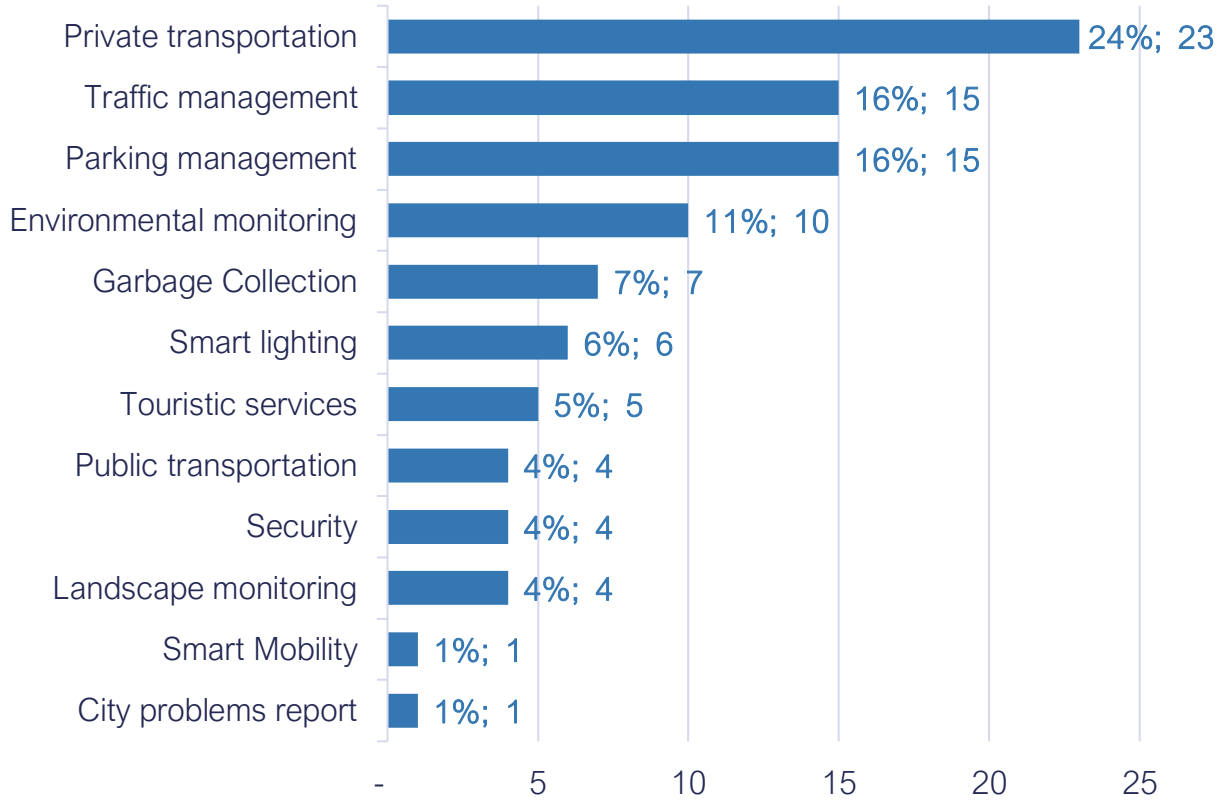

Figure 50. Smart City functionality distribution. N: 95 startups

It is not surprising though, as it one of the easiest areas to work on, because it leverages on existing assets and some of the applications just need to put in connection different stakeholders. For example, in *Parking Management*, what traditionally would be paying for a parking spot directly in the parking meter can now be done with the Smartphone, saving time for both the user and the controller. Besides, it is also useful to save money as the parking time slot can be updated or cancelled at any time. An example of this is *ParkWhiz*, which not only lets you pay for the parking sport, but also helps you find empty spots before you even arrive there.

The largest functionality is *Private Transportation* with a 24%. On-demand business models like Uber and Lyft have taken the world by storm, achieving a growth rate 10 times larger than any other mobility offer in the market [40].

Complementing that offer, and also falling inside the same category, are ridesharing, bike sharing and carsharing companies. Almost every large city has been reached also by these offerings. They provide a flexible alternative that meets diverse transportation needs across the globe, while reducing the negative impacts of private vehicle ownership. There are many examples that could be used to talk about private transportation, but the example that can really highlight the impact it has had over the last years is *Lime*. It has received a lot of investments since their foundation in 2017 as they continue to grow their fleet of scooters and electric bikes into new countries and regions of the globe. Their approach is simple, you just need a smartphone to rent one of their vehicles and when you're done with it leave it anywhere. A strong message towards sustainability and easy mobility through the city has gained them millions of users and a significant increase in revenue as well.

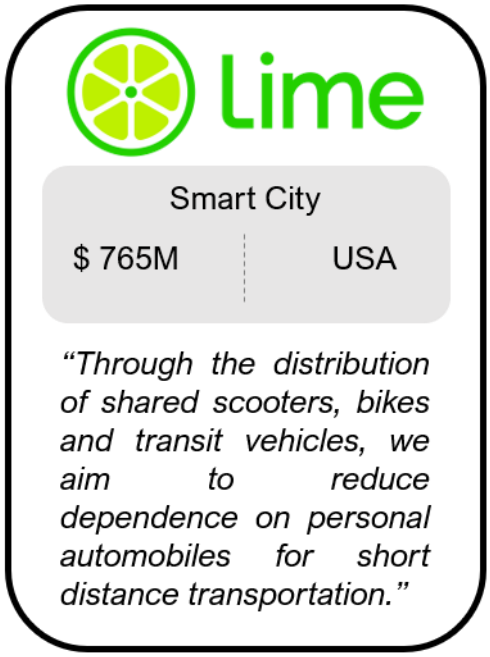

Figure 51. Lime startup information card.

All these examples link the idea, mentioned in the beginning of this chapter, of developing solutions that are helpful to everyone and can impact positively every stakeholder involved.

[40] Deloitte University Press | Smart mobility: Reducing congestion and fostering faster, greener, and cheaper transportation options. 2015.

4.2.2 Smart City geographic distribution

The geographic distribution, shown in Figure 52, shows a more equitable distribution compared against all the previous geographic analysis. In here, Europe has the most startups with a 46%, while North America has a minor 36%.

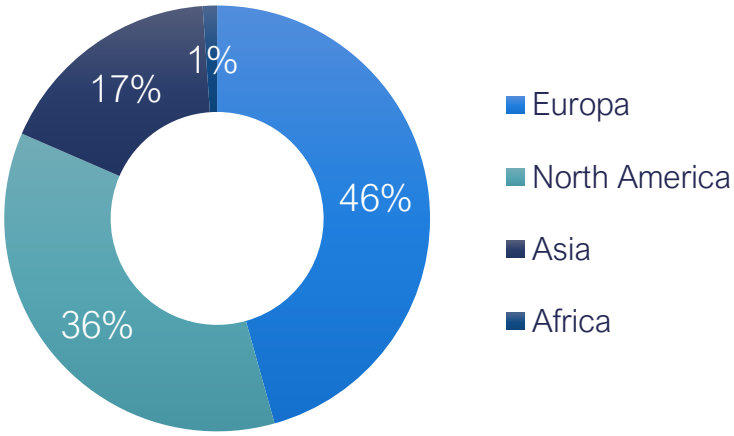

Figure 52. Smart City geographic distribution. N: 96 startups

Considering that the majority of companies belong to *Private Transportation,* it can be concluded that there is no preference in terms of geographic location. European cities are as interested as American's (if not more) for this type of offerings and developments within their societies. It definitely is a change against Smart Home and Smart Building where almost 60% was in North America.

4.2.3 Smart City target market and type of offer

Both the targeted customer and the type of offer distribution are mapped in Figures 53 and 55 respectively.

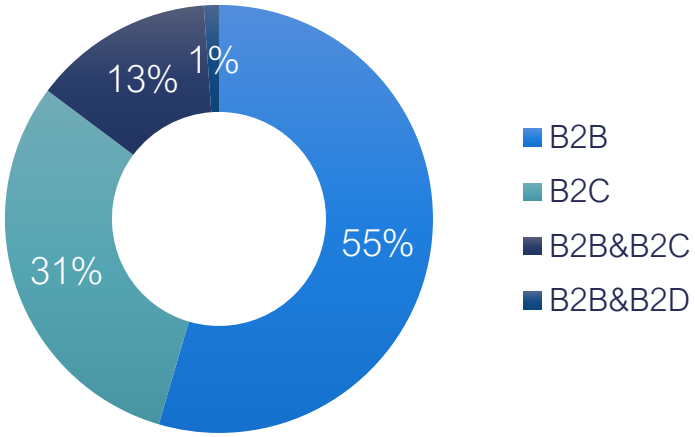

Figure 53. Smart City target market distribution. N: 96 startups

For the first one, it may seem that B2B is the dominant position with a 55%, while B2C only gather a 31%. However, and since the distribution for this field is relatively concentrated in the top three functionalities (56% of all companies belong to those three), it makes sense to go in a more detailed view for those three. This is given in the following Figure 54.

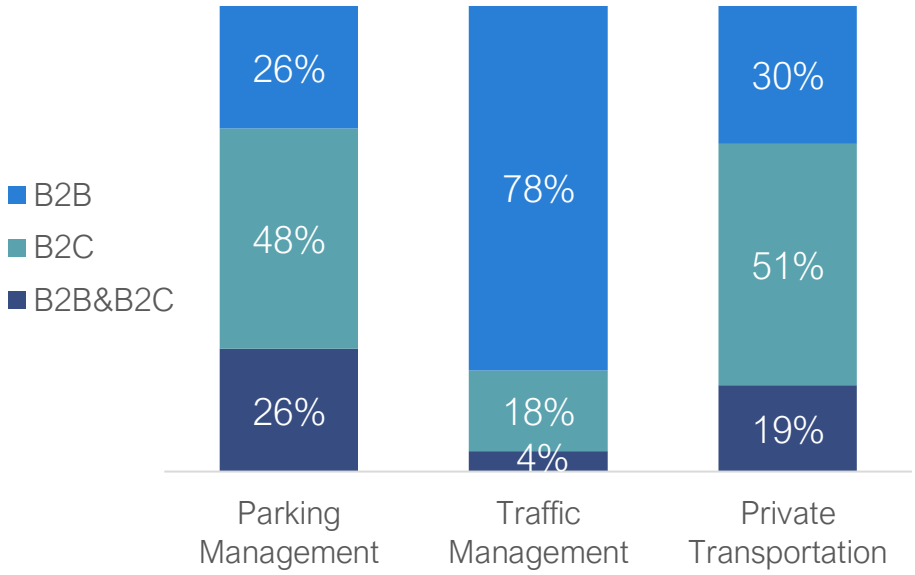

Figure 54. Target market distribution for the top three fields. N: 53 startups

With that view, we can clearly see the differences between them, as they are rather significant. Concentration of only B2B market, far from being a standardized distribution across all application, varies from a 26% in *Parking Management* up to a 78% for *Traffic Management.* We can also see how targeting end users, meaning B2C, is the largest option for *Private Transportation,* with a 51%. *Traffic Management* is largely focusing B2B market with a 78%, as their offering is largely targeted to institutions dealing with traffic issues, which tend to be publicly managed. On the *Parking Management*, there is no polarization as in the others, but B2C seems to be the main one with almost half of all companies targeting end users.

For the type of offer in Smart City, examining Figure 55, we can see that there is no leading option. Both Smart Home and Smart Building applications have one type of offer that dominates in front of the others. However, in Smart City the first three sit in a 5% difference, which is not enough, considering the number of startups involved, to determine as statistically significant.

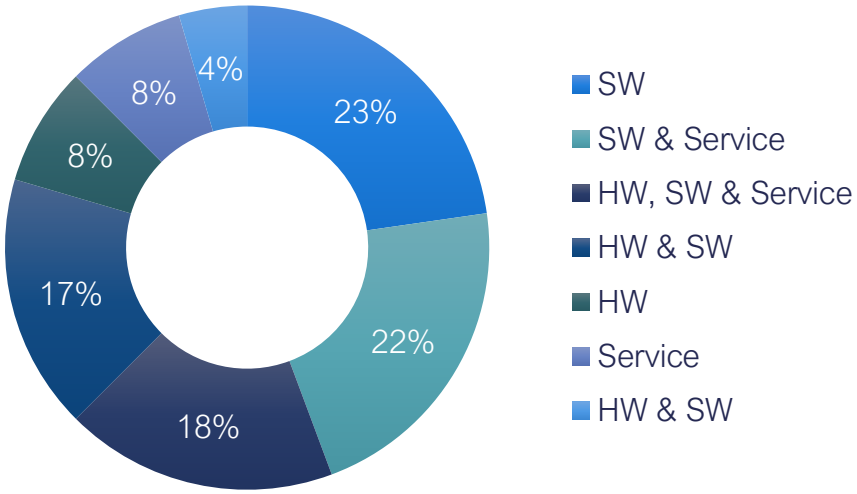

Figure 55. Smart City type of offer distribution. N: 96 startups

Despite that, it can be established that the range of possible applications registered in the Smart City field are so varied that there is no clear path to follow. Possibly meaning that all the possibilities this field offers are yet to be exploited and discovered.

4.2.4 Smart City funding and financial analysis

For the financial analysis of Smart City, it is not considered the outliers detailed at the beginning of the analysis. In there, there are three *Private Transportation* companies: *Lyft*, *Fair* and *Ofo.* Consequently, for the financial analysis purpose, their field will count with only 20 companies, leaving a total of 92 for the overall view.

Starting with the funding evolution, in Figure 56, there is again an increasing trend over the whole period, with a CAGR of 88%, the highest we have seen. Average values also increase a significant pace with a CAGR of 35% over the same period, underlining the increasing interest in investors over the years, funding with more money each year (as they will also expect a higher return from their businesses).

In the same chart we can what could be considered a little anomaly in 2017. Even thought is not as a large as the $ 1Bn. threshold we set for a company to be an outlier; it does represent almost 40% of the investments in that year. It is the case of *Lime,* also mentioned before, and if we were to take it out the chart would look more normalized and with an always-increasing pattern throughout the years.

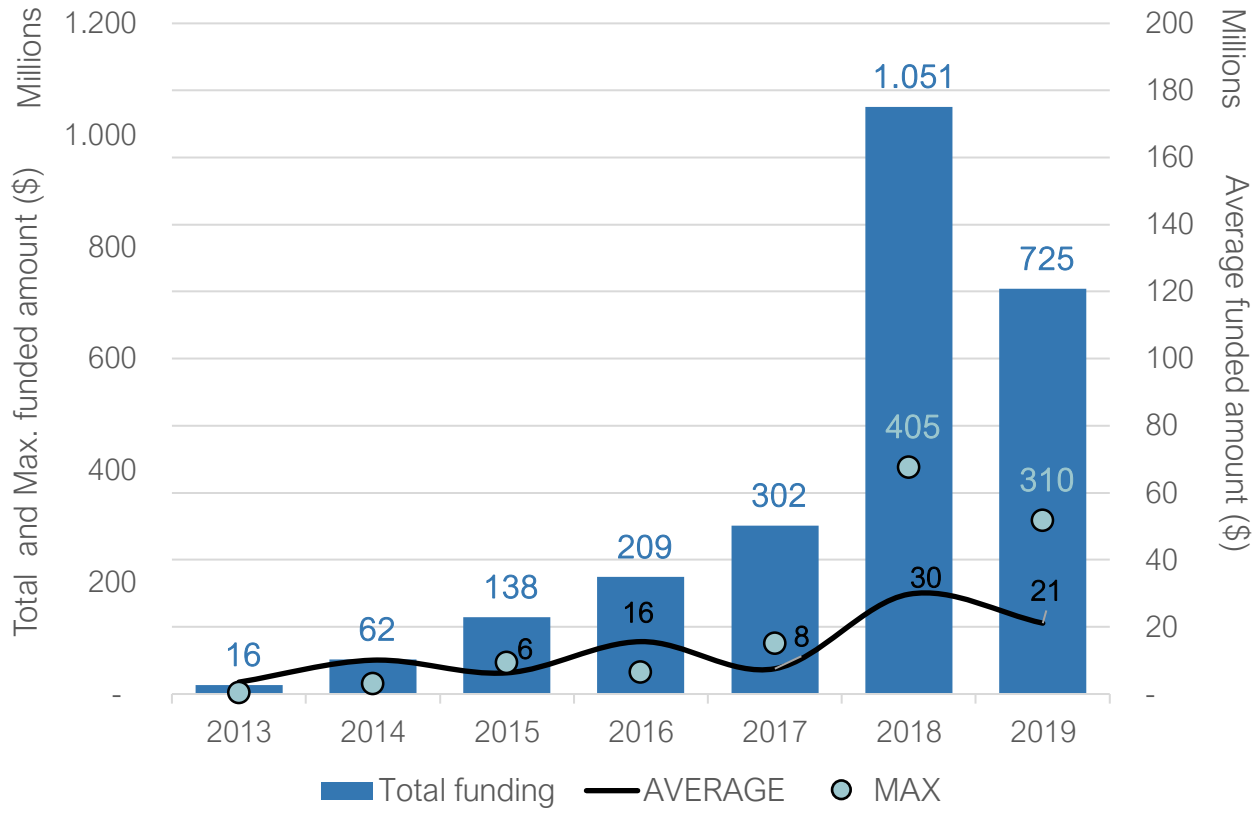

Figure 56. Smart City funding evolution. N: 92 startups

When analyzing the funding received, by functionality, shown in figure 57, the results are self-explanatory. There is an enormous dominance from *Private Transportation* startups. Keep in mind this does not include the three outliers mentioned before; adding them would make the chart look even more drastically differentiated.

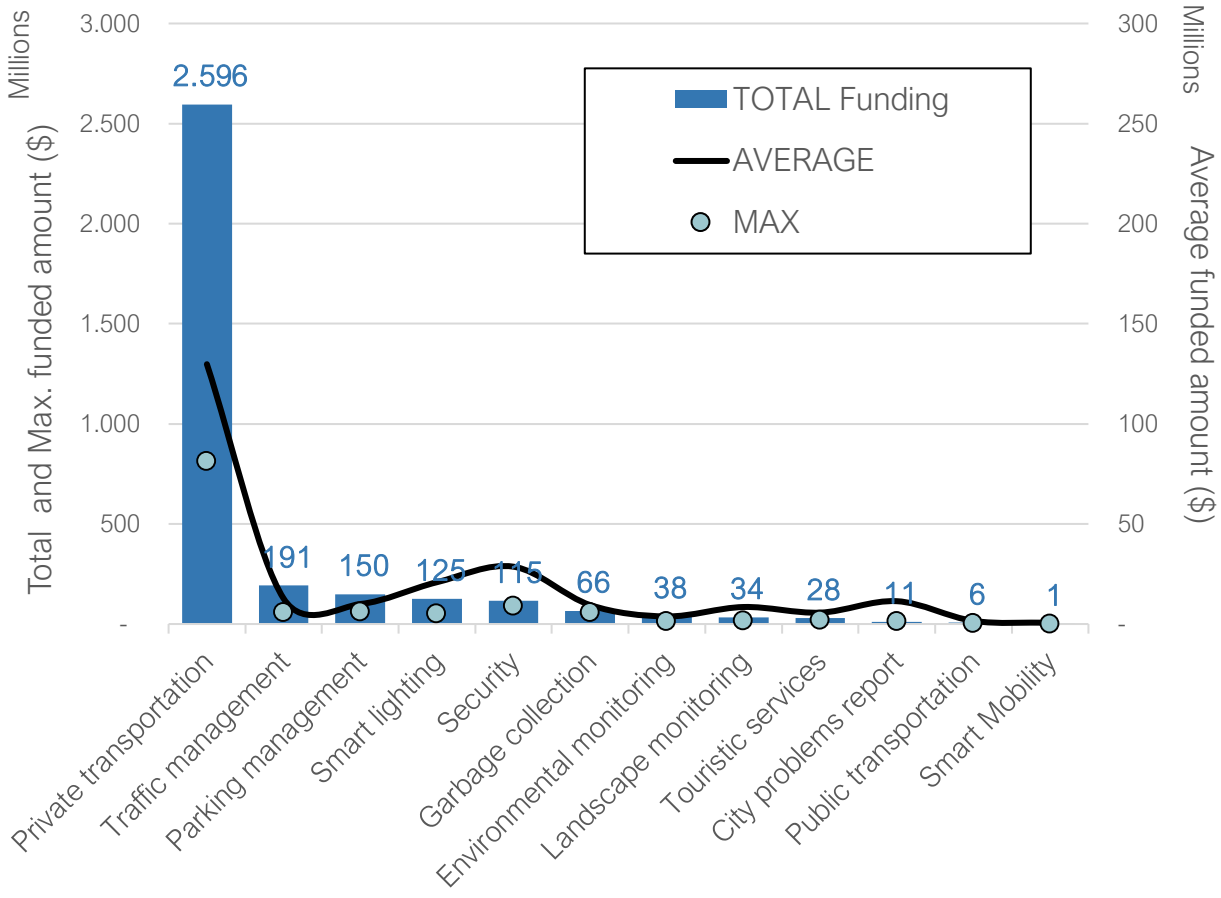

Figure 57. Smart City funding distribution by functionality. N: 92 startups

Private Transportations gathers 77% of all investments, when it only represented 24% of all companies. Several arguments have been given in order to provide an explanation to why this field is so representative and has attracted that amount of investments over the last years. But overall, it is mainly due to the creation of new business models that have disrupted the market of mobility, enabling the entry of new players to compete against the traditional Car, Metro, Taxi and Bus rectangle. Those new business models, inspired by the sharing economy and disruptive technologies, are ushering in an exciting new age in transportation: the era of smart mobility. The arrival of on-demand ride services, real-time ridesharing services, carsharing programs, bike sharing programs, and thousands of miles of new urban bike lanes are all changing how people get around.

The type of investments received by the companies inside the Smart City field are shown in the following table, Figure 58. It is yet another set of proof to see the absolute dominance of *Private Transportation*, having more than half of their companies inside the largest percentile. *Traffic* and *Parking Management* also have larger representation in the bigger groups, while the rest tend to have the majority of them in the lowest percentiles, with the exception of Smart Lighting that, somehow, has two companies also inside the largest category, which requires a minimum of $ 25M.

Field of Application	1st	2nd	3rd	4th	5th	Total %	Total #	Total $
Private transportation	10%	15%	10%	10%	55%	100%	20	$ 2.5Bn
Smart lighting	17%	0%	33%	17%	33%	100%	6	$ 125M
Traffic management	7%	7%	40%	33%	13%	100%	15	$ 191M
Parking management	33%	20%	7%	33%	7%	100%	15	$ 150M
City problems report	0%	0%	0%	100%	0%	100%	1	$ 11M
Landscape monitoring	0%	25%	50%	25%	0%	100%	4	$ 34M
Touristic services	0%	60%	20%	20%	0%	100%	5	$ 28M
Security	0%	50%	0%	25%	25%	100%	4	$ 115M
Public transportation	25%	50%	25%	0%	0%	100%	4	$ 6M
Smart Mobility	0%	100%	0%	0%	0%	100%	1	$ 1M
Environmental monitoring	40%	20%	20%	20%	0%	100%	10	$ 38M
Garbage collection	57%	14%	14%	0%	14%	100%	7	$ 66M
Grand Total	**20%**	**20%**	**20%**	**20%**	**20%**	**100%**	**92**	**$ 3.3Bn**

Figure 58. Smart City percentile distribution. N: 92 startups.

5. CONCLUSIONS AND NEXT STEPS

The different exercises done during all the analytical part of this thesis has helped understand in a global a general way, but also with a detail perspective in emerging applications, which are the main trends and characteristics.

In a geographical point of view, we have seen the increased presence of emerging countries, underlining the fact that IoT has completely reached all develop economies (and even though is still growing at high rate) and its grow focus has concentrated for regions like Asia. Despite that, we still see a large dominance on North America and Europe's region, as emerging countries still represent less than 20%.

Examining the state of the art and the current offer we were able to classify Smart Home, Multiapplication Platforms and Smart City as the ones with the most number of startups as well as being inside the top funded fields. Adding to this list of three, Smart Car, despite not being the largest in number of companies, it is by far the largest funded field mainly due to large capital injection in this segment over the last years. Applications registering the most growth are still the previous four, again with a growth leadership dictated by Smart Car and Smart City.

For the context of the offer and their business models, we were able to see a mostly predominant B2B offering, even though areas with the most investments, like Smart Home and Car, showed a preference for B2C, as their ability to reach end users directly is more profitable, avoiding third parties or intermediates. However, for the type of offering, even though there is a much more diverse context, it was seen that most of the companies decide to offer a HW product complement with SW or a Service, or both. In that sense, the need for connected devices, at the end, remains essential.

Through the more detailed analysis on emerging trends it was possible to obtain meaningful insights from Smart Home, Building and City applications, as they have been highlighted as the most relevant and increasing trends. Out of the three Smart City has is seeing the highest investments growth rate over the last 7 years at a CAGR of 88%, followed by Smart Home (69%) and then Building (51%). For their target

customers they also have different behaviors. Smart Home is mainly destined at B2C (over 70%) while Smart Building, despite having the same functionalities, seems to reach a larger B2B target than any other. For the case of Smart City, something interesting occurs. The overall shows a predominance around 50% of B2B. However, when we look in detail for the three main functionalities (Private transportation, Parking and Traffic Management) the concentration varies. The last one still shows a higher B2B orientation (78%), while private transportation and parking management applications tend to be more end user oriented with an average between both of 50% being B2C.

The future of the Internet of Things and the scope of its applications is expected to continue growing at least during the following decade, as the applications themselves will be entering new markets and exploiting different business models and opportunities.

The scope of this project is limited, as it relies on the database which only gathers accessible information by the large public, and always following the guidelines and fields preconceived. Therefore, there are many ways in which this work can be complemented and extended as future directions.

The first area for further development could be extending the knowledge of their business models. In the database it is only registered whether it is a B2B, B2C or B2D (plus the possible combinations) business model. However, there are plenty of ways to understand their business model success or failure than this simple segmentation.

Speaking of failure, the database has a very low rate of failed companies. This is due to the fact that the main focus has been placed on current operative and growing startups. However, failure is a very important part of the entrepreneur world and needs to be understood and accepted. Thus, another possible are of reach for further thesis could be exploring the most relevant success and failure factors depending on their field of application, with given examples and guidelines.

Lastly, another limitation of this work is its financial focus on investments and funding received. But there is not much complementary information to that and seems logic, since it is considering very young startups that, most of them, have not reached exit

point. It would be very interesting to analyze, for companies that have exited, how are their return on investments, maybe analyzing it also by field of application, so that a clear comparison could be done before and after exiting.

Taking all the previous mentioned into account and after overviewing all the conclusions driven by this thesis, it can be considered as a research paper that brings clear and meaningful insights of the IoT startups ecosystem, and it can be taken as a reference and background for further investigations and researches to be done in this topic.

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